Technical University of Crete
School of Mineral Resources Engineering
MSc program in Petroleum Engineering

MSc Thesis

Maximization of oil production in a North Sea reservoir by history matching and optimal location of additional injection well

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Abstract

The complexity of petroleum production from their baring geological formations is a multidimensional mathematical problem. The "a priori" accurate estimation of the future reservoir production, constitutes one of the most demanding and important tasks in Petroleum Engineering.

To overcome this difficulty the concept of "Reservoir Simulation" has been introduced in the petroleum industry. A reservoir simulation is the image projection of the actual reservoir formation, by separating the total volume of it, into many finite volumes, called "blocks"; and thus creating a finite volume system, called "Grid system". Specific properties are given to each block or group of blocks. Fluid flow is then simulated by solving specific mass balance equations, in interblock fluid exchange.

By taking into account, possible production data from the actual reservoir, the block properties may be tuned in order for the simulated reservoir behavior to match the actual observed one. This procedure is called "History matching".

One of the most known and widely used simulation software in the industry is the ECLIPSE simulator, by SCHLUMBERGER Service Company.

In this Master Thesis, a section of an actual reservoir from the Gullfaks Field in the Norwegian part of the North Sea has been obtained. Eclipse software was used in order two different history matching approaches to be developed, and eventually to be compared against each other, in terms of accuracy in future production forecasting.

To further develop the two models created in the previous step, and in order to expand the spectrum of results obtained, it was decided to investigate whether an additional injection well would have a positive effect on the field oil production total (FOPT). Therefore, six different locations of the reservoir grid have been tested.

Finally, according to the outcome of these additional simulation runs, the optimal location for an additional injection well, in order to achieve production maximization, has been proposed.

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1) Preface

This Thesis is the result of the common effort of two postgraduate students in the MSc program in Petroleum Engineering of the Mineral Resources School in the Technical University of Crete (TUC).

The common desire of Mr. Nikolaos Georgantas and Mr. Kostantinos Voumvourakis to address the issue of Reservoir Simulation has first emerged upon the lectures on the reservoir simulation module of the Master Program.

Professor Nicolaos Kalogerakis, the supervisor of this Thesis, along with the authors, after thorough discussions that took place, they decided that a team project would best serve the purpose of this Thesis, which was to endeavor to unravel the simulation of an existing reservoir.

Afterwards, the subject has been decided, which concerned a real case reservoir model, of the Gullfaks field in Norway. This is due to the courtesy of Dr. Christos Chatzichristos, one of the tutors of the reservoir simulation subject in the MSc of Petroleum Engineering, who provided us with the necessary data.

To conclude, this project has been an extraordinary experience for both of the participants, as it allowed not only a deeper insight into the philosophy, scopes and aims of the reservoir simulation concept, but also, it has been an excellent chance of acquiring fundamental experience and skills in the use of Eclipse simulation software.

Nikolaos Georgantas and Konstantinos Voumvourakis

2) Introductory Theoretical background

2.1 Reservoir

Reservoirs are usually defined as a subsurface volume of porous and permeable rock that has both storage capacity and the ability to allow fluids to flow through it. To a petroleum geoscientist, reservoirs are porous and permeable rock bodies that contain commercial amounts of hydrocarbons. Reservoirs owe their porosity and permeability to physical processes that take place, such as deposition, diagenesis, or fracturing — either individually or in combination.
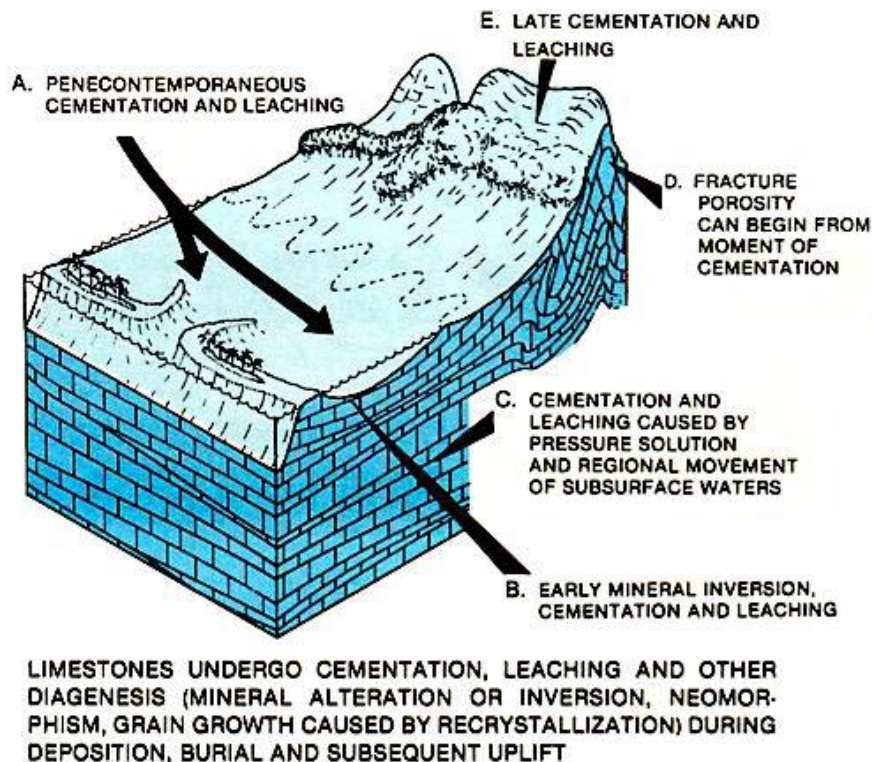
Figure 1: physical properties

More specifically, reservoirs are three - dimensional bodies composed of rock matrix and networks of interconnected pores. If the three - dimensional geometry (size and shape) of a connected pore system is known, it is possible to determine drilling locations in exploration or development prospects; to estimate the volume of the resource in the reservoir or aquifer; to achieve optimum extraction of the resource; to determine whether it is necessary to drill additional (infill) wells to achieve the optimum spacing between field wells during development, and also to predict the path that will be taken by injected fluids as they carry over any remaining hydrocarbons during secondary and enhanced recovery.

Petroleum reservoirs are broadly classified as oil or gas reservoirs. These broad classifications are further subdivided depending on:

• The composition of the reservoir hydrocarbon mixture
• Initial reservoir pressure and temperature

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• Pressure and temperature of the surface production

The conditions under which these phases exist are a matter of considerable practical importance. The experimental or the mathematical determinations of these conditions are expressed in different types of diagrams called phase diagrams. One such diagram is called the pressure-temperature diagram.
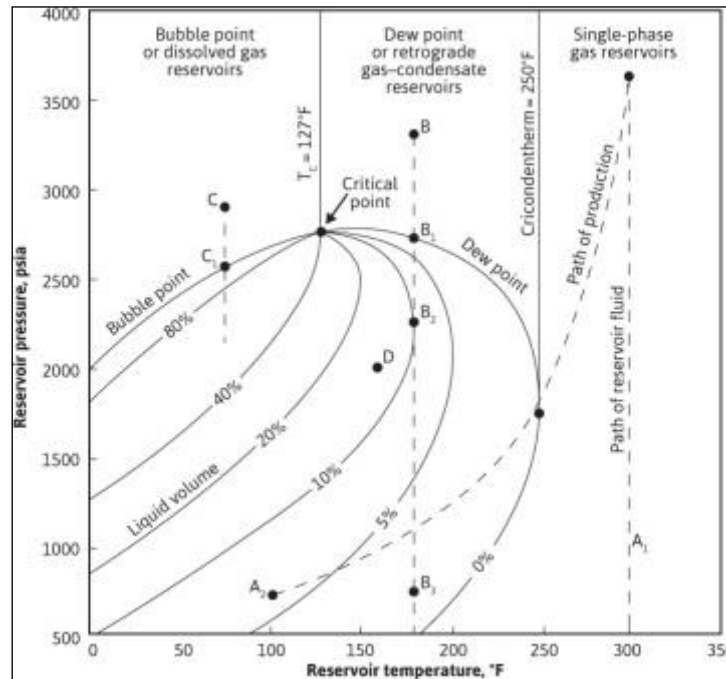
Figure 2: Phase envelope (www.informit.com)

Figure 2 shows a typical pressure-temperature diagram of a multi-component system with a specific overall composition. Although a different hydrocarbon system would have a different phase diagram, the general configuration is similar.

These multi-component pressure-temperature diagrams are essentially used to:

• Classify reservoirs
• Classify the naturally occurring hydrocarbon systems
• Describe the phase behavior of the reservoir fluid

In general, reservoirs are classified on the basis of the location of the point representing the initial reservoir pressure Pi and temperature T with respect to the pressure-temperature diagram of the reservoir fluid. Accordingly, reservoirs can be classified into basically two types.

These are:
• Oil reservoirs—If the reservoir temperature T is less than the critical temperature T_c of the reservoir fluid, the reservoir is classified as an oil reservoir.
• Gas reservoirs—If the reservoir temperature is greater than the critical temperature of the hydrocarbon fluid, the reservoir is considered a gas reservoir.

Hydrocarbons migrate upward through porous and permeable rock formations until they either reach the surface as seepage or become trapped below the surface by a non-permeable cap rock which allows them to accumulate in place in the reservoir.
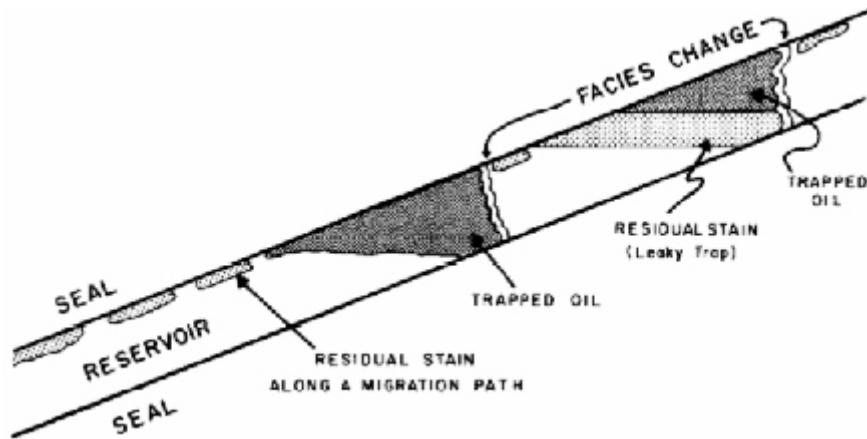
Figure 3: Hydrocarbon migration path (http://bairdusa.com)

Porosity and permeability are influenced by the depositional pore-geometries of the reservoir sediments and the post-depositional diagenetic changes that take place [Basic Petroleum Geology and Log Analysis].

Reservoir characterization, like reservoir geology, deals with physical characteristics of the reservoir. It differs from geological description in that data on petrophysics and fluid properties are included. In addition to data from direct examination of reservoir rocks, reservoir characterization involves interpretation of borehole logs, porosity – permeability measurements, capillary pressure measurements, reservoir fluid saturations, and reservoir drive mechanisms.

Reservoirs are studied throughout their economic lives to derive the information required for optimal production. In addition to geological data and borehole log characteristics, reservoir engineering deals with reservoir pressures, oil – water saturation, and gas – oil ratio in order to provide estimates of in – place hydrocarbon volumes, recoverable reserves, and production potential for each well in a field (Cossé, 1993).

Different types of reservoirs

Fundamental rock properties, how the properties are used to classify both rocks and porosity, and how fundamental rock properties are related to reservoir properties, are largely responsible in defining the type of a reservoir.

In carbonate rocks, reservoir porosity and permeability can be formed by a variety of processes. These processes create the rock properties with rigidly objective terms. Some of the formative processes may have affected reservoir rocks more than once; therefore an accurate reservoir description should incorporate terminology that classifies the altered properties, the processes

that created them, and at least an estimate of the number of times the rock properties underwent change.

Sandstone reservoirs (SiO$_2$)

They are generally created by the accumulation of large amounts of clastic sediments which is characteristic of depositional environments such as river channels, deltas, beaches, lakes and submarine fans. Sandstone reservoirs have a depositional porosity and permeability controlled by grain size, sorting, and packing of the particular sediments. Diagenetic changes may include precipitation of clay minerals in the pore space, occlusion of pores by mineral cements, or even creation of additional pores by dissolution of sediments.

Carbonate reservoirs (Limestones - CaCO$_3$, Dolomites - CaCO$_3$Mg CO$_3$)

They are created in marine sedimentary environments with little or no clastic material input and generally in a location between 30° north and south of the equator. Carbonates are anionic complexes of (CO$_3$) 2– and divalent metallic cations such as Ca, Mg, Fe, Mn, Zn, Ba, Sr, and Cu, along with a few less common others. The bond between the metallic cation and the carbonate group is not as strong as the internal bonds in the CO$_3$ structure, which in turn are not as strong as the covalent bond in carbon dioxide (CO$_2$). In the presence of hydrogen ions, the carbonate group breaks down to produce CO$_2$ and water. This breakdown reaction, commonly experienced when acid is placed on limestone, is the chemical basis for the fizz test that distinguishes carbonates from non carbonates.

Carbonates hold about half of the world's oil and gas, much of its groundwater, and extensive deposits of metallic ores, yet of the relatively few texts on reservoir geology, only a handful deal with carbonates. Porosity types of carbonate reservoirs include vuggy (pores larger than grains), intergranular (between grains), intragranular or cellular (within grains), and chalky. Diagenetic changes such as dolomitization, fracturing, dissolution, and recrystalization (rare) are extremely important because they have the ability to create very effective secondary porosity. Cementation, another type of diagenesis, generally reduces porosity and permeability.

2.2 Physical Characteristics of a Reservoir

Physical characteristics of a reservoir include original deposition and subsequent changes, the type of reservoir, sandstone or carbonate, which was discussed previously, depth, area, thickness, porosity, permeability, and capillary pressure.

2.2.1 Depth

The physical characteristics of a reservoir are greatly affected by the depth at which they occur.

Shallow reservoir

Created by the folding of relatively thick, moderately compacted reservoir rock with accumulation under an anticline or some trap. The hydrocarbons would generally be better separated as a result of lower internal reservoir pressures, less gas in solution and oil of increased viscosity, resulting from lower temperatures.

Deep reservoir

This type of reservoir is typically created by severe faulting. The hydrocarbons would be less separated with more gas in solution and oil of reduced viscosity because of higher temperatures. There is often a reduction in porosity and permeability due to increased compaction.

2.2.2 Area and Thickness

The total area of a reservoir and its thickness are of considerable importance in determining if a reservoir is a commercial one or not. The greater the area and thickness of the reservoir is, the greater the potential for large accumulations of oil and gas at that particular reservoir. However, there are reservoirs that produce substantial amounts of hydrocarbons that are not of considerable size.

2.2.3 Porosity

For a rock to be characterized as a reservoir, its porosity and permeability is not the only factors that will determine it. Reservoir behavior relative to oil and gas accumulation and production certainly involves porosity and permeability, but its performance is based upon several important engineering factors. Porosity is the ratio of void space in a rock to the total volume of rock, and reflects the fluid storage capacity of the reservoir.

Porosity $(\Phi) = V_p / V_b = (V_b - V_{gr}) / V_b$

Where, V_b = bulk volume, V_{gr} = Sand grain volume, V_p = pore volume.

Porosity is a scalar quantity because it is a function of the bulk volume, used to define the sample size, and is expressed as a percentage on a log. When used in calculations, however, it is important that porosity be expressed in decimal form. The term "porosity" is often misused in place of "pore space," which is the proper term for describing voids in a rock. Porosity is a measurement and cannot be seen, whereas what is observed is pore space, or pores.

Primary Porosity

Amount of pore space present in the sediment at the time of deposition, or formed during sedimentation. It is usually a function of the amount of space between rock-forming grains.

Figure 4: Components of sedimentary rocks (www.gly.uga.edu)

Secondary Porosity

Post depositional porosity. Such porosity results from groundwater dissolution, recrystallization and fracturing.

Effective Porosity vs. Total Porosity

Connected porosity where void space has flow through potential is called effective porosity. Effective porosity is the interconnected pore volume available to free fluids. Total porosity is all void space in a rock and matrix whether effective or non effective.

Fracture porosity

It results from the presence of openings produced by the breaking or shattering of a rock. All rock types are affected by fracturing and a rocks composition will determine how brittle the rock is and how much fracturing will occur. The two basic types of fractures include natural tectonically related fractures and hydraulically induced fractures. Hydraulic fracturing is a method of stimulating production by inducing fractures and fissures in the formation by injecting fluids into the reservoir rock at pressures which exceed the strength of the rock. Hydraulic fracturing can tremendously increase the effective porosity and permeability of a formation.

Figure 5: Natural and induced fracturing (www.spec2000.net)

Porosity in carbonate reservoirs ranges from 1 to 35%, 10% in dolomite reservoirs and 12% in limestone reservoirs.

2.2.4 Permeability

It is the property of the porous medium that measures the capacity and ability of formation to transmit fluid. It is the measurement of ease with which a liquid can flow through a porous medium. Permeability is the property of rock when we are only concerned with absolute permeability and when we talk about effective and relative permeability then it is considered as a property of fluid and rock as well. Permeability is important because it is a rock property that relates to the rate at which hydrocarbons can be recovered.

Values range considerably from less than 0.01 millidarcy (md) to well over 1 darcy. A permeability of 0.1 md is generally considered minimum for oil production. Highly productive reservoirs commonly have permeability values in the Darcy range.
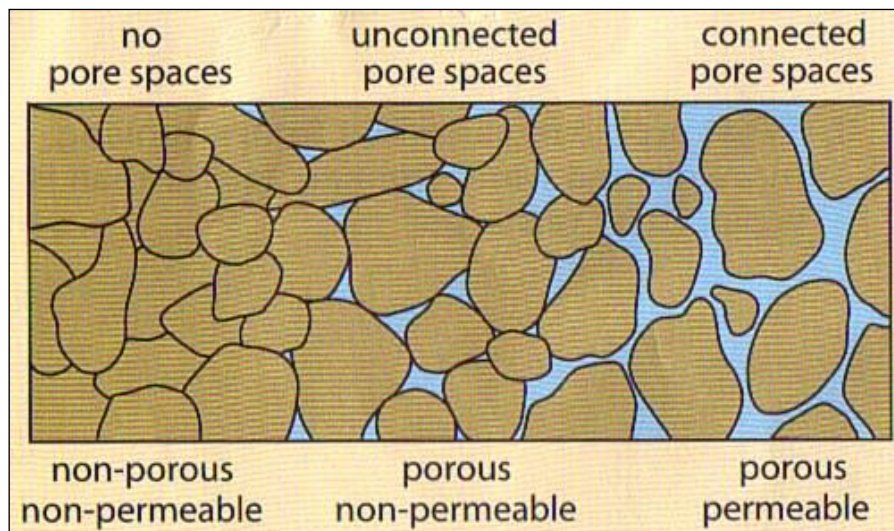
Figure 6: Relation between pore space and permeability (www.asu.edu)

Absolute permeability— if the rock is saturated with one fluid then permeability is known as absolute permeability denoted by "K". It only depends on rock properties because we calculate absolute permeability when only a single fluid exists in the pore and by the formula provided by Darcy as V = KdP/µL.

Absolute permeability is the permeability of a rock that is 100% saturated with a single fluid. In a water-wet rock only water can totally saturate the pore system, and brine permeability is normally taken as the absolute permeability. However, hydrocarbon permeability at residual water saturation is often used as absolute permeability in reservoir engineering studies.

Effective permeability

Effective permeability is the permeability of one fluid in the presence of another fluid measured at a specific saturation state. Effective permeability is always lower than the absolute permeability and will change as the saturation changes.

When more than one immiscible fluids will be present, the other fluids will provide hindrance in the path of the other particular fluid flow such that decreasing its flow area and hence the permeability of that particular fluid will get decreased as compared to absolute permeability and the new permeability obtained for that particular will be called as effective permeability which will always be less than the absolute permeability of rock.

It depends on both rock and fluid properties such that in the presence of more than one fluids, one fluid can travel much faster than the other due to low viscosity and hence its permeability will be more (like gas as compared to oil) so it is depending on nature of fluids and also the grains shape and size affect the permeability in general so it is depending on the rock type also.

Relative permeability

Relative permeability at a specific fluid saturation is the ratio of effective permeability to absolute permeability of a fluid.

2.2.5 Skin factor

The well skin effect is a composite variable. In general, any phenomenon that causes a distortion of the flow lines from the perfectly normal to the well direction or a restriction to flow (which could be viewed as a distortion at the pore-throat scale) would result in a positive value of the skin effect.

Positive skin effects can be created by "mechanical" causes such as partial completion (i.e., a perforated height that is less than reservoir height) and inadequate number of perforations (also distorting the flow lines), by phase changes (relative permeability reduction to the main fluid), turbulence, and due to damage to the natural reservoir permeability.

A negative skin effect denotes that the pressure drop in the near-well bore zone is less than what would have been from the normal, undisturbed, reservoir flow mechanisms. Such a negative skin effect, or a negative contribution to the total skin effect, may be the result of matrix stimulation (the near-well bore permeability exceeds the normal value), hydraulic fracturing, or a highly inclined well bore. Finally, note that while the skin effect is dimensionless, the associated damage zone is not.

2.3 Fluids

2.3.1 Fluid Distribution within a Reservoir

Although the composition of petroleum will contain many trace elements the key compounds are carbon (83% – 87%), hydrogen (10% - 14%), nitrogen (0.1% - 2%), oxygen (0.05% - 1.5%) and sulphur (0.05% - 6%) with a few trace metals making up a very small percentage of the petroleum composition.

The actual overall properties of each different petroleum source are defined by the percentage of the four main hydrocarbons found within petroleum as part of the petroleum composition.
The percentages for these hydrocarbons can vary greatly, giving the crude oil a quite distinct compound personality depending upon geographic region. These hydrocarbons are typically present in petroleum at the following percentages: paraffins (15% - 60%), napthenes (30% - 60%), aromatics (3% to 30%), with asphaltics making up the remainder.

The composition of petroleum is defined as laid out above, and it is this composition which gives the crude oil its properties. Raw petroleum is usually dark brown or almost black although some fields deliver a greenish or sometimes yellow petroleum. Depending upon the field and the way the petroleum composition was formed the crude oil will also differ in viscosity.

At the extreme ranges petroleum can be almost solid, and required a significant investment of resources to refine into a useable state as anything other than bitumen. At the other end of the scale the petroleum composition can be a clear fluid resembling kerosene or gasoline, needing very little refining to be useable as a fuel.

Generally, petroleum reservoirs contain a combination of three fluids:
    1) Natural Gas
    2) Oil
    3) Water

As hydrocarbons and water accumulate in a reservoir, vertical separation occurs as a result of the difference in the specific gravity of the various fluids.
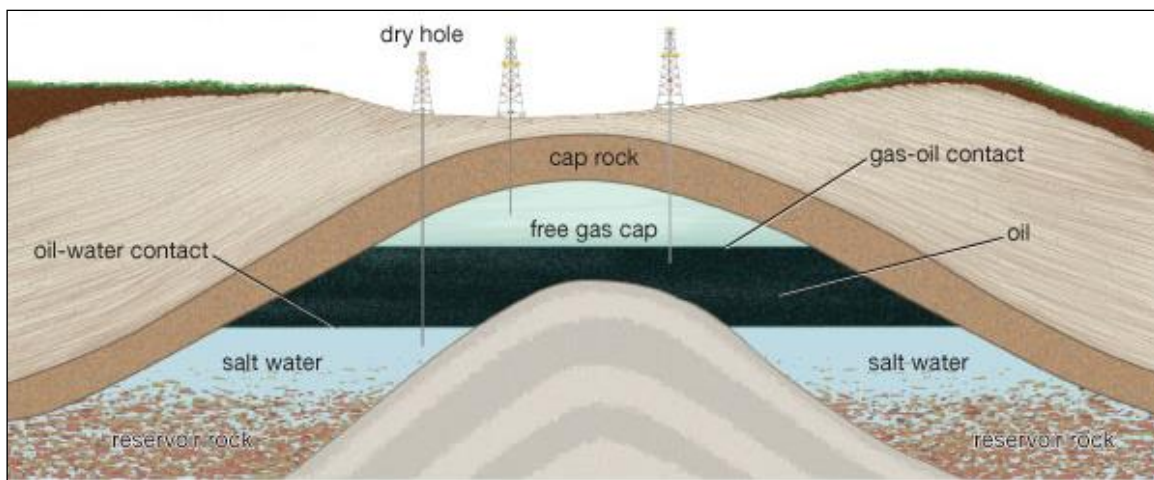
Figure 7: Fluids at a typical reservoir(www.britannica.com)

Typically, the lighter fluids, like gas, rise to the top of the reservoir. Below the lighter fluids is a gas to oil transition zone. This transition zone is a relatively thin zone above the oil accumulation. The oil accumulation may be of primary importance because it contains crude oil and possibly saturated gas. Below the oil accumulation in most reservoirs is an oil-water transition zone of varying thickness, which is partly filled with water and oil.

Finally, beneath the oil-water transition zone is that part of the formation completely saturated with water. It is important to note that all reservoirs may not contain natural gas, oil, and water. Some formations may only contain water. However, any formation that contains hydrocarbons will also contain some amount of water. It is because of this water that we are able to measure the resistivity of a formation in logging.

A reservoir contains gas if its temperature is higher than the fluid critical temperature, otherwise it contains oil. The depletion of reservoir will result in retrograde condensation in the reservoir if the reservoir temperature lies between the critical temperature and the cricondentherm, whereas no liquid will form if it is above the cricondentherm. The oil in a reservoir with a

temperature close to its critical point is more volatile than that at a lower temperature. A small reduction of pressure below the bubble point, in a reservoir with a temperature just below the fluid critical temperature, may vaporize half the oil volume. It is evident, therefore, that the location of reservoir temperature on the phase diagram can be used to classify reservoir fluids.

2.3.2 Chemical composition

Gases produced from a petroleum reservoir mainly contain alkanes lighter than heptane, with methane and ethane being the predominant components. However, light non-hydrocarbons including nitrogen, carbon dioxide, and hydrogen sulphide are also common, their proportions being related to the reservoir where they originate from. Petroleum liquid, or crude oil, contains larger molecules and its appearance, composition, and other properties vary a lot with different petroleum reservoirs. Nevertheless, nearly all naturally occurring petroleum liquids have fairly narrow limits of elemental composition

Critical temperatures of heavy hydrocarbons are higher than those of light compounds. Therefore, the critical temperature of hydrocarbon mixtures predominantly composed of heavy compounds is higher than the normal range of reservoir temperatures, and these fluids behave liquid-like, i.e., oil.

When the reservoir pressure falls below the saturation point, gas and liquid phases are produced at a ratio different to that in the original combined state, resulting in changes of the overall composition. The gravitational segregation of the two phases with different densities will also inhibit the contact between the phases.

Petroleum reservoir fluids can be classified according to various criteria. The most common method of identifying petroleum reservoir fluids is to classify them as dry gas, wet gas, gas condensate (retrograde gas), volatile oil and black oil.

2.4 Oil Reservoirs

Depending upon initial reservoir pressure pi, oil reservoirs can be sub-classified into the following categories:

1. Under-saturated oil reservoir. If the initial reservoir pressure pi is greater than the bubble-point pressure p_b of the reservoir fluid, the reservoir is labeled an under-saturated oil reservoir.

2. Saturated oil reservoir. When the initial reservoir pressure is equal to the bubble-point pressure of the reservoir fluid, the reservoir is called a saturated oil reservoir.

3. Gas-cap reservoir. If the initial reservoir pressure is below the bubble point pressure of the reservoir fluid, the reservoir is termed a gas-cap or two-phase reservoir, in which the gas or vapor phase is underlain by an oil phase. The appropriate quality line gives the ratio of the gas-cap volume to reservoir oil volume.

Crude oils cover a wide range in physical properties and chemical compositions, and it is often important to be able to group them into broad categories of related oils. In general, crude oils are commonly classified into the following types:

- Ordinary black oil
- Low-shrinkage crude oil
- High-shrinkage (volatile) crude oil
- Near-critical crude oil

The above classifications are essentially based upon the properties exhibited by the crude oil, including physical properties, composition, gas-oil ratio, appearance, and pressure-temperature phase diagrams.

2.5 Gas Reservoirs

In general, if the reservoir temperature is above the critical temperature of the hydrocarbon system, the reservoir is classified as a natural gas reservoir. On the basis of their phase diagrams and the prevailing reservoir conditions, natural gases can be classified into four categories:

- Retrograde gas-condensate
- Near-critical gas-condensate
- Wet gas
- Dry gas

2.6 Composition of petroleum fluids

The temperature of a reservoir is determined by its depth, and the phase behaviour of a reservoir fluid is determined by its composition. Petroleum reservoir fluids are multicomponent mixtures consisting primarily of hydrocarbons. The chemical composition of petroleum is largely speculative due to the difficulty of a complete identification caused by the enormous number of components. For a hydrocarbon with a given molecular formula C_xH_y, the number of possible isomers increases dramatically as the molecule becomes larger.

Methane (CH_4) is the simplest of all hydrocarbons, and also the most common component in petroleum reservoir fluids. The number of carbon atoms the reservoir fluid contains will define the category of the fluid.

Petroleum reservoir fluids may contain hydrocarbons as heavy as C200.

Hydrocarbons up to and including C5 are easily determined on a molar basis. The remaining identified components, which normally go up to 20 carbon atoms, or in some cases 30 carbon atoms, are not individual molecular compounds but rather fractions defined by a normal boiling point range. These fractions are defined based on the normal boiling point of the normal alkanes and are called the C6, C7, etc. fractions (or components) according to the carbon number of the normal alkane within the fraction. Finally, the part of the oil that cannot be analysed is called the residue or plus fraction.

A particular C7$^+$ component will belong to one of the component classes that have already been mentioned above:

Paraffins. A paraffinic compound consists of hydrocarbon segments of the type C, CH, CH2, or CH3. The carbon atoms are connected by single bonds.

Naphthenes. These compounds are similar to paraffins in the sense that they are built of the same types of hydrocarbon segments, but they differ from paraffins by containing one or more cyclic structures.

Aromatics. Similar to naphthenes, aromatics contain one or more cyclic structures, but the carbon atoms in an aromatic compound are connected by aromatic double bonds.

2.7 Reservoir Fluid Mechanics

Reservoirs are composed of rock matrix, and pores and capillaries (channels between matrix grains that connect pores, sometimes called pore throats) of varying sizes. In sedimentary rocks, all of these pores are fluid saturated. The fluid is sometimes oil and/or gas, but water will always be present. Most water found within the porosity of a reservoir is moderately saline.

The degree of salinity is dependent upon the chemical history of that water. Formation water is commonly salty because of the fact that most sediments are deposited in marine environments. During deposition of these sediments, the salty formation water will become entrapped within the porosity. The salinity of this original formation water, however, may change with geologic time. Fresh water from the surface may infiltrate the sediments, mixing with the original salty formation water to form brackish water.

In some instances, either due to osmosis or because fresh water is being driven off from nearby formations, it is possible for salty formation water to be flushed from a formation altogether. The result may be a deep, fresh water-bearing formation. In some areas, fresh water is encountered at depths as great as 5,000 feet, but in others, salt water occurs at a depth of several hundred feet. The fluids in a sedimentary rock (whether water, oil, or gas) are constantly subjected to a variety of forces which include cohesion, surface tension, adhesion, interfacial tension, and capillary pressure.

The interplay of these forces and their effect on the fluids and their movement is the subject of fluid mechanics. Basic to the understanding of fluid mechanics as it applies to hydrocarbon reservoirs is the concept of surface tension. All molecules in a fluid will attract each other mutually because of their force of cohesion.

In a droplet of water, this same surface membrane keeps the droplet round, as if a balloon filled with liquid. Where one liquid is in contact with another liquid or is in contact with a solid, there exists an attractive force on both sides of their interface called adhesion. This attractive force is not balanced across the interface because the molecules on one side of the interface are

completely different from those on the other. The tension resulting from such unbalanced attractive forces between two liquids or between a liquid and a solid is called interfacial tension.

Interfacial tension accounts for whether a fluid will be adhered to the surface of a solid or repelled from that surface. Water, for example, will spread out and adhere to glass because its interfacial tension is low in comparison to that of glass. Mercury, on the other hand, has an interfacial tension that is high compared to that of glass and therefore will not adhere to the glass, but rather contract into a droplet.
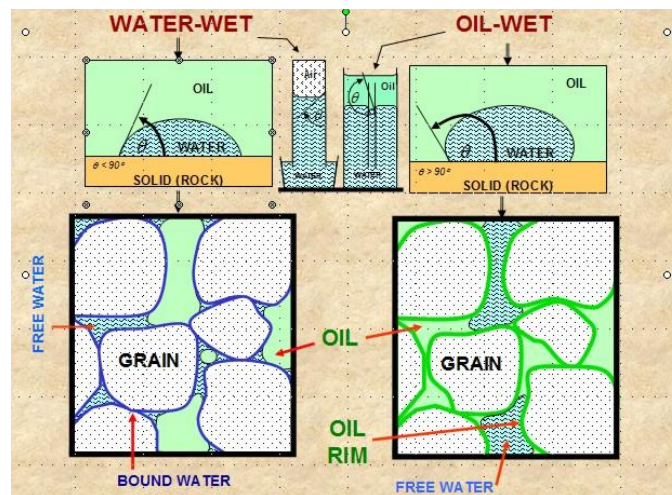
Figure 8: Interfacial Tension (www.spec2000.net)

This principle is extremely important in reservoir fluid mechanics because these same forces operate between rock material (matrix) and the fluids filling the porosity. The force of adhesion between water and most matrix material is greater than that of most oils. Therefore, if a rock contains both water and oil, typically the water will occur as a film adhering to the rock grains with the oil occupying the space between. Such a reservoir is said to be water-wet, because water is the fluid phase that is "wetting" the grains of the rock. In some instances, although rarer, the chemistry of the oil may be such that it is the fluid that is in contact with the grains of the rock. This type of reservoir is said to be oil-wet.

2.8 Production

The general mechanism of oil recovery is the movement of hydrocarbons towards the production wells due to a pressure difference between the reservoir and the production wells. The recovery stages of oil reserves are divided into three main categories:

- Primary recovery
- Secondary recovery
- Tertiary recovery (or EOR)

2.8.1 Primary Recovery

In this recovery process, oil is forced out of the petroleum reservoir by the existing natural pressure of the trapped fluids in the reservoir. This pressure originated from various forces:

- Expanding force of natural gas
- Gravitational force
- Buoyancy force of encroaching water
- An expulsion force due to the compaction of poorly consolidated reservoir rocks

Among these forces, expanding force of high-pressure natural gas contributes mainly to oil production. These forces in the reservoir can either act simultaneously or sequentially, depending on the composition and properties of the reservoir. The gravitational force is more effective in steeply inclined reservoirs, where it facilitates the drainage of oil. This force alone may not be effective in moving large amounts of oil into a production well.

Another, more effective, force for displacement oil is the encroachment of aquifer water, from the side or bottom of a reservoir. The ability of the edge water to encroach depends upon the pressure distribution in the reservoir and the permeability. Compaction of the reservoir as fluids are withdrawn also is a mechanism for movement of oil to production wells. Part of the oil will be expelled due to the decrease in the reservoir volume.

2.8.2 Secondary recovery

When oil production declines because of hydrocarbon production from the formation, the secondary oil recovery process is employed to increase the pressure required to drive the oil to the production wells. Conversion of some of the wells into injection wells and subsequent injection of gas or water for pressure maintenance in the reservoir has been designated as secondary oil recovery.

The purposes of a secondary recovery technique are:
- *Pressure restoration*
- *Pressure maintenance*

2.8.2.1 Water Injection

In water injection operations, the injected water is discharged in the aquifer through several injection wells surrounding the production well. The injected water creates a bottom water drive on the oil zone, pushing the oil upwards. In earlier practices, water injection was done in the later phase of the reservoir life, but now it is carried out in an earlier phase, so that pressure drop and gas cap formation in the reservoir is avoided.

Using water injection in an earlier phase, helps improving the production, as once a secondary gas cap has been formed, the injected water then initially tends to compress the free gas cap and later on to mobilize the oil, which results to a higher demand in the amount of water to be injected. The water injection is generally carried out when a solution gas drive is present or the water drive is weak.

Therefore, it is more efficient for the water injection process to be carried out, when the reservoir pressure is higher than the saturation pressure.

Water is injected for two reasons:

1) For pressure support of the reservoir (also known as voidage replacement).
2) To sweep or displace the oil from the reservoir, and push it towards an oil production well.

The water injection however, has some disadvantages, some of these disadvantages are:

- Reaction of injected water with the formation water can cause formation damage.
- Corrosion of surface and sub-surface equipment.

A water injection operation is usually carried out as a "water flooding". Water flooding consists of water that is injected into the reservoir formation, from injection wells that have been placed under a specific pattern relatively to the location of the production wells. The most common pattern of injection and production wells is a five-spot configuration where the water is injected in the central well displacing oil to the four surrounding production wells.

The opposite configuration, that is for the production well to be located in the center of the five-spot pattern and the injection wells in the surrounding corners, is also widely used. There are many more water flooding patterns than can be encountered in use.
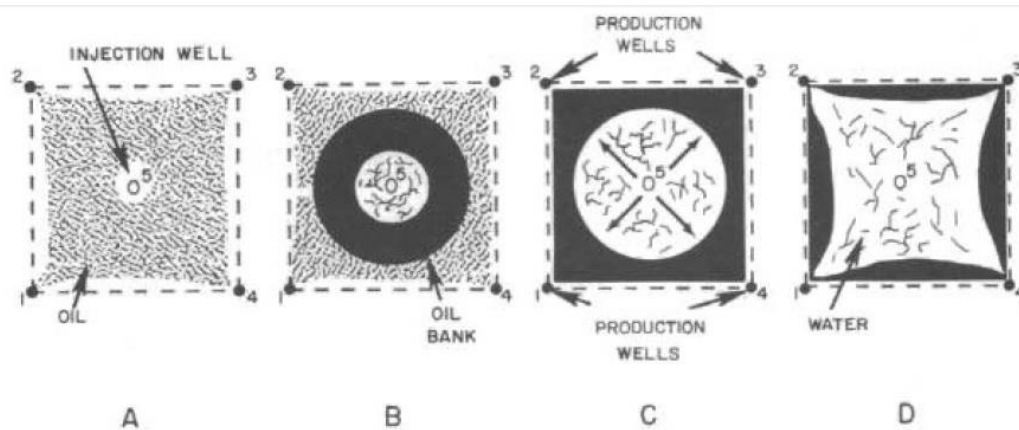
Figure 9: Five spot pattern with injector in centre, function principle

2.8.2.2 Gas Injection

It is the oldest of the fluid injection processes. This idea of using a gas for the purpose of maintaining reservoir pressure and restoring oil well productivity was suggested as early as 1864 just a few years after the Drake well was drilled.

The first gas injection projects were designed to increase the immediate productivity and were more related to pressure maintenance rather to enhanced recovery. Recent gas injection applications, however, have been intended to increase the ultimate recovery and can be considered as enhanced recovery projects.

In addition, gas because of its adverse viscosity ratio (higher mobility ratio) is inferior to water in recovering oil. Gas injection may be either a miscible or an immiscible displacement process. The

characteristics of the oil and gas plus the temperature and pressure conditions of the injection will determine the type of process involved.

The primary problems with gas injection in carbonate reservoirs are the high mobility of the displacing fluid and the wide variations of permeability. A much greater level of control over the injection process is required compared to water-flooding. In order to evaluate the sweep efficiency of the planned gas injection, a short-term pilot gas injection test should be driven. At the same time, this test would provide the necessary data to calculate the required volumes of gas; this in turn, will aid in the design of compressor equipment and estimating the number of injection well which will be required.

In some cases gas injection can increase the ultimate recovery of oil, as is the case of carbonate reservoirs. The benefits obtained by the gas injection are dependent upon horizontal and vertical sweep efficiency of the injected gas. The sweep efficiency depends on the type of porosity system present.

Oil fields that have low oil saturation and a gas cap, either primary or secondary formed are prime candidates for improved recovery by gas injection into the gas cap. Further the shrinkage of oil is reduced by gas injection. As much as it maintains a relatively high pressure gradient on the oil phase, relative permeability to oil remains high as well and oil is produced faster and in greater quantity.

In reservoirs having high permeability and high vertical span, gas injection may result in high recovery factors because of gravity segregation. Reservoirs containing volatile oil may have a similar response, thus high oil recovery.

In a few words, if the reservoir has a sufficient vertical permeability or relief for gravity segregation to be effective then, gas injection might be a favorable and optimal solution.

2.8.3 Tertiary or Enhanced Oil Recovery (EOR)

Tertiary or enhanced recovery refers to processes in the porous medium that recovers oil that has not been produced by the conventional primary and secondary production methods. EOR is meant to improve the sweep efficiency in the reservoir by the use of injectants that can reduce the remaining oil saturation below the level that has been achieved by conventional injection methods. Included in the remaining oil that has been defined here, are both the oil trapped in the flooded areas by capillary forces (residual oil), and the oil in the areas that haven't been flooded by the injected fluid (bypassed oil). Examples of injectants are CO_2 or chemicals to be added to the injected water. In summary, EOR is to reduce the residual oil saturation and to improve the sweep efficiency in all directions.

The oil recovered by both primary and secondary processes ranges from 20 to 50 % of the Oil-in-Place, depending upon oil and reservoir properties. The goal of enhanced oil recovery processes is to recover at least a part of the remaining, non-produced oil-in-place. These methods change the reservoir fluid properties. The objective of EOR is to increase the pressure difference between the reservoir and production wells, or to increase the mobility of the oil by reduction of the oil viscosity, decrease of the interfacial tension between the displacing fluids and oil or by altering the wettability of the reservoir matrix. There are several EOR processes that are considered to be promising:

- Chemical processes
  - Surfactant flooding
  - Polymer flooding
  - Caustic flooding

- Thermal processes
  - In-situ combustion
    - Wet combustion – water added to air to carry more heat forward to oil zone
    - Dry combustion – Only air is used for ignition

  - Steam injection
- Miscible displacement processes

- Microbial EOR methods (MEOR)
  - Huff and puff method
  - Microbial flooding

These processes are the overall of the EOR techniques, as shown in below there are more EOR methods than secondary recovery techniques.
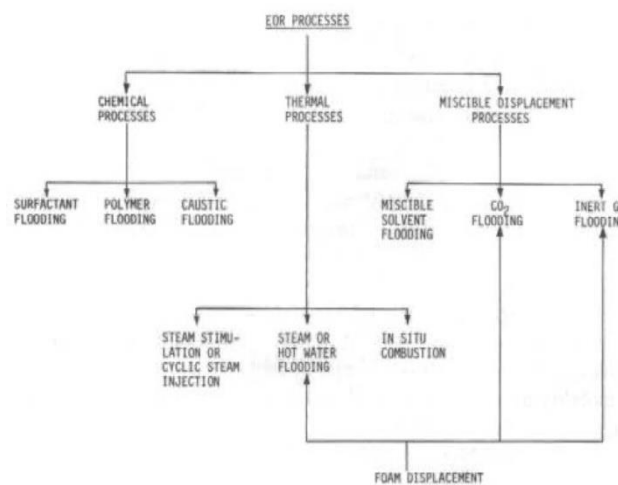
Figure 10: Classification of EOR processes

A common procedure for determining the optimum time to start EOR process after water flooding depends on:

- Anticipated oil recovery
- Fluid production rates
- Monetary investment
- Costs of water treatment and pumping equipment
- Costs of maintenance and operation of the water installation facilities
- Costs of drilling new injection wells or converting existing production wells into injectors.

The viability of secondary and Tertiary oil recovery processes depends upon the following factors:

1) **Volumetric displacement efficiency**: It is a macroscopic displacement effect which is a function of mobility ratio (M). The efficiency of water-flooding can be improved by lowering the water-oil mobility ratio. Mobility (λ= permeability/fluid viscosity) of a fluid is a quantitative measure of its ability to flow through the channels.

$$M = [\frac{k_{rw}}{\mu_w} \Big/ \frac{k_{ro}}{\mu_o}]$$

Where :
k_{rw} = effective water permeability (mD)
k_{ro} = effective oil permeability (mD)
μ_w & μ_o = viscosities of water and oil respectively (cP)

A mobility ratio greater than one is unfavorable because water is more mobile than oil. Water would finger through the oil zone and, therefore, reduce the oil recovery efficiency. If the mobility ratio is less than unity, the displacement of oil by water occurs more or less in pistonlike displacement

2) **Unit displacement efficiency** : It is a microscopic displacement phenomenon. With constant oil density, the definition of displacement efficiency for oil becomes:

$$E_D = \frac{Amount\ of\ oil\ displaced}{Amount\ of\ oil\ contacted\ by\ displacing\ agent}$$

Fluid, rock and fluid-rock properties also affect E_D.

If the displacing fluid, will contact all of the oil initially present in reservoir, then the volumetric sweep efficiency (E_V), will be unity.

Where :

$$E_V = \frac{Volume\ of\ oil\ contacted\ by\ displacing\ fluid}{Total\ volume\ of\ oil\ in\ place}$$

E_V can be decomposed into two parts, "areal sweep efficiency" (E_A) and "vertical sweep efficiency" (E_I), thus:

$$E_V = E_A \times E_I$$

And

$$E_A = \frac{Area\ contacted\ by\ displacing\ fluid}{Total\ area}$$

$$E_I = \frac{Cross-sectional\ area\ contacted\ by\ displacing\ fluid}{Total\ cross-sectional\ area}$$
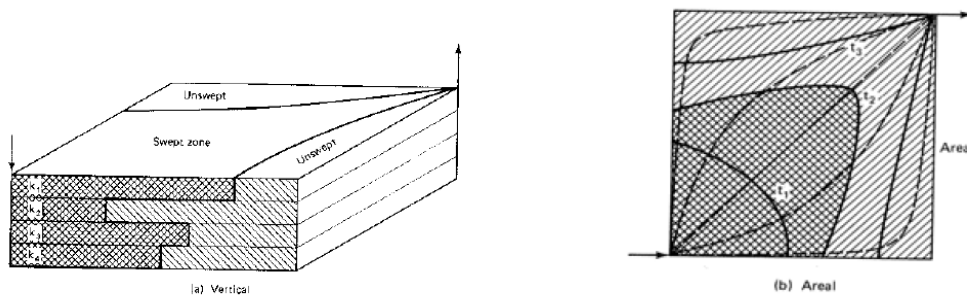
Figure 11: Sweeping effect

2.8.4 Tracers

Tracers are used in the oil industry in order to qualitatively or quantitatively gauge how the fluids flows through the reservoir, as well as being a useful tool for estimating residual oil saturation. Tracers can be used in either interwell (well to well) tests or single well tests. In interwell tests, the tracer is injected at one well along with the carrier fluid (water in a waterflood or gas in a gasflood) and detected at a producing well after some period of time, which can be anything from days to years. In single well tests, tracer is injected into the formation from a well and then produced out the same well. The delay between a tracer that does not react with the formation (a conservative tracer) and one that does (a partitioning tracer) will give an indication of residual oil saturation, a piece of information that is difficult to acquire by other means.

Tracers can be radioactive or chemical, gas or liquid and have been used extensively in the oil industry and hydrology for decades.

2.8.4.1 Well to Well tracer tests

Well-to-well tracer tests contribute significantly to the reservoir description, which is essential in determining the best choice of production strategy. Direct dynamic information from a reservoir may be obtained, in principle, from three sources: production history, pressure testing, and tracer testing.

Tracers may be roughly classified as passive or active. In principle, a passive tracer blindly follows the fluid phase in which it is injected. Active tracers interact with the other fluids in the system or with the rock surface. Interpretation of tracer-production curves must account for this. The results from the application of active tracers may give information about fluid saturation and rock surface properties. This information is especially important when enhanced-oil-recovery techniques that use expensive fluids such as surfactants, micellar fluids, or polymers are considered.

In the last 50 years, many tracer studies have been reported and even more have been carried out without being published in the open literature. Wagner pointed out six areas in which tracers could be used as a tool to improve the reservoir description.

- Volumetric sweep.
- Identification of offending injectors.
- Directional flow trends.
- Delineation of flow barriers
- Relative velocities of injected fluids.
- Evaluations of sweep-improvement treatments.

Many companies apply tracer on a routine basis. The reservoir engineer's problem generally is a lack of adequate information about fluid flow in the reservoir. The information obtained from tracer tests is unique, and tracer tests are a relatively cheap method to obtain this information. The information is an addendum to the general field production history and is used to reduce uncertainties in the reservoir model.

2.8.4.2 Types of Tracers available

A passive tracer that labels gas or water in a well-to-well tracer test must fulfill the following criteria. It must have a very low detection limit, must be stable under reservoir conditions, must follow the phase that is being tagged and have a minimal partitioning into other phases, must have no adsorption to rock material, and must have minimal environmental consequences. The different tracer types that are used by the industry can be separated in the following categories.

- Radioactive water tracers
- Chemical water tracers
- Radioactive gas tracers
- Chemical gas tracers

3) Principles of Reservoir Simulation

Simulation is defined as "assuming the appearance of without the reality" according to *The Merriam-Webster Dictionary.* Simulation of petroleum reservoir performance refers to the construction and operation of a model whose behavior assumes the appearance of actual reservoir behavior. The model itself is either physical (for example, a laboratory sandpack) or mathematical. A mathematical model is a set of equations that, subject to certain assumptions, describes the physical processes active in the reservoir. Although the model itself obviously lacks the reality of the reservoir, the behavior of a valid model simulates — assumes the appearance of — the actual reservoir.

The reservoir is depicted as a body consisting of a finite number of geometrical 3D shapes (blocks), more usually in the form of rectangular or hexahedral shapes, in neighboring contact with one another, most usually referred as "gridding system". Specific properties such as permeability and porosity are given to each of the blocks in the gridding system, in an attempt to depict the reservoir properties as realistic as it can be.

The purpose of simulation is estimation of field performance (e.g., oil recovery) under one or more producing schemes. Whereas the field can be produced only once, at considerable expense, a model can be produced or run many times at low expense over a short period of time. Observation of model results that represent different producing conditions aids selection of an optimal set of producing conditions for the reservoir.

The tools of reservoir simulation range from the intuition and judgment of the engineer to complex mathematical models requiring use of digital computers. The question is not whether to simulate, but rather which tool or method to use.

Models have been referred to by *type*, such as *black-oil*, *compositional*, *thermal*, *generalized*, or *IMPES*, *Implicit*, *Sequential*, *Adaptive Implicit*, or *single-porosity*, *dual-porosity*, and more. These *types* provide a confusing basis for discussing models; some refer to the application (e.g., thermal), others to the model formulation (e.g., implicit), and yet others to an attribute of the reservoir formation (e.g., dual-porosity). The historical trend, though irregular, has been and is toward the *generalized* model, which incorporates all the previously mentioned types and more. The generalized model, which represents most models in use, is under development today.

3.1 The Generalized Model

Any reservoir simulator consists of $n + m$ equations for each of N active gridblocks comprising the reservoir. These equations represent conservation of mass of each of n components in each gridblock over a timestep Δt from t^n to t^{n+1}. The first n (primary) equations simply express conservation of mass for each of n components such as oil, gas, methane, CO_2, and water, denoted by subscript $I = 1,2,…, n$. In the thermal case, one of the "components" is energy and its

equation expresses conservation of energy. An additional m (secondary or constraint) equations express constraints such as equal fugacities of each component in all phases where it is present, and the volume balance $S_w + S_o + S_g + S_{solid} = 1.0$, where S solid represents any immobile phase such as precipitated solid salt or coke.

There must be $n + m$ variables (unknowns) corresponding to these $n + m$ equations. For example, consider the isothermal, three-phase, compositional case with all components present in all three phases. There are $m = 2n + 1$ constraint equations consisting of the volume balance and the $2n$ equations expressing equal fugacities of each component in all three phases, for a total of $n + m = 3n + 1$ equations. There are $3n + 1$ unknowns: p, S_w, S_o, S_g, and the $3(n - 1)$ independent mol fractions x_{ij}, where $i = 1,2,..., n - 1$; $j = 1,2,3$ denotes the three phases oil, gas, and water. For other cases, such as thermal, dual-porosity, and so on, the m constraint equations, the $n + m$ variables, and equal numbers of equations and unknowns can be defined for each gridblock.

Because the m constraint equations for a block involve unknowns only in the given block, they can be used to eliminate the m secondary variables from the block's n primary or conservation equations. Thus, in each block, only n primary equations in n unknowns need be considered in discussions of model formulation and the linear solver. The n unknowns are denoted by P_{i1}, P_{i2},..., P_{in}, where P_{in} is chosen as pressure p_i with no loss of generality. These primary variables may be chosen as any n independent variables from the many available variables: phase and overall mol fractions, mol numbers, saturations, p, and so on. Different authors choose different variables. Any sensible choice of variables and ordering of the primary equations gives for each gridblock a set of n equations in n unknowns which is susceptible to normal Gaussian elimination without pivoting. The (Newton-Raphson) convergence rate for the model's timestep calculation is independent of the variable choice; the model speed (CPU time) is essentially independent of variable choice.

The primary or conservation equation for block "i" is :

$$M_{iI}^{n+1} - M_{iI}^n = \Delta t \left(\sum_{j=1}^{j=N} q_{ijI} - q_{iI} \right) I = 1,2,....n,$$

(1)

where M_{iI} is mass of component I in gridblock i, q_{ijI} is the interblock flow rate of component I from neighbor block j to block i, and q_{iI} is a well term. With transposition, this equation is represented by $f_{iI} = 0$, the Ith equation of gridblock i. All n equations $f_{iI} = 0$ for the block can be expressed as the vector equation $F_i = 0$ where f_{iI} is the Ith element of the vector F_i. Finally, the vector equation

$$\mathbf{F}\left(\mathbf{P}_1, \mathbf{P}_2, ..., \mathbf{P}_N \right) = 0$$

(2)

represents the entire model, where the ith element of the vector $\mathbf{F}$ is F_i. $\mathbf{F}$ is a function of the N vector unknowns $\mathbf{P}_i$, where the Ith scalar element of $\mathbf{P}_i$ is P_{iI}. Application of the Newton-Raphson method gives :

$$\mathbf{F}^l + \delta\mathbf{F} = \mathbf{F}^l + A\delta\mathbf{P} = 0,$$

(3)

, where $\delta \mathbf{P}$ is $\mathbf{P}^{l+1} - \mathbf{P}^l$ and the $N \times N$ matrix A represents the Jacobian $\partial \mathbf{F}/\partial \mathbf{P}$. The element A_{ij} of A is itself an $n \times n$ matrix $\partial \mathbf{F}_i/\partial \mathbf{P}_j$ with scalar elements $a_{rs} = \partial f_{ir}/\partial P_{js}$, r and s each $= 1,2,...,n$. The previous equation is solved by the model's linear solver. The matrix A is very sparse because A_{ij} is 0 unless block j is a neighbor of block i.

The calculations for a timestep consist of a number of Newton (*nonlinear* or *outer*) iterations terminated by satisfaction of specified convergence criteria. Each Newton iteration requires:

(a) Linearization of the constraint equations and conservation **Eq.1**.
(b) Linear algebra to generate the *A* matrix coefficients.
(c) Iterative solution of **Eq.3** (*inner* or *linear* iterations).
(d) Use of the new iterate $\mathbf{P}^{l+1}$ to obtain from **Eq.1** the moles of each component in the gridblock.
(e) A flash to give phase compositions, densities, and saturations which allow generation of the *A* matrix coefficients for the next Newton iteration.

3.2 Formulations

A major portion of the model's total CPU time is often spent in the linear solver solution of **Eq.3**. This CPU time in turn reflects the many multiply operations required. The model formulation has a large effect on the nature and expense of those multiplies.

The interblock flow term in **Eq.1**

$$q_{ijI} = T_{ij} \sum_{J=1}^{J=3} \lambda_{jJ} \rho_J x_{IJ} \left(\Delta p_J - \gamma_J \Delta Z \right),$$

(4)

, uses phase mobilities, densities, and mol fractions evaluated at the upstream blocks. A gridblock is *implicit* in, say, the variable S_g if the new time level value S_g^{n+1} is used to evaluate interblock flow terms dependent upon it. The block is *explicit* in S_g if the old time level value S_g^n is used.

The Implicit Forumulation. The implicit formulation expresses interblock flow terms using implicit (new time level) values of all variables in all gridblocks. As a consequence, all nonzero A_{ij} elements of the A matrix of **Eq.3** are full $n \times n$ matrices. The resulting multiplies in the linear solver are then either matrix-matrix or matrix-vector multiplies, requiring work (number of scalar multiplies) of order n^3 or n^2, respectively.

The IMPES Formulation. The basis of the IMPES (implicit pressure, explicit saturations) formulation for the black-oil case: take all variables in the interblock flow terms explicit, except for pressure, and eliminate all nonpressure variables from the linearized expressions for M_{iI}^{n+1} in **Eq.1**. The obvious extension to any type model with any number of components was presented later, and numerous IMPES-type compositional models have been published.

The Sequential Formulation. The stability of the IMPES formulation for the two-phase water/oil case was improved by following the IMPES pressure equation solution with solution of a water

saturation equation using implicit saturations (mobilities). This concept was extended to the three-phase case and called the *sequential* formulation. For each Newton iteration, this method requires solution of the IMPES pressure, followed by solution for two saturations from a similar equation where the A_{ij} elements of A are 2 × 2 matrices.

A sequential compositional model was described and mentioned the desirability of a sequential implicit treatment of mol fractions in addition to saturations.

The Adaptive Implicit Forumlation. The Adaptive Implicit Method (AIM) uses different levels of implicitness in different blocks. In each gridblock, each of the n variables may be chosen explicit or implicit, independent of the choices in other gridblocks. The choices may change from one timestep to the next. This results in the same equation as the Implicit formulation except that the elements A_{ij} of the A matrix are rectangular matrices of variable size. The numbers of rows and columns in A_{ij} equal the numbers of implicit variables in blocks i and j, respectively; all A_{ii} are square matrices.

The CPU expense per Newton iteration of an AIM model lies between those of IMPES and Implicit models, tending toward the former as more blocks are taken implicit in pressure only.

3.3 Gridding in Reservoir Simulation

The aim of gridding in reservoir simulation is to turn the geological model of the field into a discrete system on which the fluid-flow equations can be solved.

The basic structure of an oil reservoir is a set of geological horizons representing bedding planes. The reservoir may contain faults, at which the strata are displaced. It is usually possible to identify many more layers in the geological model than it is practical to include in reservoir flow simulation, so some upscaling of rock properties will normally be carried out. Even after this process, the geology to be represented is rarely homogeneous at the scale of the simulation grid.

Two related issues are involved in choosing a grid for reservoir simulation: the accuracy with which the geological description of the reservoir is matched, and the discretization of the flow equations. In a classical finite-difference scheme, the point values of pressures and saturations are used as solution variables, and the differential operators that appear in the fluid-flow equations may be expanded as difference expressions of these point values to some order.

An alternative approach is to use an *integral finite-difference* or *finite-volume* method in which the fluid-flow equations are integrated over a set of cell volumes. This yields a set of equations in which the mass conservation conditions for the fluid in the simulation cell volumes are related to the flows through the interfaces between those cell volumes. Rock properties such as porosity are assumed constant over the cell or controlled volume. This yields a discretization scheme which is conservative (each outflow from one cell is an inflow to another) and for which the fluid in place may be obtained straightforwardly. The mass conservation equations for a timestep from T to $T + \Delta T$ then become:

$$V_{pa}^{T+\Delta T} \cdot m_{ca}^{T+\Delta T} - V_{pa}^{T} \cdot m_{ca}^{T} = \Delta T \cdot \left(Q_{ca} + \sum_b \sum_p F_{cpab}\right),$$

(5)

where V_{pa} is the pore volume of cell a, m_{ca} is the density of conserved component c in cell a, Q_{ca} is the injection or production rate of component c because of wells, and F_{cpab} is the flow rate of component c in phase p from cell a to its neighbor b. In general, the flows F_{cpab} may involve the solution values of a number of cells, the number of cells involved defining the stencil of the numerical scheme. The linear pressure dependence of flows given by Darcy's law leads to an expression of the type:

$$F_{cpab} = \sum_x T_{ax} M_{cpax} \Delta \Phi_{pax} .$$

(6)

M_{cpax} is the mobility of component c in phase p for the contribution to the flow between a and x, given by $x_{cp}.K_{rp}/\mu_p$, where x_{cp} is the concentration of component c in phase p, K_{rp} is the relative permeability of phase p, and μ_p is the viscosity of phase p. This is often set to an *upstream* value of the mobility, depending upon the sign of the potential difference.

$\Delta \Phi_{pax}$ is the potential difference of phase p between cell a and cell x, which includes pressure, gravity and capillary pressure contributions:

$$\Delta \Phi_{pax} = P_a - P_x - g\rho_p \cdot (d_a - d_x) + P_{cpa} - P_{cpx} .$$

(7)

The constant coefficients of mobility and potential difference products, T_{ax}, are commonly termed the *transmissibilities*.

When the flows between two cells a and b can be expressed as a function of the solution values in just those two cells, so that the summation over cells includes just $x = b$, the flow expression takes a two-point form. The flow expression then takes a simple form:

$$F_{cpab} = T_{ap} M_{cpab} \Delta \Phi_{pab} .$$

(8)

When solution values from other cells are required, the flow takes a *multipoint* form.

3.3.1 Cartesian Grid

A simple 3D grid is the regular *Cartesian* grid. Cells in such a grid may be simply identified using their (i,j,k) index values.
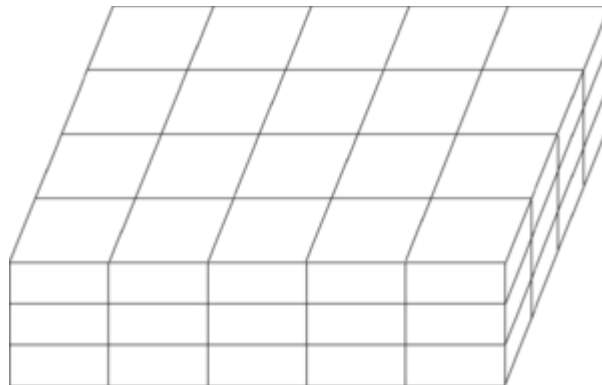
Figure 12: Cartesian Grid System

Each of the grid elements will be assigned a single permeability or porosity value. In this case, it is possible to obtain the transmissibility value as a harmonic average:

$$T_{ap} = 1/(1/T_a + 1/T_b), \ T_a = K_a \cdot A_a/(d_a/2), \ T_b = K_b \cdot A_b/(d_b/2),$$

(9)

where cell *b* is the neighbor to cell *a* in some direction and *K* is the cell permeability in that direction. *A* is the area of the cell orthogonal to the direction of flow, and *d* the dimension of the cell in that direction. Such a two-point transmissibility assumes a permeability tensor with primary axes aligned along the grid axes.

Although regular grids are normally defined in normal Cartesian coordinates, it is also possible to use an (*r*, *Φ*, *z*) radial system. The resulting grid is *cylindrical* and is important for the special case of near-well studies dominated by radial inflow. For a 3D system, regular grids yield seven-point schemes, in which the flow equations for a cell involve solution values for just the cell and its six neighbors. Not all the elements in the grid need represent active solution variables in the simulation. Some cells may be inactive, representing volumes of the reservoir with zero porosity. Such inactive cells are usually compressed out of reservoir simulation solution arrays prior to the memory and time-intensive flow solution stage, and enable reservoirs with irregular boundaries to be represented within extended simulation grids.

The horizons that delimit rock strata are generally not horizontal, but are dipped, curved, or faulted. Unless extremely fine, a true regular grid that is orthogonal in all three axes will be unable to assign rock properties accurately to cell volumes. Such a layer-cake structure can be used, but will generally misalign property values in which the orthogonal grid provides a rather poor match to the dipping strata represented by the shaded layers. However, it is possible that improving computer power will bring such *rasterized* grids to a level of refinement at which a sufficiently good representation may be obtained.
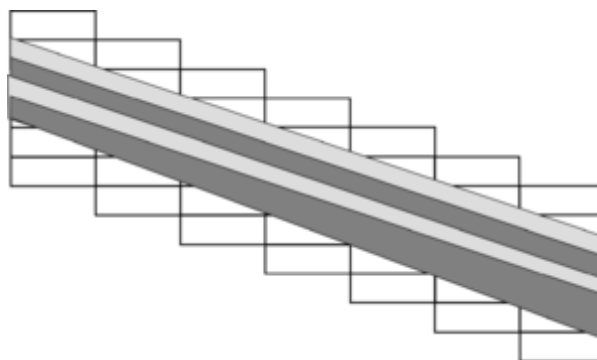
Figure 13: Rasterized grid system

3.3.2 Hexahedral Grids

Further improvements in geological modeling threw an emphasis on describing faults, and made it important to distinguish depth displacements due to dip and faulting. This is difficult in block centre geometry in which the cell is positioned by its centre depth and Δx, Δy, Δz dimensions. To define faulting more precisely it is useful to define the position of grid cell by its corner point

locations. A hexahedral shape with eight corners and bilinear planes as surfaces then describes the cell geometry. Faults, both vertical and inclined, may be described precisely.
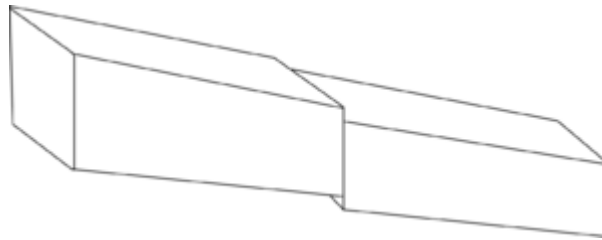
Figure 14: Hexahedral grid

Many other types of grids are in use, such as:
- Unstructured grids
- Truncated regular grids
- Triangular or tetrahedral grids
- Curvilinear grids

3.3.3 Grid Refinement

A common requirement in reservoir simulation is an increased level of detail around an item of interest such as a well. This is frequently obtained in structured grids by *local grid refinement*, replacing a set of cells in the original grid by a finer grid. The inserted grid may be Cartesian or radial. Local refinement may be regarded as a form of multiple domain structured grid, in that it consists of a number of linked structured grids. Flows at the edges of local refinements generally take a multipoint form.
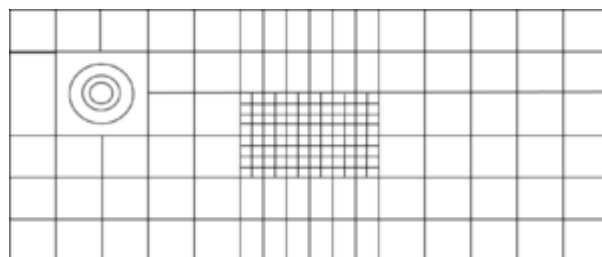
Figure 15: Grid Refinement

3.3.4 Upscaling of Grid Properties

Upscaling, or homogenization, is substituting a heterogeneous property region consisting of fine grid cells with an equivalent homogeneous region made up of a single coarse-grid cell with an effective property value. It is performed for each of the cells in the coarse grid and for each of the grid properties needed in the flow-simulation model. Therefore, the upscaling process is essentially an averaging procedure in which the static and dynamic characteristics of a fine-scale model are to be approximated by that of a coarse-scale model. A conceptual illustration of the upscaling process is shown below.
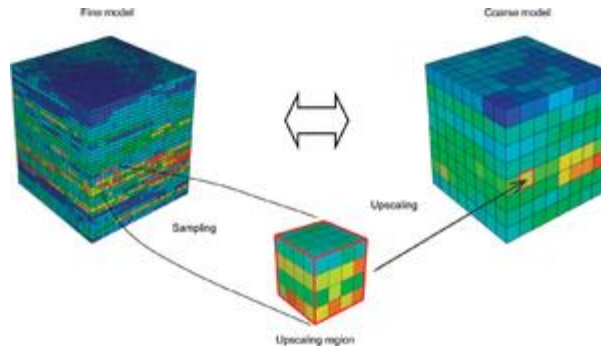
Figure 16: Upscaling of grid properties

Because it used to be too time-consuming to compute the fine-scale pressure field for the complete geo grid in a single operation, the flow-based methods have traditionally been restricted to solving the pressure field locally—that is, for a single flow cell at a time. Hence, the effective cell permeability is computed separately and independently of the other flow cells, which may or may not be correct depending on how representative the imposed pressure conditions along the faces of the flow cell are.

Different types of artificial boundary conditions for the flow cell have been suggested over the years, all with the objective of providing as good an approximation of the real boundary conditions as possible. An important design criterion for the artificial boundary conditions is the conservation of flux in and out of the flow cell.

The first type of boundary conditions proposed for the local solution of the pressure equation was published by Warren and Price in 1961. Their approach is to impose a constant pressure gradient in a selected direction of flow by specifying a pressure of 1 on the inflow face and a pressure of 0 on the outflow face. By allowing no flow to pass through the sides of the cell, all fluxes are forced to go in the principal direction of flow. Therefore, this type of boundary conditions is often referred to as the no-flow or sealed-sides boundary conditions. The sealed-sides boundary conditions are graphically illustrated in the following figure for flow in the vertical direction (here in the case of a flow cell containing a barrier).
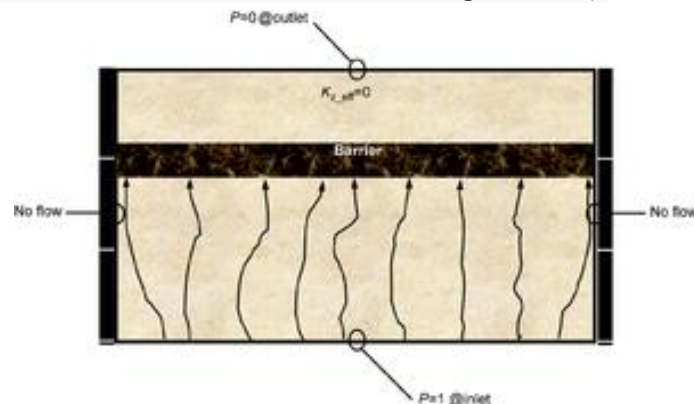
Figure 17: Sealed sides boundary conditions

The choice of boundary conditions emulates the way core permeability is measured in the lab. This is hardly a coincidence. As in the coreflood experiment, the local numerical flow simulation

is in effect 1D because the cell faces parallel to the main flow direction are sealed. This implies that the estimated effective permeability will be scalar. Hence, the maximum number of directional permeability components that can be obtained with this type of boundary conditions is three, one for each of the principal directions of flow. In practice, the diagonal permeability tensor is derived by setting up the boundary conditions for *x*, *y*, and *z* directions, respectively, in three independent single-phase simulations.

A tensor technique based on the sealed-sides boundary conditions tends to bias the estimated effective permeability toward a low value. The physical implication of this is most clearly seen in the case of a bimodal permeability system of sand and shale. This is because the sealed-sides method consistently underestimates the reservoir flow characteristics by thickening shale barriers and narrowing sand channels. The latter effect also has a tendency of disconnecting stacked sand channels.

By the end of the 1980s, 3D geological models had started to appear more regularly on the modeling scene. This resulted in a new demand for advanced upscaling. In this renewed effort, two alternative boundary conditions for solving the local pressure solution in a flow-based method were suggested more or less at the same time. One was based on linear boundary conditions, the other on periodic boundary conditions.

The use of linear boundary conditions in flow-based upscaling was suggested by Guerillot *et al*. in 1989 and Samier in 1990 to enable the computation of a full-permeability tensor. Instead of setting the flow through the sides of the cell to zero, the pressure along the sides is allowed to vary in a linear fashion that matches the constant pressure on the two cell faces perpendicular to the flow. Hence, the imposed pressure gradient is still constant, but the flow is allowed to enter and leave the cell at any point along the sides parallel to the main flow direction. Therefore, this type of boundary conditions is also referred to as the open-sides boundary conditions.

3.3.4.1 Regional Upscaling

Regional upscaling is applied to reduce the influence of the artificial boundary conditions on the effective permeability estimate by moving the boundary of the computational region away from the flow cell. This implies that the influence of neighboring geo cells is taken into account in addition to the geo cells inside the flow cell. In other words, regional upscaling represents an expansion of the local computational region outside the volume of the flow cell. The size of the so-called buffer or skin around each flow cell is usually given in number of neighboring geo cells to either side of the flow cell and must be specified by the modeler for each of the three coordinate directions.

The permeability estimate of a regional upscaling method will improve as the size of the buffer region increases, and it will ultimately be equal to the "true" effective permeability when the buffer size has reached the boundaries of the geo model for all three directions. The gain in accuracy is largest in the beginning (i.e., for small buffer values).

3.3.4.2 Global Upscaling

Strictly, the fine-scale pressure field must be determined for the entire geo grid simultaneously to compute "exact" effective permeabilities for the flow cells. In the past, however, this has been too CPU-intensive to be performed in practice. With the introduction of new and promising solution algorithms such as the Output Least Squares (OSL) method, global upscaling schemes can now be realized. In the paper by Holden and Nielsen, the OSL method is used to minimize the difference in pressure, as well as velocity, between the geo and flow grids in an iterative process. Because the CPU consumption of the applied equation solver is proportional to the number of geo cells, a global solution will use approximately the same amount of computational time as the sum of all the local computations. Therefore, the new global upscaling scheme is just as fast as any local method.

An obvious advantage with the global upscaling approach is that one avoids using artificial boundary conditions around the upscaling region (i.e., instead of guessing what the boundary conditions for the flow cells might be, the pressure conditions surrounding the cells are explicitly known). Another important benefit is that a poor separation of scales in the upscaling will no longer occur because the size of the computational region is the same as the geo model.

Although still in its research stage, global upscaling has much potential for improving today's permeability estimators, especially for models containing a complex facies architecture with large permeability contrasts between facies. In fact, preliminary results show an improvement factor of 10 in some cases.

Still, the global upscaling approach is not enough to ensure maximum accuracy in the modeling of the effective permeability. Because the value of the effective permeability is influenced by changes in the pressure field, the flow-cell permeabilities should strictly be recomputed by the global method for every timestep taken by the multiphase flow simulator. In practice, though, it might be good enough to update the effective permeability field whenever a significant change occurs as a result of altering the well configuration or production/injection rates and so on. Hence, the ultimate upscaling scheme for the absolute permeability might be the one that is coupled with the multiphase flow simulator and automatically updates the absolute effective permeability field for each timestep. With the current computer power and the lack of proper integration between the geological model and the simulation model, this is hardly achievable yet.

3.3.5 Selection

Selecting the proper upscaling method from the many available choices can be quite a challenge. The choice of sophistication in the upscaling method generally depends on one or several of the following factors:

- The complexity of the fine-scale permeability distribution (i.e., the geo model).
- The degree of upscaling that needs to be performed (i.e., the coarsening factor).

- The number of permeability realizations that need to be upscaled.
- The time available to the project for performing upscaling.
- The intended use of the flow model.

3.4 History Matching

The simulation of a hydrocarbon reservoir can be divided into two separate phases. The "History matching" and the "Future performance prediction" phase. Once a reservoir model has been acquired and has been characterized as "valid", then the simulator can be used to predict the future performance of the reservoir, under different production schemes and thus to assist the reservoir management team to decide the optimal schedule.

The validity of the reservoir simulation model is ensured, when the recorded (observed) performance of the reservoir match the predictions of the model for the same reservoir under the same production scheme for the same period of time. The procedure which leads to this result is referred as "History Matching".

History Matching is the adjustment of the reservoir parameters in the model, until the simulated performance matches the measured information. It is usually the most time consuming phase of a simulation study. In order for an acceptable match to be obtained, the model must execute several runs under different adjustments every time, so that the simulation engineer may be able to understand which variables have to be altered and how much, in order not to harm the physical validity of the model.

As observed values, the following can be taken into consideration: production rates, Bottom-hole pressures, top well pressures, Gas to Oil Ratio (GOR), Water Cut, Water production, Gas to Water Ratio and others.

Mathematically speaking, the history match procedure is an inverse problem case. That means the model and the results are known, but the inputs to the model are the unknowns. There are several mathematic solution algorithms for inverse problems. However, when dealing with hydrocarbon reservoirs, these techniques are not suitable due to the high complexity and the highly non-linear nature of the problem. It is therefore, more suitable that the procedure is carried out, by using a trial and error approach.
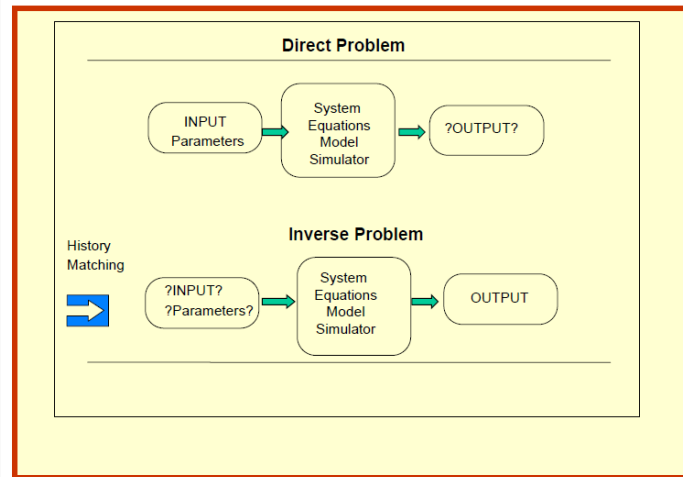
Figure 18: Outline of "direct problem" Vs "Inverse Problem"

History matching is a valuable procedure, even when the final matching has not been achieved yet. The reason for that importance is that it can reveal to the engineers, possible weaknesses in the available data. The identification of these weaknesses can then lead to reconsideration of the validity of the data and may even lead to a decision for a test to be executed again, such as a well test or a bottom hole pressure measurement.

Upon completion of the history match, the reservoir model can also be used for a better reservoir description.

3.4.1 Performing the History Match

Once an upscaled grid has been created, the static modeling team, consisting of geologists, petrophysicists and well test specialists, will provide the reservoir managers an estimation of the initial input parameters. These parameters are the absolute permeability, the relative permeability for each phase, the reservoir porosity, the oil and water saturations, as well as the estimated transmissibilities for the gridding system. These values are given with a level of uncertainty. The level of uncertainty is sometimes not expressly given.

There is a wide range of variables that can modify the model performance and thus to be altered in order to obtain a good match. These variables can be the following:

- Porosity
- Water Saturation
- Permeability
- Gross Thickness
- Net Thickness
- Relative permeability ratios
- Transmissibility
- Aquifer connectivity and size
- Pore Volume

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- Fluid properties
- Rock compressibility
- Capillary pressures
- Mobile Oil volume
- Datum Pressure
- Original Fluid contact
- Well inflow parameters
-

However, it is not wise that all of the previous mentioned parameters, to be modified. Some of them are considered to be of "low uncertainty" while others of "high uncertainty".

The low uncertainty parameters are the ones that their values have been determined experimentally in lab tests, or have been directly measured and thus it is not recommended to be altered, unless it is agreed, upon reconsideration with the static modeling teams. A change in the global porosity, for example, suggests that the estimated reserves will automatically be altered, as they are derived as a function of porosity. These variables can be the following:

- Porosity
- Gross Thickness
- Net Thickness
- Reservoir structure
- Fluid properties
- Rock compressibility
- Capillary Pressure
- Datum Pressure
- Original Fluid Contact
- Production Rates

On the contrary, the high uncertainty parameters are the most preferable for altering during the history matching procedure. These parameters have been obtained as estimations which have been derived by correlations and thus, their exact value can never be known. They consist of the most useful parameters for history matching. These are:

- Pore Volume
- Permeability
- Transmissibility
- Vertical to Horizontal permeability ratio
- Relative permeability curves
- Aquifer properties
- Mobile oil volumes
- Well inflow parametres

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During history matching, the engineer can control specific processes such as the initial quantity and distribution of the fluids within the system, as well as their movement and their mobility in the system, under pressure gradients.

3.4.2 Uncertainties in the Data

The available data however, may suffer from uncertainties caused by technical issues in the production facilities, by data management issues or even human error in measuring. For example, the oil production rates are usually measured systematically, but the Gas to Oil Ratio (GOR) and Water to Oil Ratio (WOR) are done occasionally. This implies that the values between the measurements are unknown and can only be estimated if assumed that the trend in the curve is not altered.

The fluctuations in the Rates are usually smoothed out, so they can rarely appear on the engineers' desk. Also the Gas rates are not measured with extreme accuracy, especially if a significant portion of the gas, is flared.
The injection data can be less accurate than production data due to measurement errors, fluid losses into other intervals due to leaks in the casing or flow behind the pipe.
The well test data are usually reliable when build up records are taken.

The reservoir parameters are usually measured at the locations of specific observation-wells. These parameters can be the porosity, the permeability, the relative permeability, the capillary pressure and others. However, the information obtained from these wells, at their total, represent only a small fraction of the reservoirs' total volume (less than 1%). Thus the value of the parameters at locations between wells, are usually associated with a high level of uncertainty. The spatial distribution of these values is usually performed by using special geostatistical techniques, such as kriging.

3.4.3 Validity of the match

Even when having a set of the parameters that fully match the reservoir performance up to the available recorded point, the accuracy in future performance predictions is not guaranteed. This is because, when the actual production of the reservoir moves on, areas in the reservoir that had not previously been active (pressure disturbance had not yet reached that area) or, while in waterflooding opperations, areas that were not swept previously have now been reached by the water. Thus it is expected that future predictions will not be completely accurate.

The proper use of the simulation model is to be updated constantly and to test different production schemes in relation with one another. The future plans are to be re-evaluated whenever a new update of the model occurs, due to new reservoir history available, to assess whether or not the previous prediction was accurate within the allowed limits and to search for the reasons of the errors occurrence.

The duty of the reservoir management is to direct efforts in simulation studies, in order to quantify the uncertainty in the future performance predictions.

3.4.4 Workflow

Before beginning of the history matching procedure, the error tolerance between the data to be matched and the predicted values must be determined. This is a very crucial step because the validity of the simulation model will strongly depend upon the determined tolerance. Tolerance itself depends upon the objectives of the study, the quality of the available data, the coarseness of the model, the time available for a match to be obtained and finally the available budget for the simulation project.

It is of highly importance for the engineer to know which variables have the most significant effect on the history match and which may not. The knowledge of the variables' effect on the models' performance consists of a very useful guide for the work to follow. These effects can be obtained by performing a sensitivity analysis of the key parameters, before the initiation of the workflow.

The most recommended sequence, while performing history match on a reservoir, is at first to attempt to match against the recorded pressure data. Pressure is the most important parameter on a reservoir, since it consists of the primary driving force for the fluids to flow through the porous media. By matching the pressures the next parameter to be matched are the fluids saturations, although this particular parameter is in most cases estimated and not accurately known, thus with high uncertainty.

The next parameters to be matched against are all the observed and recorded production data. Production rates, and cumulative production of oil, water, and gas, are the most common available parameters. In the absence of Pressure records, the match will be applied, by using the recorded production Data. However, in this case, the simulator will adjust the pressure distribution in the reservoir accordingly. Caution is recommended in order to avoid physically unacceptable values of the pressures.

3.4.5 Error estimation

In general, the goal while performing a history match procedure is to minimize the error between the observed data and predicted performance. A technique that is popular in use is the minimization of an objective function "Q", over the period of history. "Q" itself is a function of the summation of the squared total errors for all the matched parameters, modified by an appropriate weight factor.

$$Q = \sum_{i=1}^{n} R_i^2$$

Where:

$$R = w_i (X - X_o)_i$$

- w_i = weight factor
- X = calculated data
- X_o = actual data

The previous method is to be used under the scheme of computationally assisted history matching, and thus to be implemented in supporting algorithm.

If such an algorithm is not available, or if a faster error estimation procedure is preferred, especially when calculations are to be performed manually, the use of the infinite norm is to be applied. In this case, the procedure follows the philosophy of the "minimization of the maximum distance" for every parameter. Modification by the use of a weight factor is also applied. The procedure is to be fully described in a following chapter.

4) The Eclipse Software

ECLIPSE is an oil and gas reservoir simulator originally developed by ECL (Exploration Consultants Limited) and currently owned, developed, marketed and maintained by SIS(formerly known as GeoQuest), a division of Schlumberger. The name ECLIPSE originally was an acronym for "ECL´s Implicit Program for Simulation Engineering". Ian Cheshirewas the team leader.

ECL was, as its name implied, an exploration oriented consulting firm. Ted Daniels, CEO and Chairman of ECL, decided to expand into reservoir engineering in order to broaden the base of the company and to avoid the cyclic downturns in exploration based revenues, and specified the requirements for corner point geometry in order to better model the subsurface geology. That and the implicit technology enabled ECLIPSE to set new standards in reliability, stability and accuracy for reservoir simulators. ECL had previously been awarded the Queens Award for Exports and, based upon the success of ECLIPSE, was subsequently awarded the Queens Award for Technology.

The first ECLIPSE sale was made to BHP in Australia, followed shortly by major sales to Statoil in Norway. The program ran on a wide range of computers from large IBM systems to the HP 9000, a desk top unit. It is written in Fortran 77 and was used to help debug F77 compilers at IBM and Cray Research.
ECLIPSE uses the finite volume method to solve material and energy balance equations modeling a subsurface petroleum reservoir.

The ECLIPSE simulator suite consists of two separate simulators: ECLIPSE 100 specializing in black oil modeling, and ECLIPSE 300 specializing in compositional modeling. ECLIPSE 100 is a fully-implicit, three phase, three dimensional, general purpose black oil simulator with gas condensate options. ECLIPSE 300 is a compositional simulator with cubic equation of state, pressure dependent K-value and black oil fluid treatments. ECLIPSE 300 can be run in fully implicit, IMPES and adaptive implicit (AIM) modes.

Both programs are written in FORTRAN and operate on any computer with an ANSI-standard FORTRAN90 compiler and with sufficient memory.
For large simulations the simulators can be run in parallel mode. The Parallel option is based on a distributed memory architecture implemented using MPI (message passing interface).

4.1 Model set up

When run, the simulator will require input data that defines the system to be modeled and it will generate output data that represents the results of the calculations which have been performed. The input file must therefore be set up before starting the simulation run. The data file is divided into certain key sections that define:

- Model dimensions

- Grid and rock properties
- Fluid properties
- Initial conditions
- Output requirements
- Production schedule
-

Additional optional sections may allow for manipulation of an imported grid structure and for subdivision of the grid into regions.

Individual parts of the input data may be set up by other programs that may be supplied by the same supplier as the simulation code, or by other companies. These are referred to as pre-processors: They are used to perform calculations that set up the model in advance of the actual reservoir fluid flow calculation. Typically, a pre-processor is used to set up the grid and to define the rock properties (permeability, porosity, etc.) of each cell. Setting up a model with more than a few hundred cells would be very laborious if performed by hand. These gridding packages are usually designed to generate output that conforms to the input format of several of the more widely used simulators.

Thus, the reservoir simulation input data file need only refer to these grid files by means of a simple "include" statement, and no further manipulation of the grid is required by the flow simulator.

Pre-processors may be used to:

- Define grid and rock properties
- Define fluid properties
- Convert the results of special core analysis data to a form that can be used in the simulation
- Upscale rock data so that it is appropriate for the size of grid cells being used
- Define vertical flow performance tables
- Set up the production schedule

The output of the reservoir flow calculations comes in two forms, which in both cases results in the creation of files that can be stored and read at a later date. The first category of output data is typically referred to as "summary" data and the second type of output consists of grid data. Usually both of these output files are created after every simulation. The two types are as follows:

(a) *Summary data:* this consists of calculated parameters such as oil, water and gas production rates, well bottom hole or tubing head pressures, etc. These data may be plotted as line charts, usually as a function of time, either by using specialised post-processing software, or by using standard graphing software such as Microsoft Excel or Lotus 1, 2, 3.

(b) *Grid data:* in this type of data, values such as pressure or saturation to be plotted for each cell at a given time step. These files are typically in binary format, which means that they may only be read by appropriate post-processing software. The reason that ASCII format is not generally used is one of disk space usage. For example, a 100,000 cell model, with output data for 20 time steps, would generate 2 million values of pressure (usually to eight significant figures) during the course of the simulation, and similarly for every other property such as phase saturations, etc.

ECLIPSE uses free format. This means that, with a few exceptions, as many or as few spaces, tabs and new lines may be used as desired. However, arranging the file appropriately, such as by lining data up in columns, etc., can improve readability, reducing unnecessary typographical mistakes, and saving time in the long run. The following additional rules should be noted:

- Each section starts with a keyword
- There must be no other characters (or spaces) on the same line as a keyword (i.e. each keyword must start in column 1, and be immediately followed by a new line keystroke)
- All data associated with a keyword must appear on the subsequent lines
- Data entry is terminated by a forward slash symbol (/)
- Lines beginning with two dashes (--) are ignored, and treated as comment lines
- Blank lines are ignored

An example of how a keyword is to be used is shown in the (figure 1) bellow.

FEATURE	EXAMPLE FROM DATA FILE		
Comments	-- Number of cells		
	-- NX	NY	NZ
	-- --	--	--
KEYWORDS	DIMENS		
Data (followed by /)	5	5	3 /

Figure 19: Keyword formatting style

4.2 Input Data file

The first step in setting up a model is to define:

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- Title of run
- Type of geometry to be used (Cartesian or radial, though Cartesian is often the default)
- Number of cells in each direction (x, y, z, or r, θ, z)
- Phases to be modeled (oil, water, gas, vapourised oil in the gas, dissolved gas in the oil)
- Units to be used (field, metric or lab)
- Number of wells
- Start date for simulation (usually corresponding to the date of first oil production)

Cartesian is the default geometry used by ECLIPSE, so it does need to be specified explicitly. ECLIPSE allows wells to be grouped together so that the cumulative production or injection rates may be specified or calculated.

Generated output should be written to a single unified output file. The ECLIPSE default is to create a separate output file for every time step, which has the advantage that not all the data output data is lost if one file is in some way corrupted, but this may result in an unmanageable number of files being generated.

All the information that it is required for defining the dimensioning data of a reservoir goes in the first section of an ECLIPSE data file, referred to as the RUNSPEC section. The form in which this data should be entered is shown in the following figure. The keywords to be used are:

- **RUNSPEC** Section header
- **DIMENS** Number of cells in X, Y and Z directions
- **OIL** Calculate oil flows
- **WATER** Calculate water flows
- **FIELD** Use field units throughout (i.e. feet, psi, lb, bbl, etc.)
- **WELLDIMS** Number of wells, connections per well, groups, wells per group
- **UNIFOUT** Unified output file
- **START** Start date of simulation (1st day of production)

```
TUT1A. DATA

Base case for tutorials
 - -
 - -
 - -==================================================================
RUNSPEC


TITLE
        3D 2-Phase


 - -    Number of cells
 - -    NX      NY    NZ
 - -    - -     - -    - -
DIMENS
        5       5     3 /



 - -    Phases
OIL

WATER



 - -    Units
FIELD


 - -    Maximum well / connection / group values
 - -    #wells        #cons/w      #grps      #wells/grp
 - -    - - - -       - - - -      - - -      - - - - -

WELLDIMS
        2             3            2          1 /




 - -    Unified output files
UNIFOUT



 - -    Simulation start date
START
        1 JAN 2001 /
```

Figure 20: Runspec section

Having identified the number of grid cells in the X, Y and Z directions required to model the reservoir or part of the reservoir being studied, the following grid properties must be defined:

- Dimensions of each cell
- Depth of each cell (or at least the top layer)
- Cell permeabilities in each direction (x, y, z, or r, θ, z)
- Cell porosities

If a Cartesian grid is being used, then the size of each cell may be specified by providing data on the length, width and height of each cell.

This represents the minimum information that is required for defining the grid and rock properties for the second section of an ECLIPSE data file, referred to as the GRID Section. It is useful to output a file that allows these values to be viewed graphically by one of the post-processors. This enables a quick visual check that the grid data has been entered correctly. The following keywords are used:

- **GRID** Section header
- **DX** Size of cells in the X direction
- **DY** Size of cells in the Y direction
- **DZ** Size of cells in the Z direction
- **TOPS** Depth of cells
- **PERMX** Cell permeabilities in the X direction
- **PERMY** Cell permeabilities in the Y direction
- **PERMZ** Cell permeabilities in the Z direction
- **PORO** Cell porosities
- **INIT** Output grid values to .INIT file

ECLIPSE normally assumes that grid values, such as DY, DZ, PERMX, PORO, etc., are being entered for the whole grid. If values are only being entered for a subsection of the grid, then the BOX and ENDBOX keywords may be used to identify this subsection. If no BOX is defined, or after an ENDBOX keyword, ECLIPSE assumes that cell values are being defined for the entire grid.

The values of each grid property, such as cell length, DX, are read in a certain order. If the co-ordinates of each cell are specified by indices (i, j, k), where i is in the X direction, j is in the Y direction, and k is in the Z direction, then the values are read in with i varying fastest, and k slowest. The first value that is read in is for cell (1, 1, 1), and the last one is for cell (NX, NY, NZ), where NX, NY and NZ are the number of cells in the X, Y and Z directions respectively.

An example of a grid definition can be seen in the figure bellow:
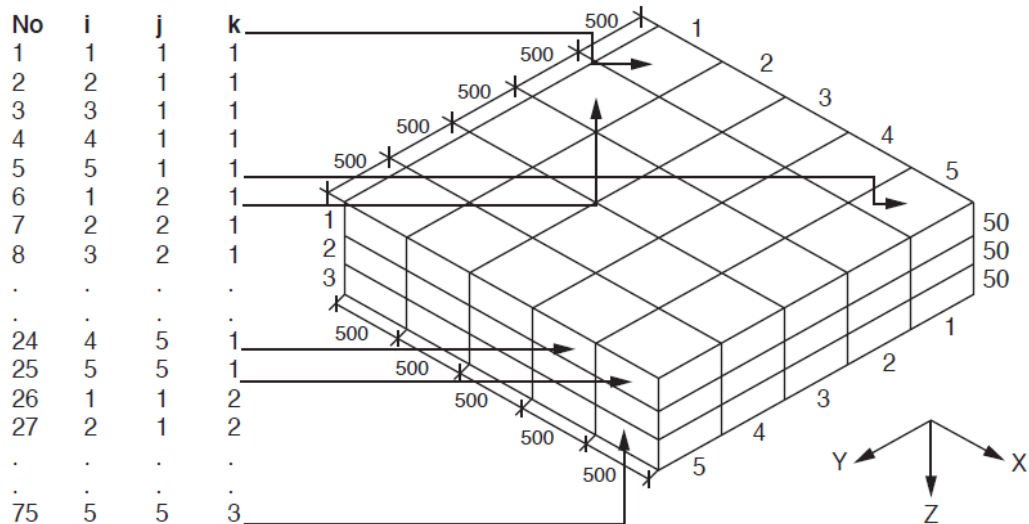
Figure 21: Grid property definition

Most simulators will allow the definition of multiple cells, each with the same size, to be lumped together. In ECLIPSE this is done by prefixing the value (cell size) by the number of cells to be assigned that value, and separating these two numbers by a "*".

Note that the multiplier comes first, then the "*" operator, then the value. There should be no spaces on either side of the "*". This convention may be used for all other grid parameters.

If cell depths are only to be defined for the top layer of cells using the TOPS keyword, then a box must be used to identify this top layer as the only section of the grid for which depths are being defined.

```
GRID


--     Size of each cell in X, Y and Z directions
DX
75*500 /



DY
75*500 /



DZ
75*50 /



--     TVDSS of top layer only
--           X1    X2      Y1    Y2      Z1    Z2
--           --    --      --    --      --    --
BOX
             1     5       1     5       1     1 /



TOPS
25*8000 /



ENDBOX


--     Permeability in X, Y and Z directions for each cell
PERMX
25*200  25*1000  25*200 /

PERMY
25*150  25*800  25*150 /

PERMZ
25*20  25*100  25*20 /


--     Porosity of each cell
PORO
75*0.2 /


--     Output file with geometry and rock properties (.INIT)
INIT
```

Figure 22: GRID section

4.2.1 Fluid properties

Having defined the grid and rock properties such as permeability and porosity, the following Pressure/Volume/Temperature (PVT), viscosity, relative permeability and capillary pressure data must be defined:

- Densities of oil, water and gas at surface conditions
- Formation factor and viscosity of oil vs. pressure
- Pressure, formation factor, compressibility and viscosity of water
- Rock compressibility
- Water and oil relative permeabilities, and oil-water capillary pressure vs. water saturation

This data should be inserted in the third section of the ECLIPSE data file, the PROPS section. The form in which this data should be entered is shown in the following Figure. The following keywords are used:

- **PROPS** Section header
- **DENSITY** Surface density of oil, water and gas phases
- **PVDO** PVT data for dead oil relating FVF and viscosity to Pressure
- **PVTW** PVT data for water relating FVF, compressibility and viscosity to pressure
- **ROCK** Compressibility of the rock
- **SWOF** Table relating oil and water relative permeabilities and oilwater capillary pressure to water saturations

```
PROPS
 -- Densities in lb/ft3
 --          Oil        Water      Gas
 --          --         --         --
DENSITIES
             49         63         0.01 /



 -- PVT data for dead oil
 --          P          Bo         Vis
 --          ---        ---        ---
PVDO
             300        1.25       1.0
             800        1.20       1.1
             6000       1.15       2.0 /



 -- PVT data for water
 -- P        Bw         Cw         Vis    Viscosibility
 -- --       --         --         --     ------

PVTW
     4500    1.02       3e-06      0.8    0.0 /



 -- Rock compressibility
 --          P          Cr
 --          --         --
ROCK
             4500       4e-06 /


 -- Water and oil rel perms and capillary pressure
 --          Sw         Krw        Kro    Pc
 --          --         --         --     --
SWOF
             0.25       0.0        0.9    4.0
             0.5        0.2        0.3    0.8
             0.7        0.4        0.1    0.2
             0.8        0.55       0.0    0.1 /
```

Figure 23: PROPS section

4.2.2 Initial conditions

Once the rock and fluid properties have all been defined, the initial pressure and saturation conditions in the reservoir must be specified. This may be done in one of three ways:

1) Enumeration
2) Equilibration
3) Restart from a previous run

1) **Enumeration.** In this method of initializing the model, the pressure, oil and water saturations in each cell at time = 0 are set in much the same way as permeabilities and porosities are set. This method is the most complicated and least commonly used. A failure to correctly account for densities when setting the pressures in cells at different depths will result in a system that is not initially in equilibrium.

2) **Equilibration.** This is the simplest and most commonly used method for initialising a model. A pressure at a reference depth is defined in the input data, and the model then calculates the pressures at all other depths using the previously entered density data to account for hydrostatic head. The depths of the water-oil and gas-oil contacts are also specified if they are within the model, and the initial saturations can then be set depending on position relative to the contacts. (In a water-oil system, above the oil-water contact the system is at connate water saturation, below the contact S_w = 1.)

3) **Restart from a previous run.** If a model has already been run, then one of the output time steps can be used to provide the starting fluid pressures and saturations for a subsequent calculation. This option will typically be used where a model has been history matched against field data to the current point in time, and various future development scenarios are to be compared. A restart run will use the last time step of the history matched model as the starting point for a predictive calculation, which may then be used to assess future performance. Time is saved by not repeating the entire calculation.

An output file containing initial cell pressures and saturations for display should be requested so that a visual check can be made that the correct initial values of these properties have been calculated.

This initialisation data should be inserted in the fourth section of the ECLIPSE data file, the SOLUTION section. The form in which this data should be entered is shown in the following Figure. The following keywords are used:

- **SOLUTION** Section header
- **EQUIL** Equilibration data (pressure at datum depth and contact depths)
- **RPTRST** Request output of cell pressures and saturations at t = 0

Figure 24: SOLUTION section

4.2.3 Output requirements

The parameters that should be calculated are specified in the SUMMARY section by the use of appropriate keywords, but for this section only the keywords are not found in the main section of the manual, but in the Summary Section Overview. Most of the summary keywords consist of four letters that follow a basic convention.

1st letter:
- **F** - field
- **R** - region
- **W** - well
- **C** - connection
- **B** – block

2nd letter:
- - oil (stb in FIELD units)
- **W** - water (stb in FIELD units)
- **G** - gas (Mscf in FIELD units)
- **L** - liquid (oil + water) (stb in FIELD units)
- **V** - reservoir volume flows (rb in FIELD units)
- **T** - tracer concentration
- **S** - salt concentration
- **C** - polymer concentration
- **N** - solvent concentration

3rd letter:

- **P** - production
- **I** - injection

4th letter:

- **R** - rate
- **T** – total

Thus, use of the keyword FOPR requests that the Field Oil Production Rate be output, and WWIT represents Well Water Injection Total, etc.

Keywords beginning with an F refer to the values calculated for the field as a whole, and require no further identification. However, keywords beginning with another letter must specify which region, well, connection or block they refer to. Thus, for example, a keyword such as FOPR requires no accompanying data, but WWIT must be followed by a list of well names, terminated with a /. If no well names are supplied, and the keyword is followed only by a /, the value is calculated for all wells in the model.

The form in which this data should be entered is shown in Figure below. The following keywords are used:

- **SUMMARY** Section header
- **FPR** Field average pressure
- **WBHP** Well Bottomhole pressure
- **FOPR** Field Oil Production Rate
- **FWPR** Field Water Production Rate
- **FOPT** Field Oil Production Total
- **FWPT** Field Water Production Total
- **WWCT** Well Water Cut
- **CPU** CPU usage
- **EXCEL** Create summary output as Excel readable Run Summary file

```
SUMMARY


    − −     Field average pressure
FPR

    − −     Bottomhole pressure of all wells
WBHP
/

    − −     Field oil production rate
FOPR

    − −     Field water production rate
FWPR

    − −     Field oil production total
FOPT

    − −     Field water production total
FWPT

    − −     Water cut in PROD
WWCT
PROD /


    − −     CPU usage
TCPU

    − −     Create Excel readable run summary file (.RSM)
EXCEL
```

Figure 25: SUMMARY section

4.2.4 Schedule file

Having defined the initial conditions (t = 0) in the SOLUTION Section, the final part of the input data file defines the well controls and time steps (t > 0) in the SCHEDULE Section. The main functions that are performed here are:

- Specify grid data to be output for display or restart purposes
- Define well names, locations and types
- Specify completion intervals for each well
- Specify injection and production controls for each well for each given period (time step)

Basic pressure and saturation data should be generated at every time step to enable a 3-D display of the model to be viewed at each time step.

A number of keywords in the SCHEDULE section will be able to read in data that the user may wish to default or not supply all. This can be done by using the "*" character, with the number of

values to be defaulted or ignored on the left, and the space to the right left blank. Thus "1*" ignores one value, "2*" ignores the next two values, etc.

The keywords to be used are:

- **SCHEDULE** Section header
- **RPTRST** Request output of cell pressures and saturations at all time steps (t > 0)
- **WELSPECS** Define location of wellhead and pressure gauge
- **COMPDAT** Define completion intervals and wellbore diameter
- **WCONPROD** Production control
- **WCONINJ** Injection control
- **TSTEP** Time step sizes (for output of calculated data)
- **END** End of input data file

These keywords should appear as the last section of the data file as shown in the Figure bellow. Although not the case in this simple example, this section will typically be the longest, containing flow rates for each well on a monthly basis for the history of the field. It should be noted that the time steps input here refer to time intervals at which data are output. The simulator will try to use these time step sizes as numerical time step also, but if the calculations do not converge, it will automatically cut the numerical time step sizes.

```
SCHEDULE

- -   Output to Restart file for t > 0 (.UNRST)
- -       Restart file            Graphics
- -       every step              only
- -   - - - - -             - - - - -
RPTRST
         BASIC=2                NORST=1  /

- -   Location of wellhead and pressure gauge
- -       Well    Well       Location    BHP       Pref.
- -       name    group     I    J      datum     phase
- -   - - -   - - -   - -   - -   - - -   - - -
WELSPECS
         PROD    G1    1    1     8000    OIL    /
         INJ     G2    5    5     8000    WATER /
/

- -   Completion interval
- -       Well        Location    Interval    Status          Well
- -       name       I     J     K1   K2     0 or S          ID
- -   - - -   - -   - -   - - -   - - - -     - - -
COMPDAT
         PROD        1     1     1    3      OPEN    2*    0.6667 /
         INJ         5     5     1    3      OPEN    2*    0.6667 /
/

- -   Production control
- -   Well      Status   Control   Oil    Wat    Gas     Liq.   Resv   BHP
- -   name               mode      rate   rate   rate    rate   rate   lim
- - - -   - - -   - - -   - -   - -   - -   - -   - -   - -
WCONPROD
         PROD   OPEN   LRAT           3*             10000 1*   2000 /
/

- -   Injection control
- -   Well     Fluid    Status   Control   Surf   Resv   Voidage   BHP
- -   Name     TYPE              mode      rate   rate   frac flag lim
- - - -   - - -   - - -   - - -   - - - - -   - - -   - - - -   - - -
WCONINJ
         INJ    WATER   OPEN  RATE   11000           3*        20000 /
/

_ _   Number and size (days) of timesteps
TSTEP
10*200 /

END
```

Figure 26: SCHEDULE section

4.3 FloViz and Office post-processors

The GeoQuest post-processors are Office and FloViz. FloViz is used for 3D displays of the model, showing, for example, progression of the water flood by displaying saturations varying with time (Figure). Office is used to display line charts such as water cut vs. time, etc. Office may be used for setting up data files and viewing results.
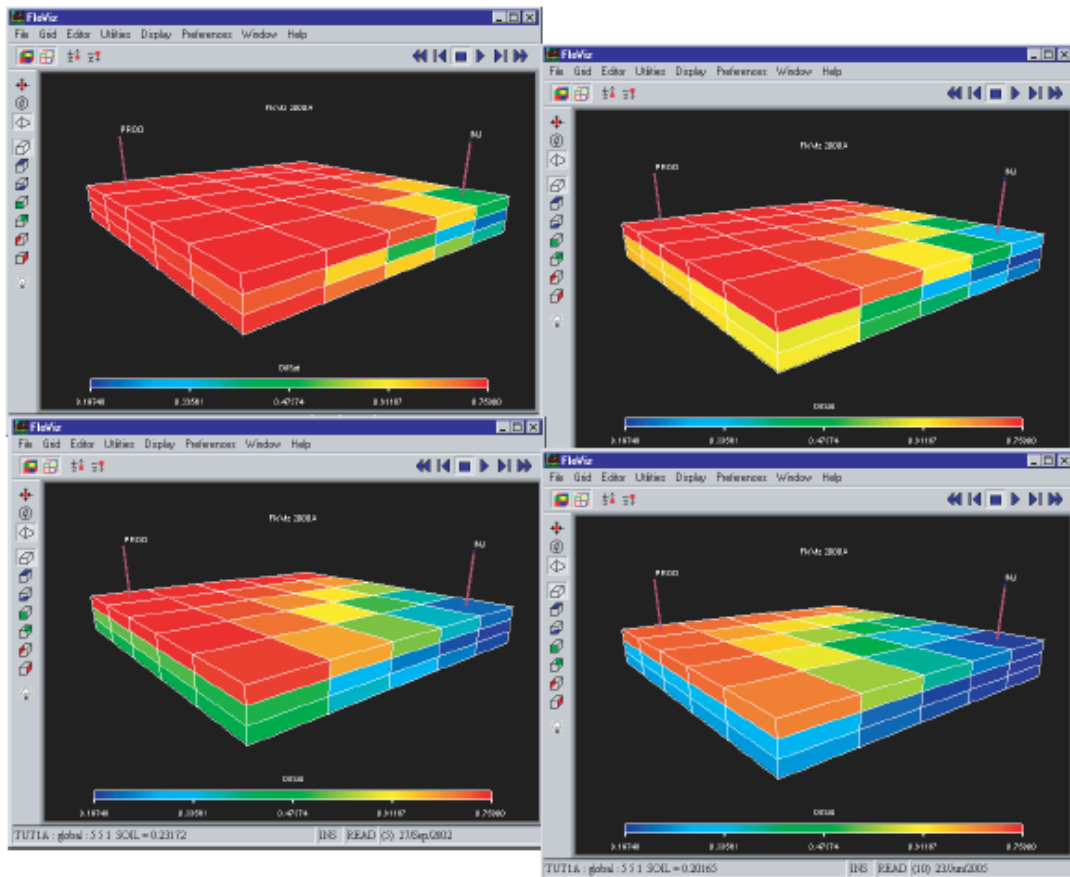
Figure 27: FloViz visualization

5) Norwegian reservoir of the "Gullfaks field"

Gullfaks is an oil and gas field in the Norwegian sector of the North Sea operated by Statoil. It was discovered in 1978 in block 34/10, approximately 175 km northwest of Bergen, at a water depth of 130-230 meters; the initial recoverable reserve is 2.1 billion barrels (330×106 m^3). This oil field reached peak production in 2001 at 180,000 barrels per day (29,000 m^3/d).

Figure 28: Gullfaks field (www.statoil.com)

It has been developed with three large concrete production platforms. The Gullfaks A platform began production on 22 December 1986, with Gullfaks B following on 29 February 1988 and the C platform on 4 November 1989. The field set a production record of 605,965 barrels for a single day on 7 October 1994. Three satellite fields – Gullfaks South, Rimfaks, Gullveig, Gimle, Gulltop and Skinfaks and – have been developed with subsea wells remotely controlled from the Gullfaks A and C platforms. Production from the first three satellites started in 1998, while Gimle came on stream in 2005; whereas Gulltop and Skinfaks operation started in 2007.

The reservoir description is similar to the Gullfaks main field, but the fields contain more gas than oil; often with a significant gas cap. The initial pressure of Gullfaks South is 450 bars at datum depth of 3300 m below mean sea level and at Rimfaks it is 450 bars at datum 2860 m below mean sea level. The fields in the Gullfaks area are found in sandstones of early and middle Jurassic age, 1800-4000 m subsea.

Figure 29: Overview of the fields at Gullfaks area (www.ogj.com)

Gullfaks has proved to be excellent in improving the oil and gas recovery rates and has managed to increase the recovery rate from the planned 46% to 61%. Measures to improve recovery included horizontal and extended-reach wells, new completion and sand control technology, and water alternating gas (WAG) injection. The 2008 Gulltopp well was the world's longest producing offshore well with a length of 9910 meters and a depth of 2500 meters. Moreover, Gullfaks is one of the first fields to introduce wet gas compression on the seabed.

5.1 Reservoir management

After the peak year of 1994, when production exceeded 30 Msm^3, the main field was on decline and production was reduced more than a third. A few years ago recoverable oil reserves were estimated at 360 Msm^3, of which approximately 330 Msm^3 have been produced by the end of 2006. The uppermost Brent sequence contains roughly 80% of the reserves, with the deeper formations contributing the remainder.

The Gullfaks main field has been produced with pressure maintenance, mostly through water injection, but natural water influx has also contributed. Gas injection has been employed in the past to drain attic oil, but also to avoid reducing oil production during periods of restricted gas export. Gas flaring as a production control mechanism was eliminated in 1998. Water and gas injection was also employed in parts of the field to improve vertical sweep. Due to the dense fault pattern which has been described above, close well spacing in some areas was necessary, which again; often combined with good internal reservoir quality, has resulted in rapid water and gas breakthrough in producers.

The Gullfaks satellites fields have been produced with pressure maintenance by gas for Rimfaks and to some extent Gullfaks South. Gullveig, Gulltopp and Skinfaks had water influx and were produced with natural depletion while Gimle had water injection.

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5.2 Reservoir description

The goal of this thesis is to build a simulation model for a reservoir section, which is only a part of a larger reservoir that belongs to Gullfaks field. Reservoir quality is general very high, with permeability ranging from tens of mD to several Darcys depending on layer and location.

It is consisted of 6 different producers; P-A1H, P-A2AH, P-A39A, P-A17, P-A35& P-ABRH, and 4 different injectors; I-A38, I-A5H, I-H2 & I-INJEC. Figure 30 illustrates the exact location of the wells on the reservoir grid. The reservoir grid consists of 10400 blocks in total. It is divided in 13 layers and the total grid dimensions are 20 x 40 x 13.
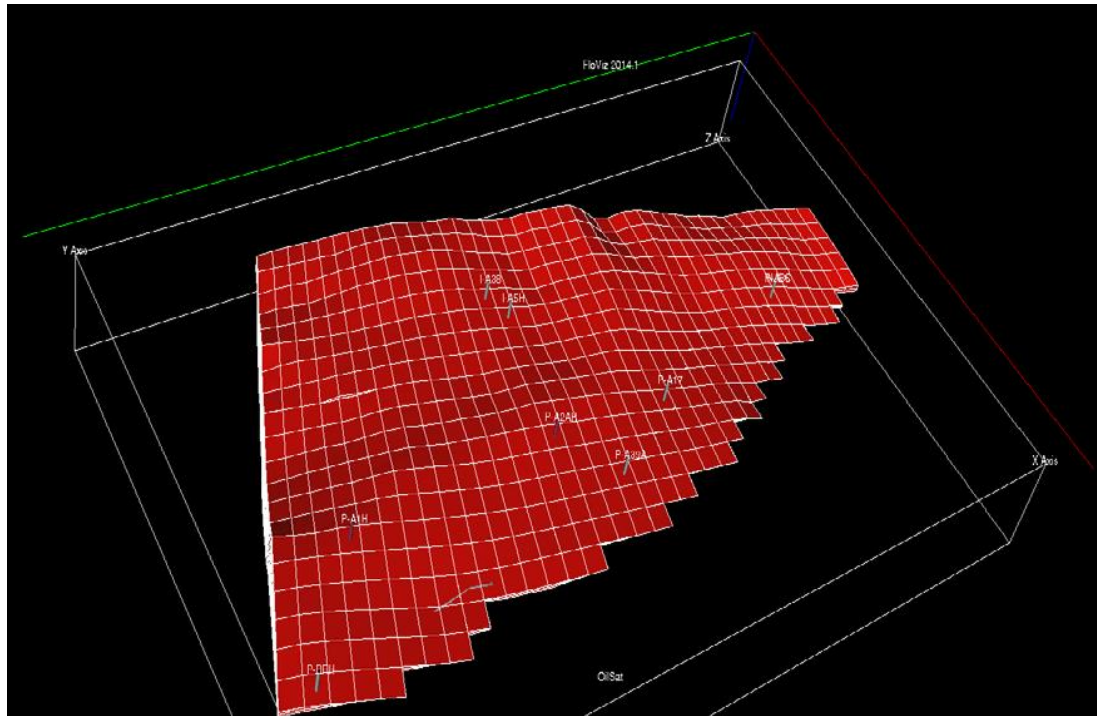
Figure 30: Location of the wells in the reservoir grid

The Gullfaks main field is over pressured, with an initial pressure of 310 bars at datum depth of 1850 m below mean sea level, and a temperature of 70 degrees C^o. The oil is under saturated, with a saturation pressure of approximately 245 bars, depending on formation depth and location. The GOR ranges between 90 and 180 sm^3/sm^3, with stock tank oil gravity of around 860 kg/m^3.

Structurally, the field is very complex and can be further divided into three regions with different structure. Rotated fault blocks at the west; a horst area at the east; and in between there is a complex zone characterized by folding structures. The north-south faults that divide up the field have throw up to 300 meters. The field is further cut by smaller faults, with throws of zero to few tens of meters, both in the dominant north-south as well as east-west direction. Many of these lesser faults have slopes of 50-80 degrees. This results in complex reservoir communication and drainage patterns, and is a major challenge in optimally placing wells in the reservoir.

5.2.1 Well locations

In the next figure (figure 31), in which the reservoir is colorless and without gridlines, a sense of the complexity of the reservoir is evident. It is clear that not all the wells are vertical, and that some of them are horizontal wells, which in turn makes more difficult to appreciate and evaluate the behavioral conditions that apply and affect the reservoir under flowing fluids. The horizontal wells are P-A1H, P-A2AH, P-A17, whereas P-A39A is a vertical one and reaches the area right next to P-A1H. So apart from the variability in the geology structure of the reservoir, that is another significant reason which strongly influences the behavior of the reservoir. Injection wells I-A5H and I-H2 are vertical; whereas injector I-A38 is deviating from the vertical axis until it reaches the area next to I-H2.
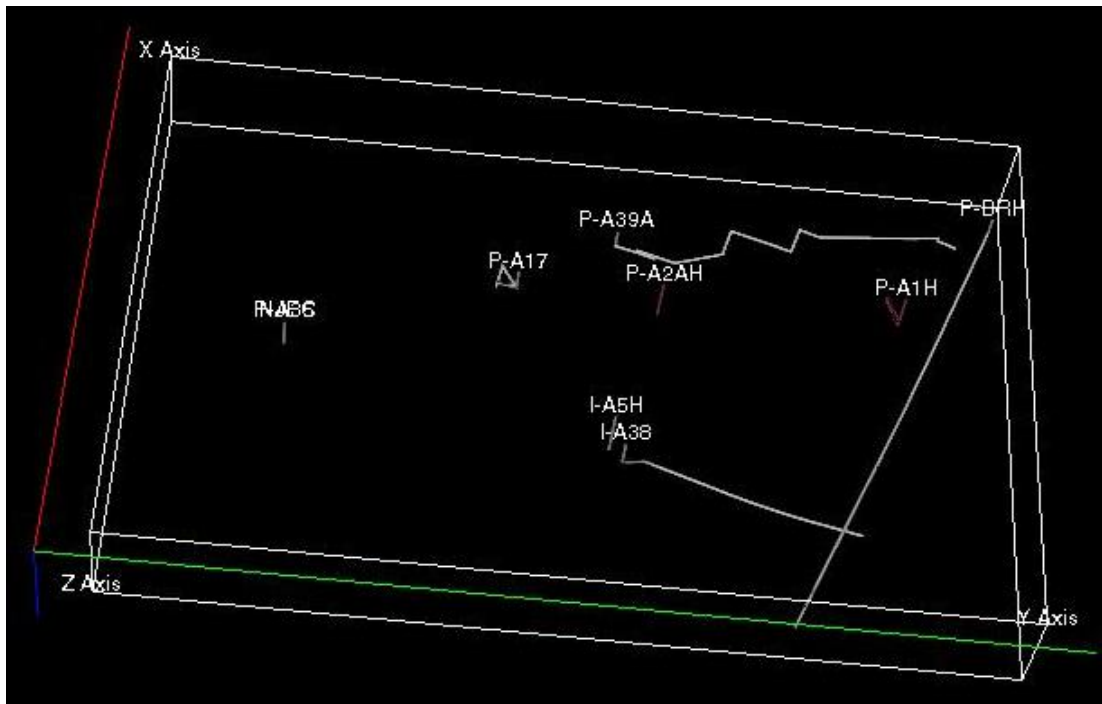
Figure 31: Reservoir wells in space

The following table summarizes the exact position of each well and which layers each well passes through.

Wells	Direction	X	Y	Z (layer)
I-H2	Vertical	1	1	3, 4
I-A38	Horizontal	5	14	3,4,6,7,8,9,12
I-A5H	Vertical	6	15	3,4,5,6,7,8,9,10, 11,12
P-A1H	Deviated	15	4	3,4,5,6,7,8,9,10, 11,12
P-A2AH	Vertical	12	15	6,7,8,9,10,11,12
P-A17	Horizontal	11	22	5,6,9,10,11,12
P-A35	Deviated	6	33	3,4,5,6,9,10,11, 12
P-A39	Vertical	14	18	10,11,12

5.2.2 Reservoir fluid description

Some important information is automatically entered in the simulation model, regarding are the initial oil/water saturations, the placement and the geometry of the wells, initial conditions and the fluid characteristics. These are the following:

- Reference pressure = 308.2 bars
- Water formation volume factor = 0.977
- Compressibility = 4.64E-05
- Reference viscosity = 0.42

The reservoir fluid is consisted of oil, water and gas, and the respectful density by standard terms is 883 psi for the oil, 1038 psi density of water, and 0.66 psi is the density of the gas.

The table below summarizes the oil and water saturation and the respective relative permeability:

Sw	Krw	So	Kro
0.15	0	0	0
0.25	0.000	0.2	0.000
0.4	0.197	0.4	0.035
0.6	0.366	0.6	0.194
0.8	0.614	0.75	0.614
1.0	1.000	1.0	1.000

The oil characteristics are given in terms of dead oil model, as pairs of oil formation volume factor and viscosity for every measured pressure level. This information can be seen in the following table.

Pressure (BARS)	Bo (RM^3/SM^3)	Viscosity (CP)
227	1.26	1.042
253.4	1.255968	1.072
281.6	1.250676	1.096
311.1	1.246266	1.118
343.8	1.24173	1.151
373.3	1.237698	1.174
395.5	1.235556	1.2

6) Description of the Matching attempts

6.1 General

The available History record for the given reservoir consists of production data for all of the five producing wells, for a recorded period of 4300 days. The starting date is January 1st 1987. During this period, a full schedule record is available. The recorded history is in the form of oil production rates, water production rates, water cuts, total oil production and total water production for the entire field, and for each well separately. Also, injection history data are available for the injection wells, thus the total injected amount of water can be calculated at any time.

The changes in the production and injection schedule are made in order for the flow to be directed and eventually for the oil to be extracted, from specific wells and at specific time intervals. The ultimate goal of this manipulation of the production is for the pressure levels to be maintained in allowable high values, so that the production does not ceases and the oil does not enter the biphasic state due to pressure drop.

In the chart that follows, the schedule for the production and injection wells is shown. Number zero (0) stands for inactive well, while number one (1) stands for active.

Time (Days)	Injectors			Producers				
	I-A5H	I-H2	I-A38	P-A1H	P-A2AH	P-A17	P-A35	P-A39
0-600	1	0	0	1	1	0	0	0
600-1150	1	0	0	1	1	1	0	0
1150-2200	1	1	0	1	1	1	0	0
2200-2300	1	1	1	1	1	1	0	0
2300-2500	0	0	1	1	0	1	0	1
2500-3200	0	0	1	0	0	1	0	1
3200-4300	0	0	1	0	0	0	1	1

Figure 32: Function schedule of wells.

The production well P-A39 is stopped by schedule at the exact time of the end of the recorded history. It is therefore assumed that the production in the later times is to be resumed only with well P-A35 to be active.

Division in half of the available record

For the purposes of the present Thesis project, the available recorded history has been separate in half and two different History matching procedures have been followed. One has been conducted by using the entire history available, and the second attempt has been conducted by using, as recorded history, half of the available records, that is from the start of the production day, until the day "2300". The performance of the two different matched attempts is to be compared and their accuracy level is to be evaluated.

Reservoir performance before history matching for the entire recorded history.

Before proceeding to explaining the matched models in detail as well as how they have been derived, the overall performance of the reservoir, both according to history as well as the simulated performance, before any history match is executed, is to be presented.

Bellow, the total Field cumulative production as well as the total Field Production Rates, for the entire recorded History, are to be presented.

6.2 Field performance

In the figure that follows, the cumulative oil production for the entire field is demonstrated. The green line corresponds to the actual recorded production, while the blue line corresponds to the simulated performance for the same time period. It can be seen that the simulation underestimates the reality by about 400,000 standard cubic meters (SM^3) of oil production. It is an interesting point though, that in the early days of prediction, about the first 500 days, the simulator gives a quite accurate estimation. The first error appears in the days to follow the 500th until it stabilizes in the 1000th day and then moves on with that error for about until the 3300th day where it reaches a maximum value. From that day forward, the error returns to the previously stabilized 0.4 million SM^3.
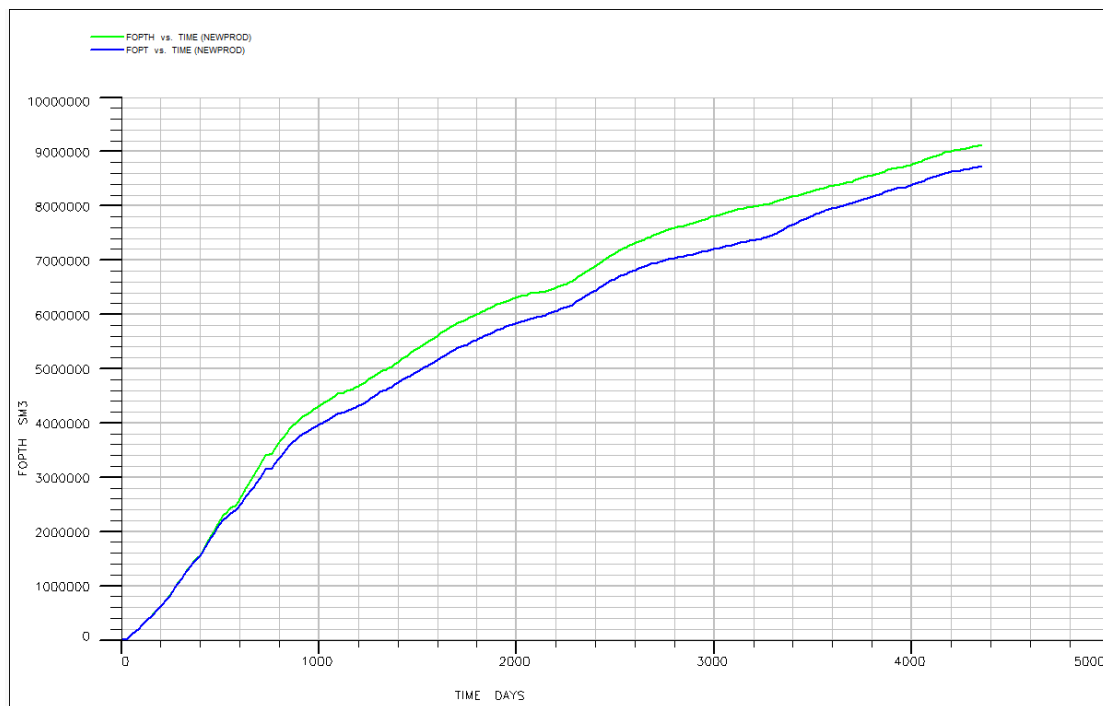
Figure 33: Field Oil Production Total (FOPT)

It is worth to mention here, that the simulator at the moment, functions in "liquid rate control". That means that given a history record, the simulator is automatically forced to predict the exact rate of total liquid production, as the summation of both oil and water quantities. The respective rates of oil and water, are adjusted in that way, so both the convergence criteria for both the

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given reservoir attributes and the total liquid rates are satisfied at any given time, as a first priority. An ideal match of the reservoir properties will demonstrate a perfect match on all the liquid, oil and water production rates.

In the figure that follows, the total field oil production rate is presented. The green line corresponds to the recorded history rate, while the blue line is the estimated performance by the simulator. Again the general trend is for the simulator to underestimate the overall performance, systematically, except at the later days of the records, where the opposite behavior takes place. Last, the accuracy during the last days of the records is in a very good level.
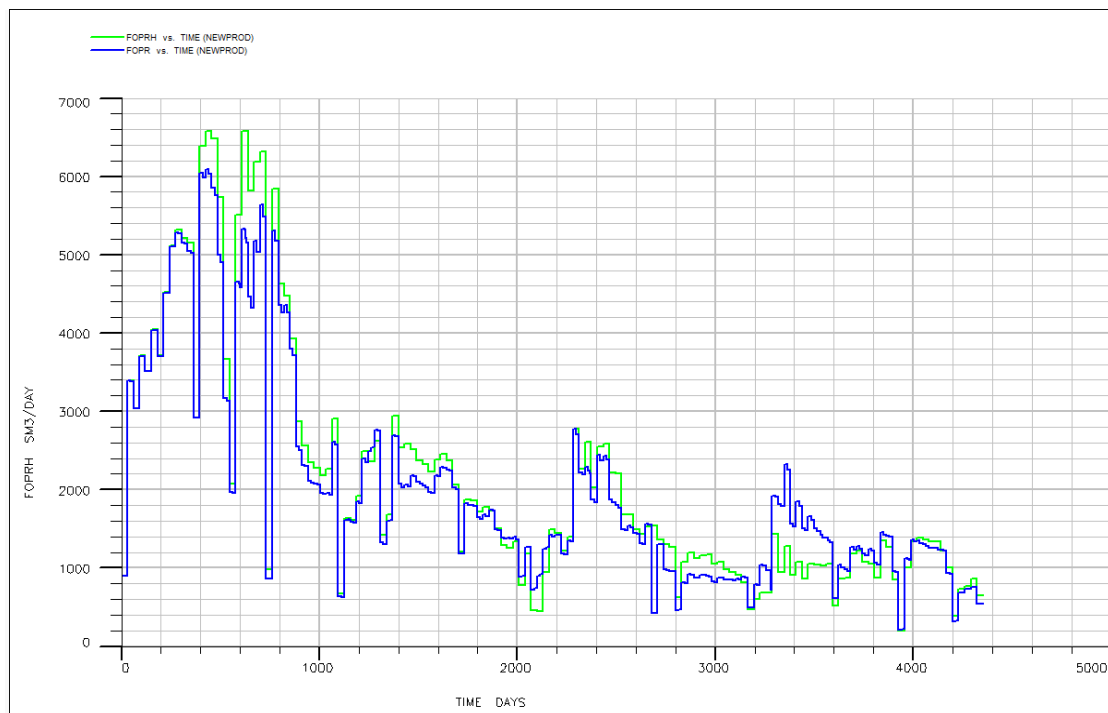
Figure 34: Field Oil Production Rate (FOPR)

The water production rate for the entire field appears below, with the dark blue line to be the actual production rate and the light blue to be the estimated. The trend is for the estimated rate, to be higher than the actually observed during the early days of production, until day 1700, and after a small era of good matching productions is observed until day 2500 where the initial behavior is observed again. Finally, a significant underestimation is observed for days 3200 until 3600, and then the behavior returns to a good match until the end of the production history.
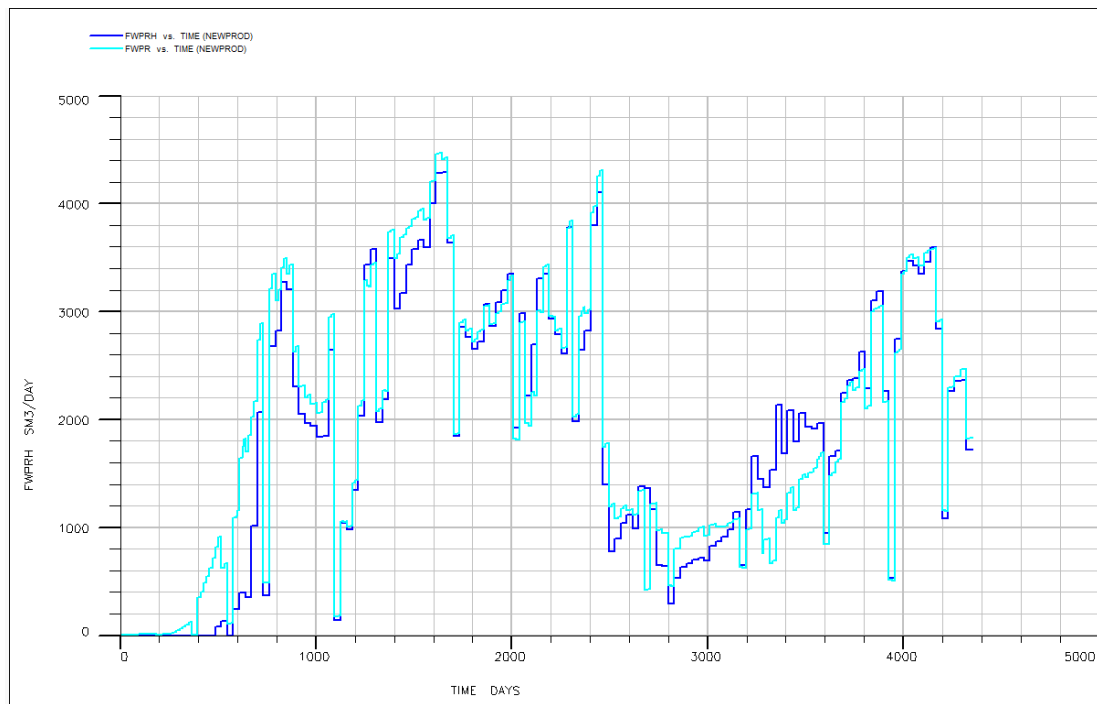
Figure 35: Field Water Production Rate (FWPR)

The last chart to be presented for the total field performance is the watercut. Watercut is expressed as the water to oil ratio of production for every given time. Thus it receives values ranging from 0,00 (100% oil production) to 1,00 (100% water production).

Here, same as the previous case, the light blue line corresponds to the estimated performance, while the dark blue one corresponds to the recorded history performance.

The simulator tends to overestimate the watercut values, from the beginning of production until day 1700, where the simulator fails to predict a peak value performance, which lasts for about 300 days and tops at day 2100. After that day, a good match is observed for the following 200 days. From there on and until the day 3150, a systematical overestimation is observed until to be followed by a severe underestimation until day 4000 when the simulator starts to overestimate again until the end of the history date.
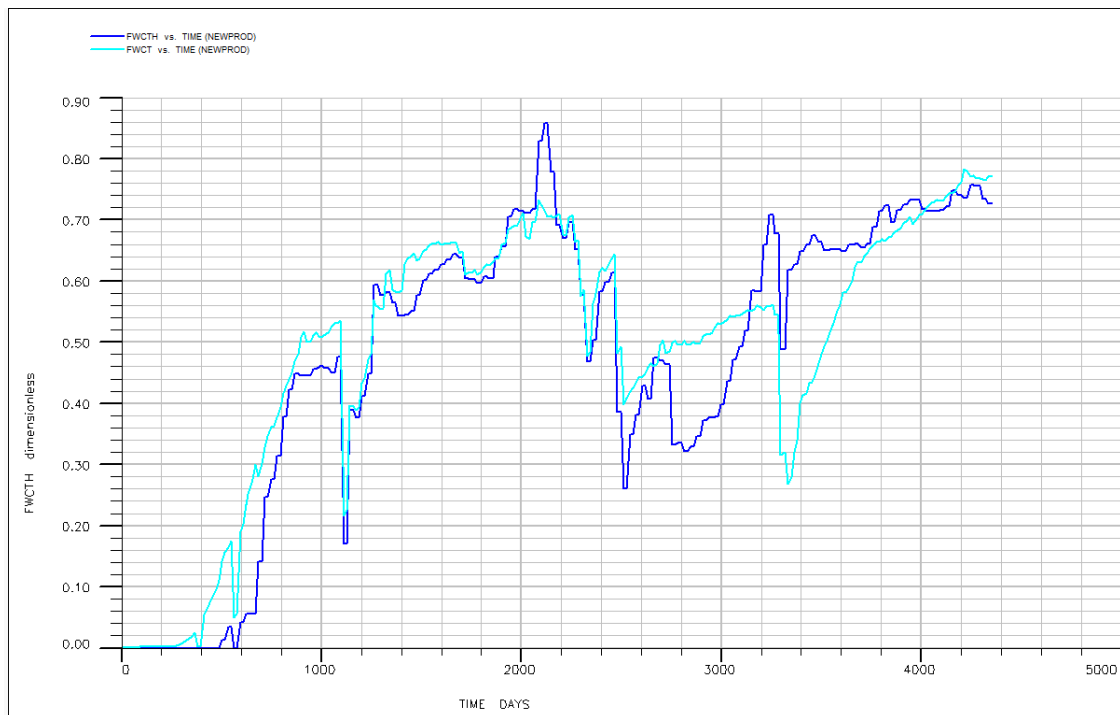
Figure 36: Field WaterCut (FWCT)

6.3 Production well performance

Similar graphic representations are available for all the producing wells that operate into the particular given sector of the reservoir. Bellow the graphs are to be presented for every producing well.

All wells are evaluated according to the error between the predicted and recorded actual production, in terms of Oil production Rate, Total Oil production, Water production Rate and Watercut.

P-A1H

The first well to be presented is the P-A1H production well. As it can be seen from the charts to follow, well P-A1H has a maximum oil production rate of 4200 SM^3 per day, recorded at day 400. From there on, the production is showing a downfall with a few abrupt production peaks located between day 1200 and 1400. The abrupt stop at the production at the day 2050 is due to a well shutdown, caused probably by a work-over operation.
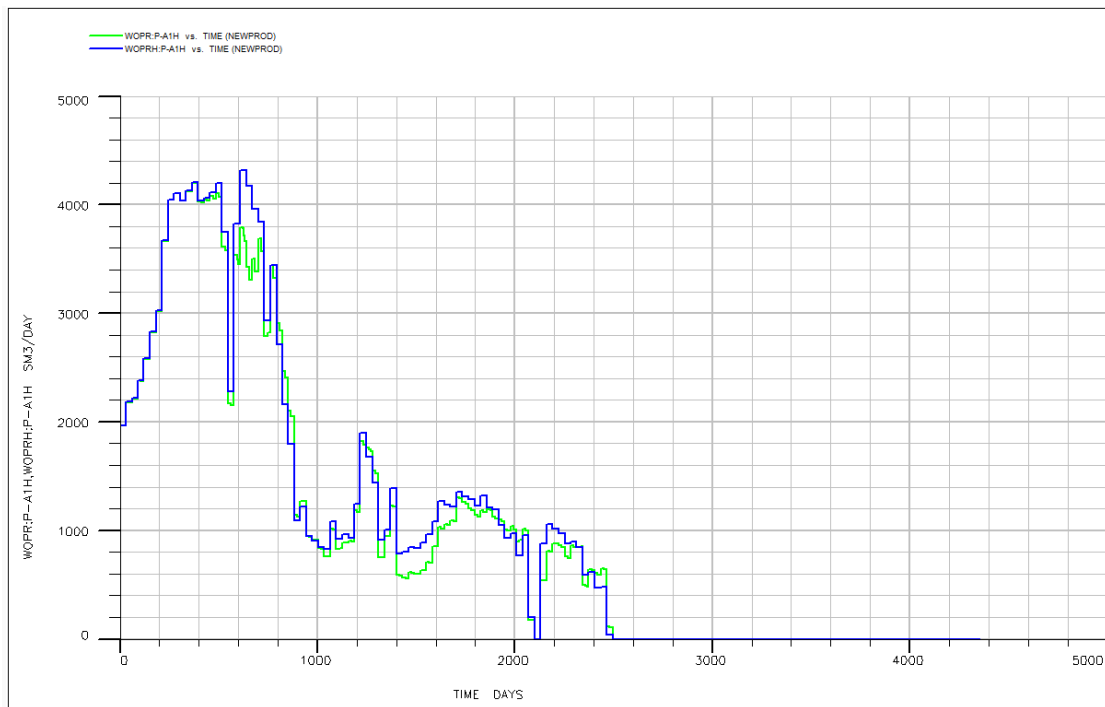
Figure 37: P-A1H Oil Production Rate (WOPR). (Recorded history values are exhibited with blue and estimated performance values with green.)

The well remains productive until day 2500. By the end of its producing life, that particular well, has produced 4,000,000 SM^3 of oil. It is more than clear, that the reasons that led to the shutting of that particular well are the high amount of watercut that was recorded close to the late days of the wells life. At that time the watercut level had reached the value of "0.95" which stand for a water production rate of 3500 SM^3/day.

Bellow the figures corresponding to the wells description may be seen.
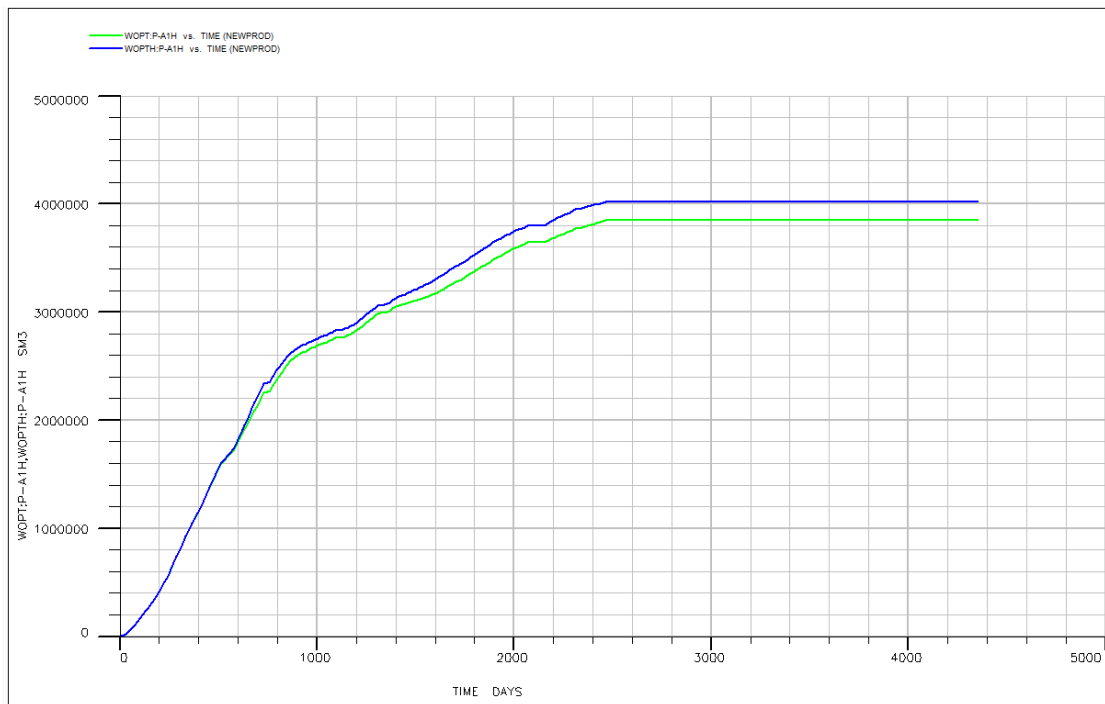
Figure 38: P-A1H Oil Production Total (WOPT). (Recorded history values are exhibited with blue, and estimated performance values with green.)
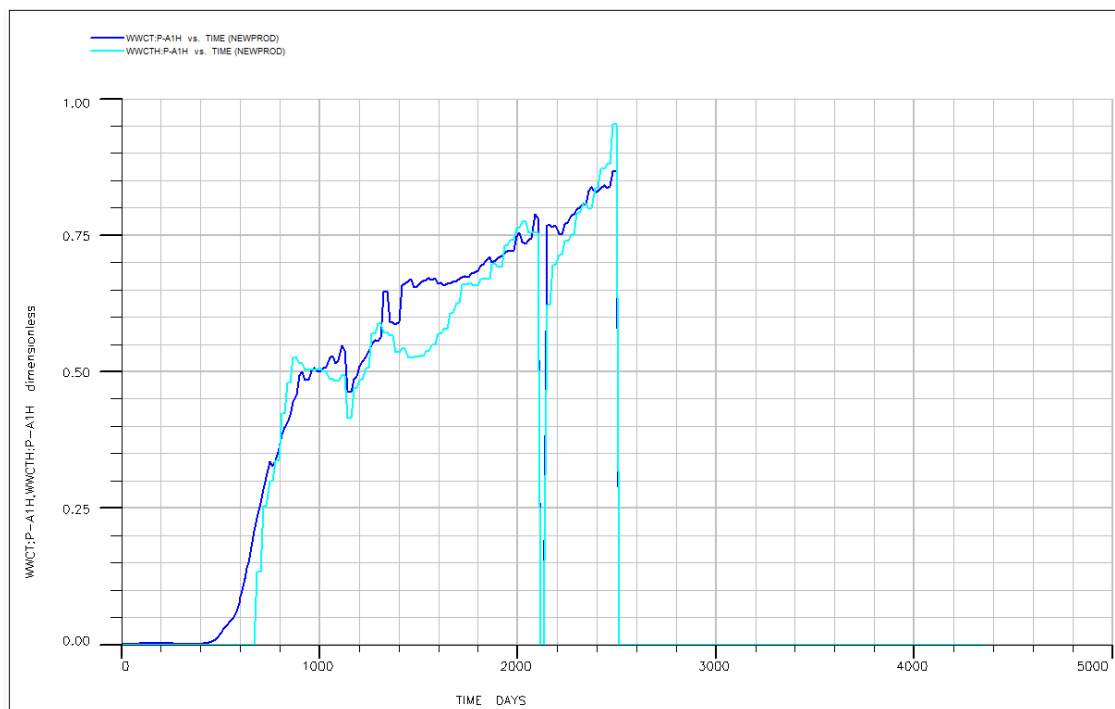
Figure 39: P-A1H Water cut (WWCT). (Recorded history values are exhibited with light blue, and estimated performance values with dark blue.)
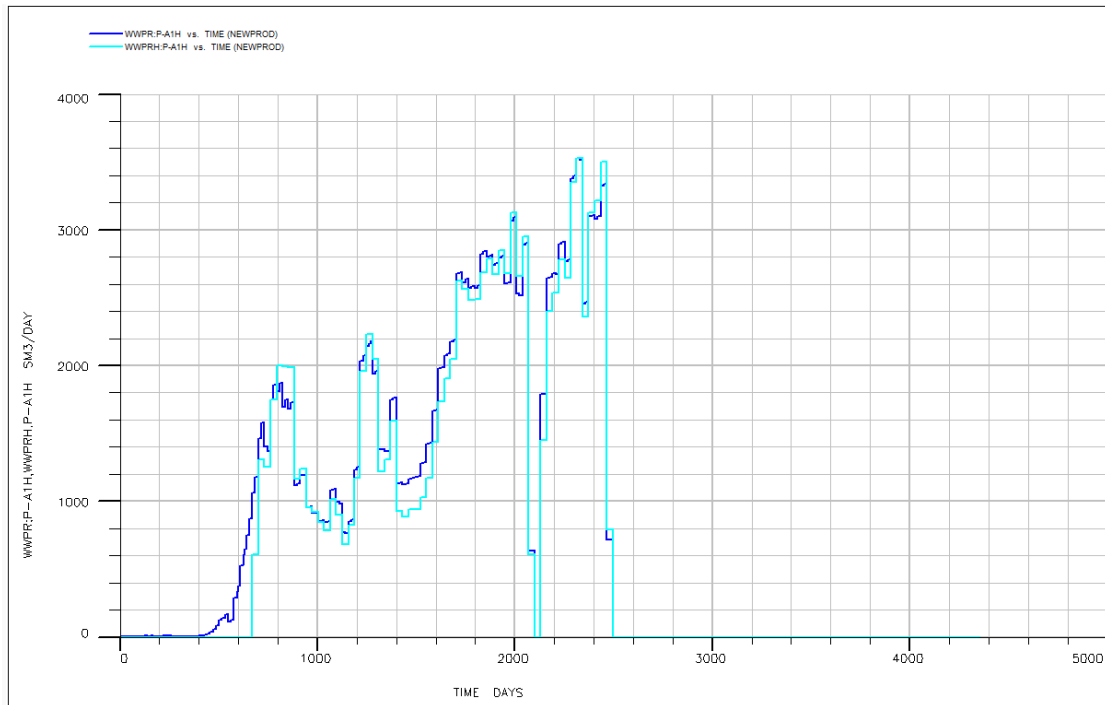
Figure 40: P-A1H Water production Rate (WWPR). (Recorded history values are exhibited with light blue, and estimated performance values with dark blue.)

P-A2AH

The next well to be presented, is the P-A2AH. This well operates until day 2200 and it exhibits a maximum oil production rate of almost 2600 SM^3/day, recorded at day 450. By the end of its producing life, well P-A2AH has produced almost 1,800,000 SM^3 of oil.

It is more than obvious that the well was shut down , due to the high level of watercut, where in some cases, it has reached the value of 100% water production. The maximum rate of water production is close to the value of 2700 SM^3/day, recorded at the days prior to its shutdown.
By looking at the charts to follow, it can be seen that there were at least two shutdowns during the wells life, which may correspond to work-overs in an attempt to optimize the wells productivity.

Bellow the charts for the well P-A2AH are presented.
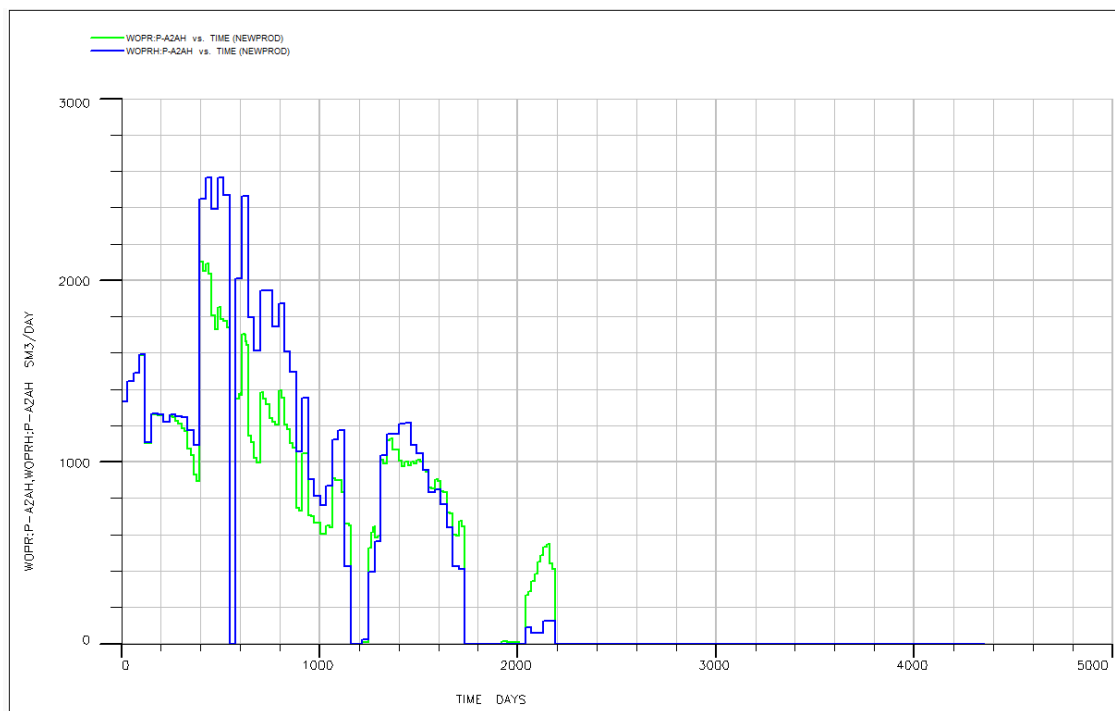
Figure 41: P-A2AH WOPR. (Recorded history values are exhibited with blue and estimated performance values with green.
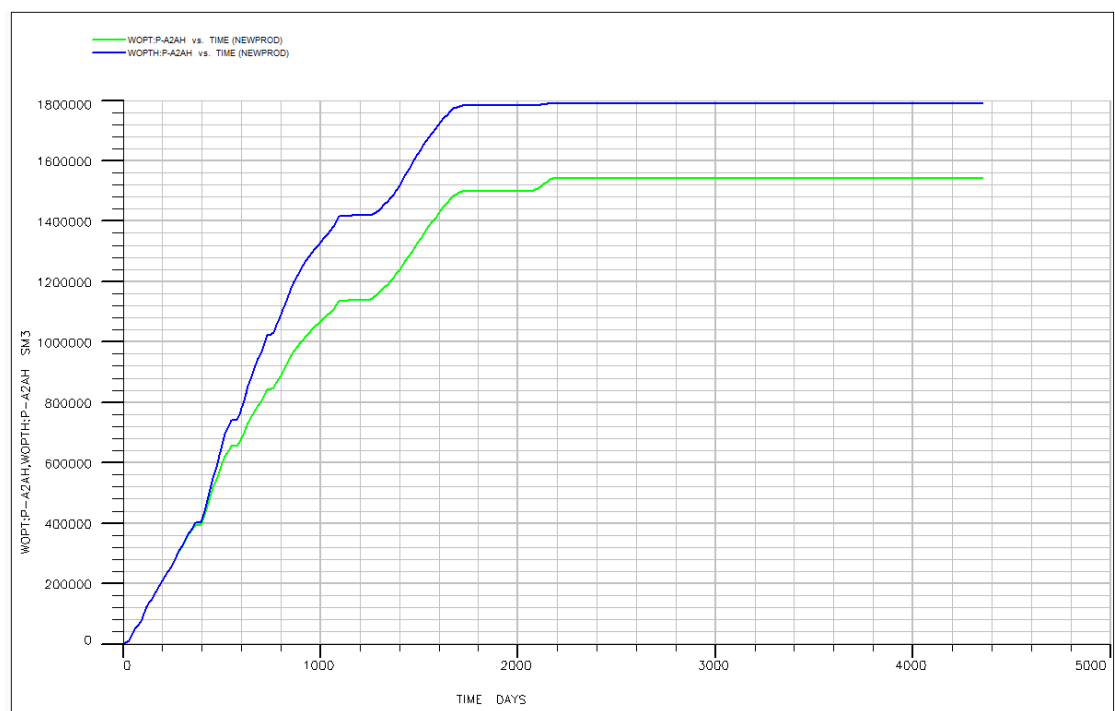
Figure 42: P-A2AH WOPT. (Recorded history values are exhibited with blue and estimated performance values with green.)
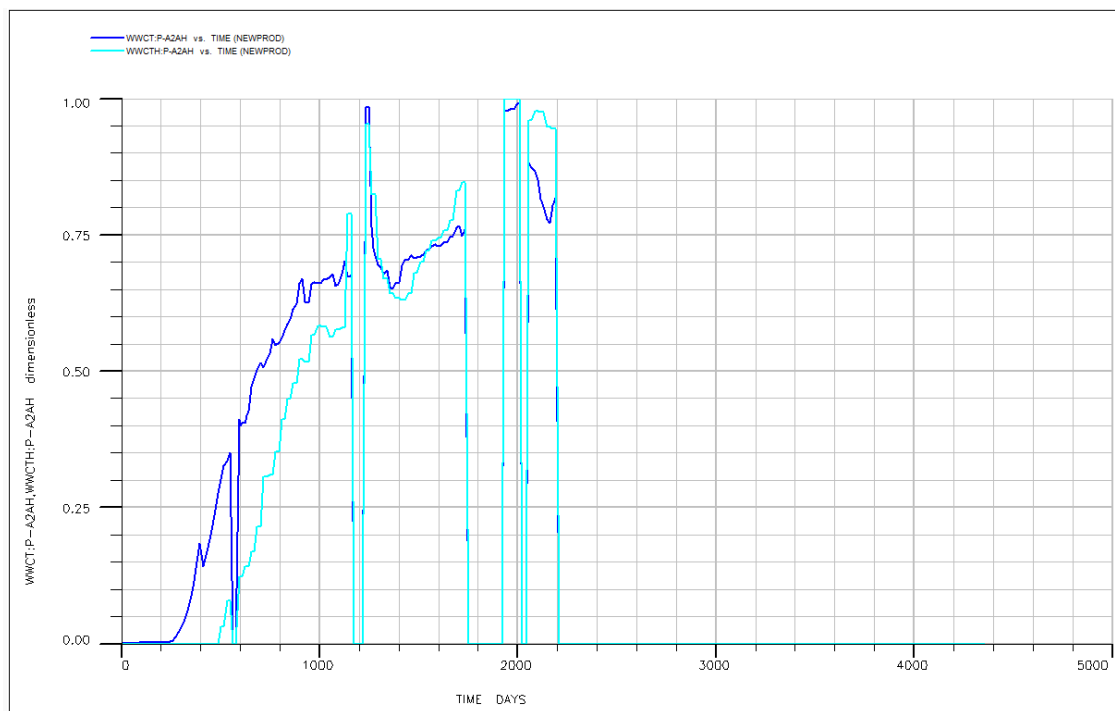
Figure 43: P-A2AH WWCT. (Recorded history values are exhibited with light blue, and estimated performance values with dark blue.)
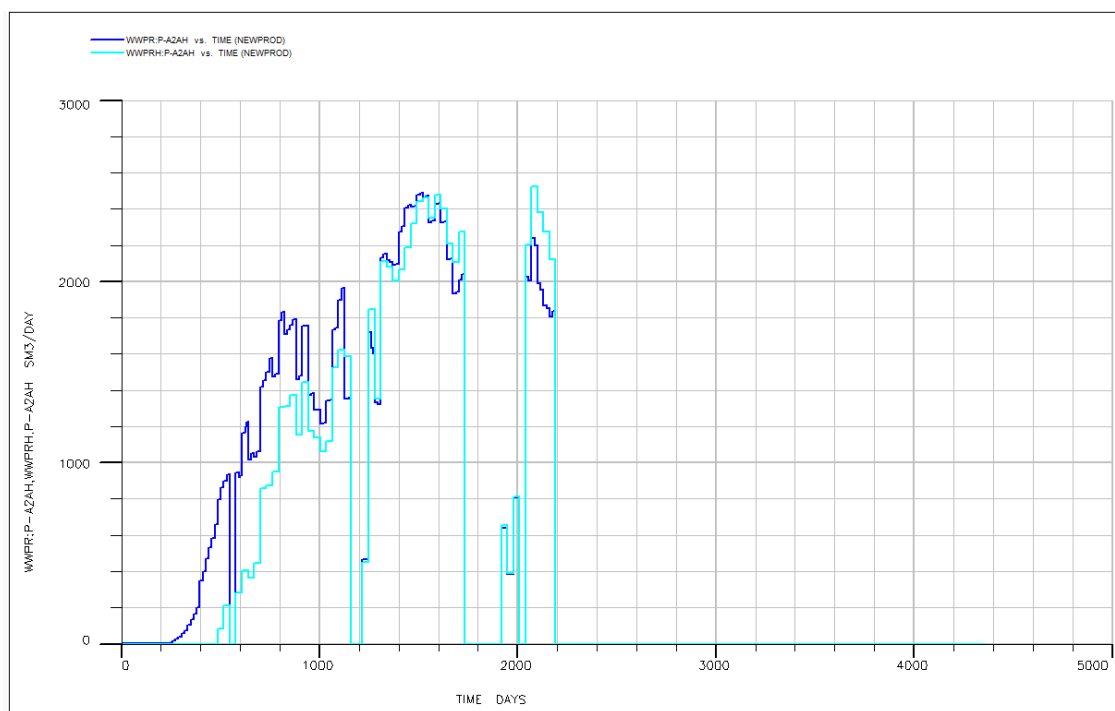
Figure 44: P-A2AH WWPR. (Recorded history values are exhibited with light blue, and estimated performance values with dark blue.)

P-A17

Well P-A17 has operated in the field for about 2600 days. Beginning its production at day 620 and lasting for about until the day 3230, well P-A17 has exhibited a maximum oil production rate of 1060 SM^3/day at the beginning of its production. The production rate then follows an almost smooth decline until the value of 240 SM^3/day where it seizes to produce.
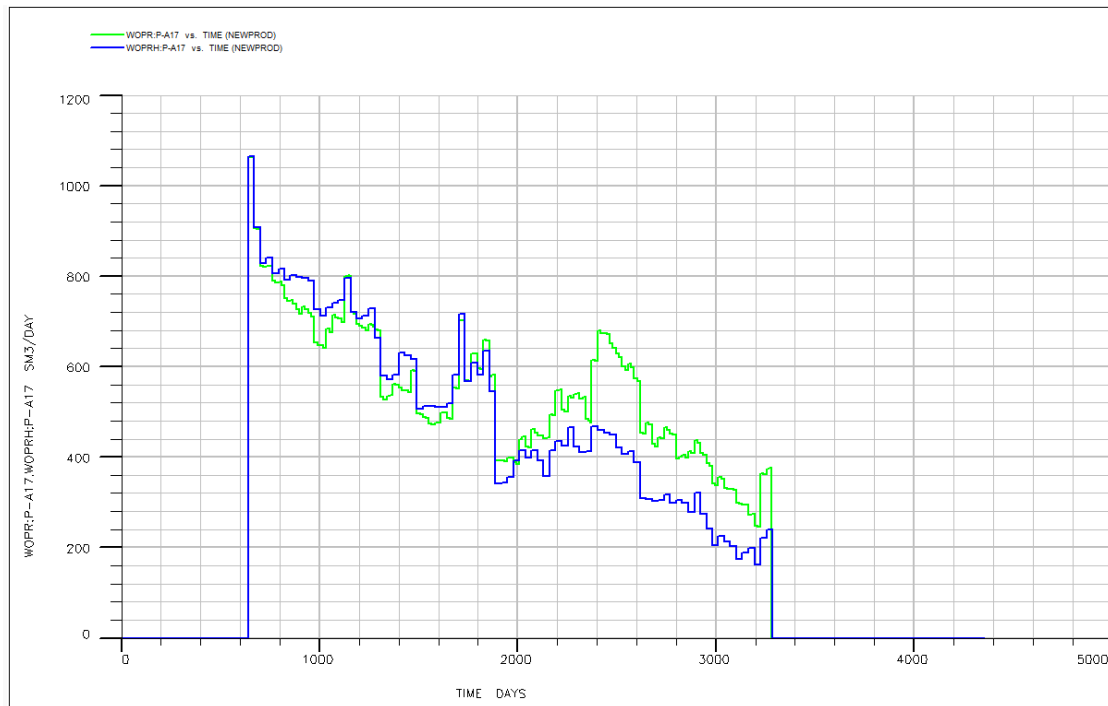
Figure 45: P-A17 WOPR. (Recorded history values are exhibited with blue and estimated performance values with green.)

The wells total cumulative oil production until the end of its life reaches the amount of 1,180,000 SM^3. In this particular well, the productive procedure seems to be quite smooth. The watercut level starts from the level of zero, and it escalates in a smooth increasing form, without any abrupt sudden changes, until the value of "0.76" at the end of its producing life. The respective water production rate has peaked at the end of the production life as well, exhibiting a value of 780 SM^3/day.
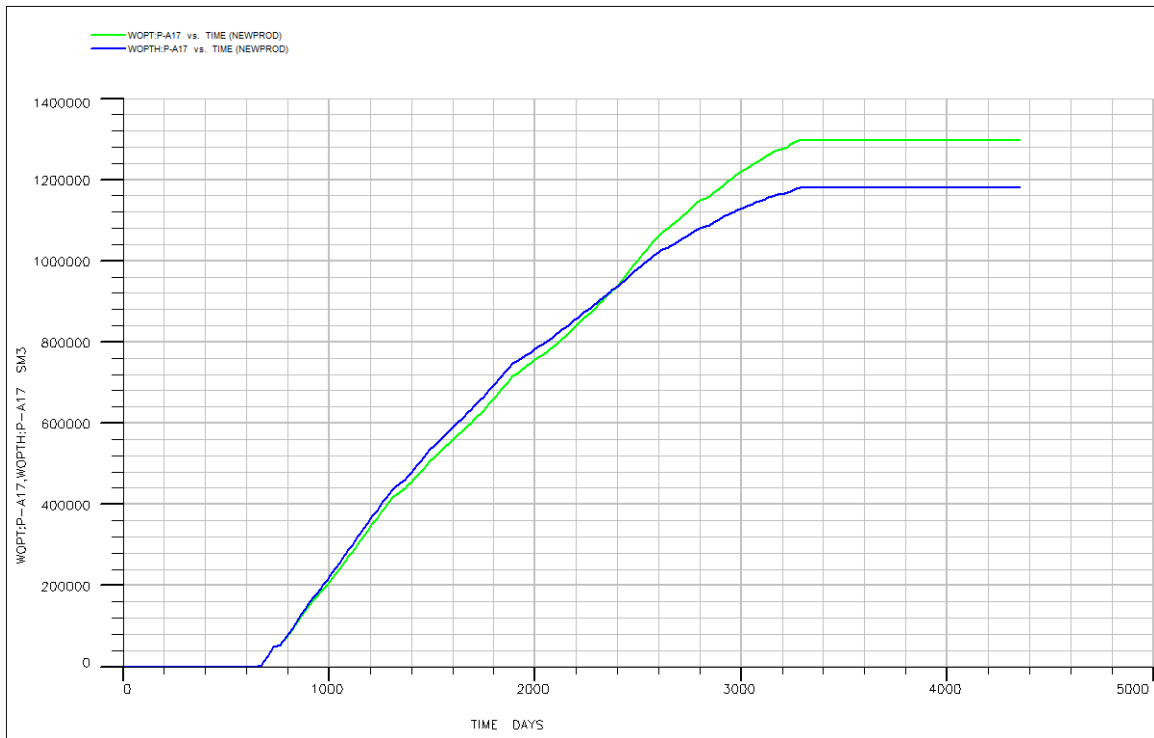
Figure 46: P-A17 WOPT. (Recorded history values are exhibited with blue and estimated performance values with green.)
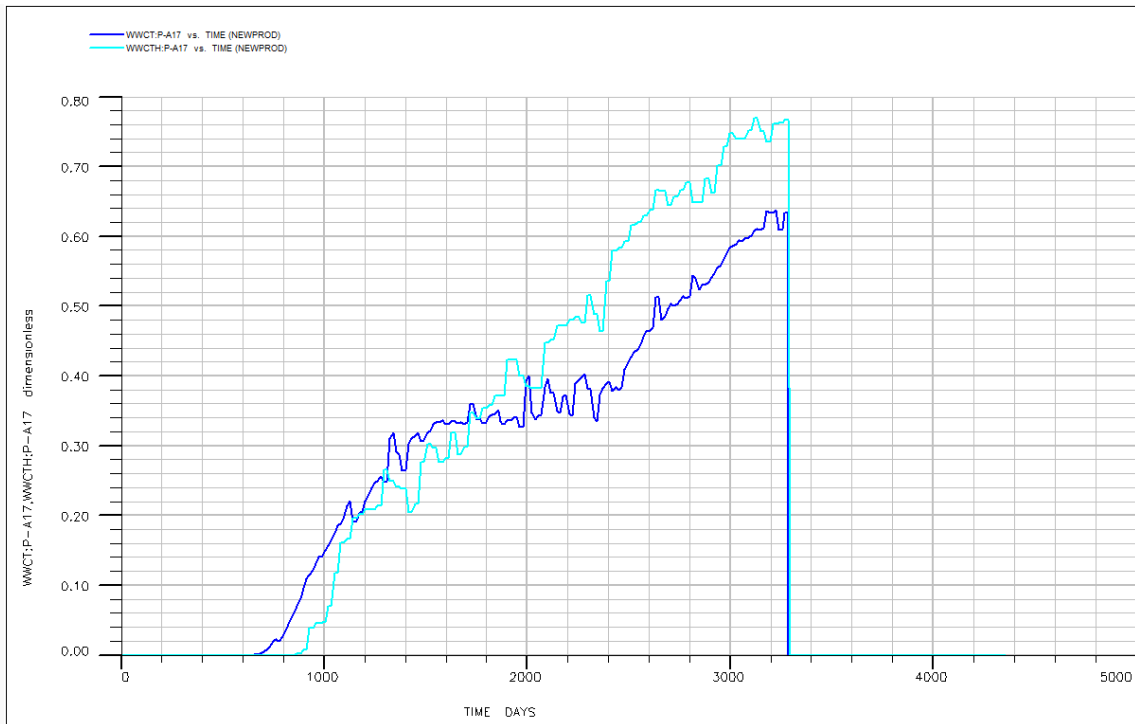
Figure 47: P-A17 WWCT. (Recorded history values are exhibited with light blue, and estimated performance values with dark blue.)
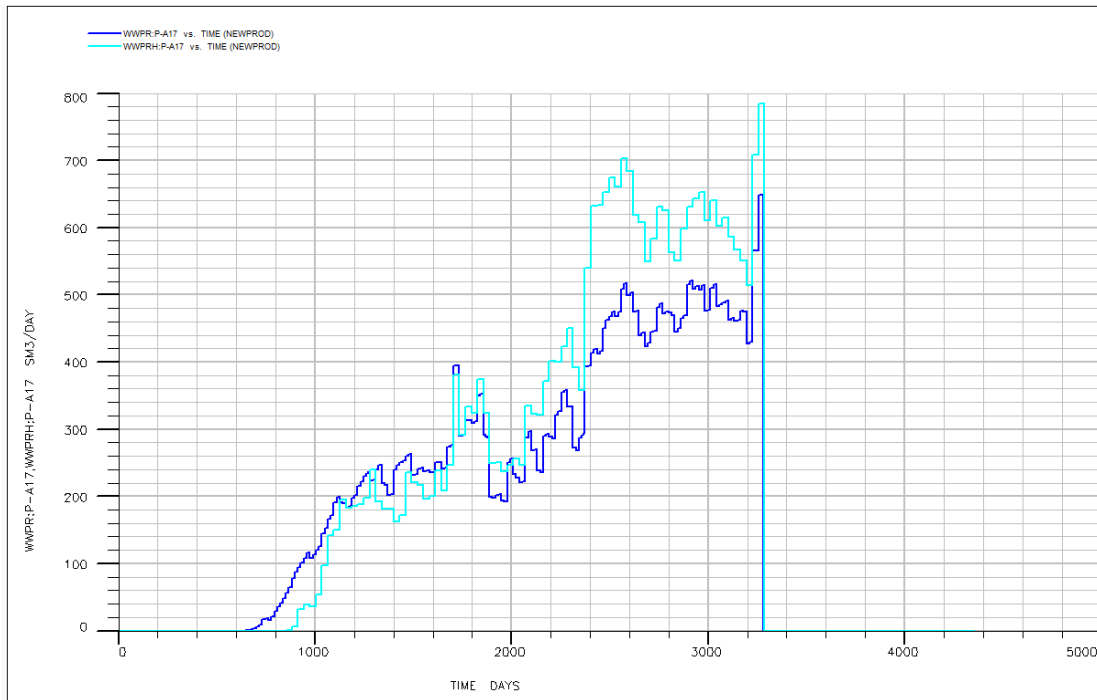
Figure 48: P-A17 WWPR. (Recorded history values are exhibited with light blue, and estimated performance values with dark blue.)

P-A35

One of the last two wells to be presented is well P-A35, to exhibited bellow.
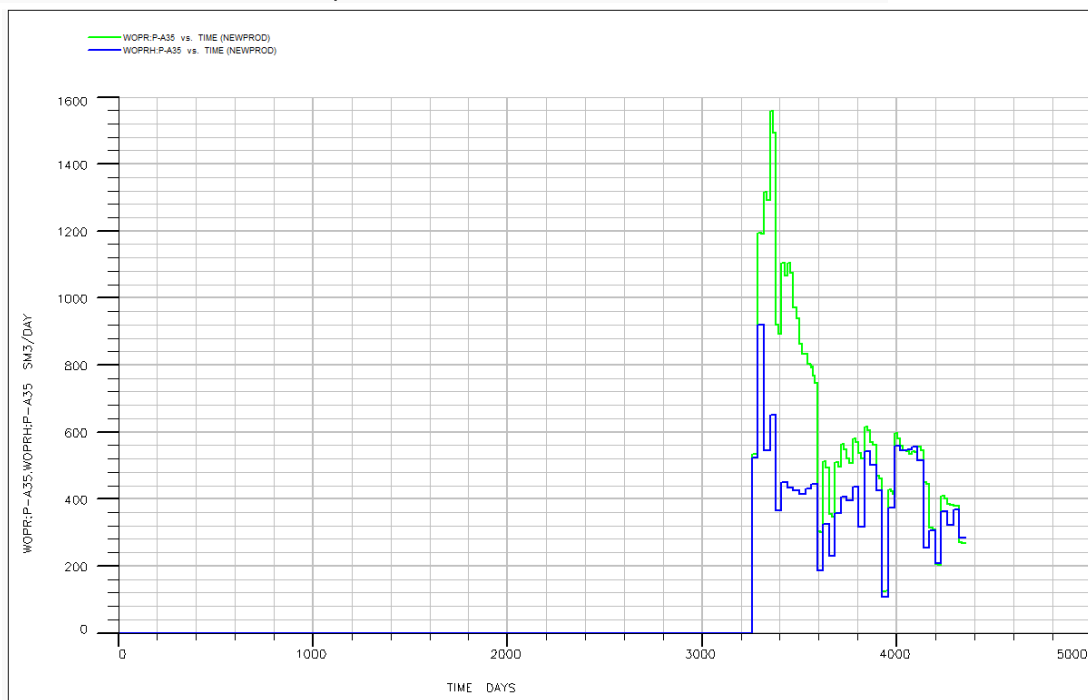
Figure 49: P-A35 WOPR. (Recorded history values are exhibited with blue and estimated performance values with green.)

This particular well, exhibits severe disagreements between the production data and the estimated behavior from the simulator, in almost all sizes to be reported.
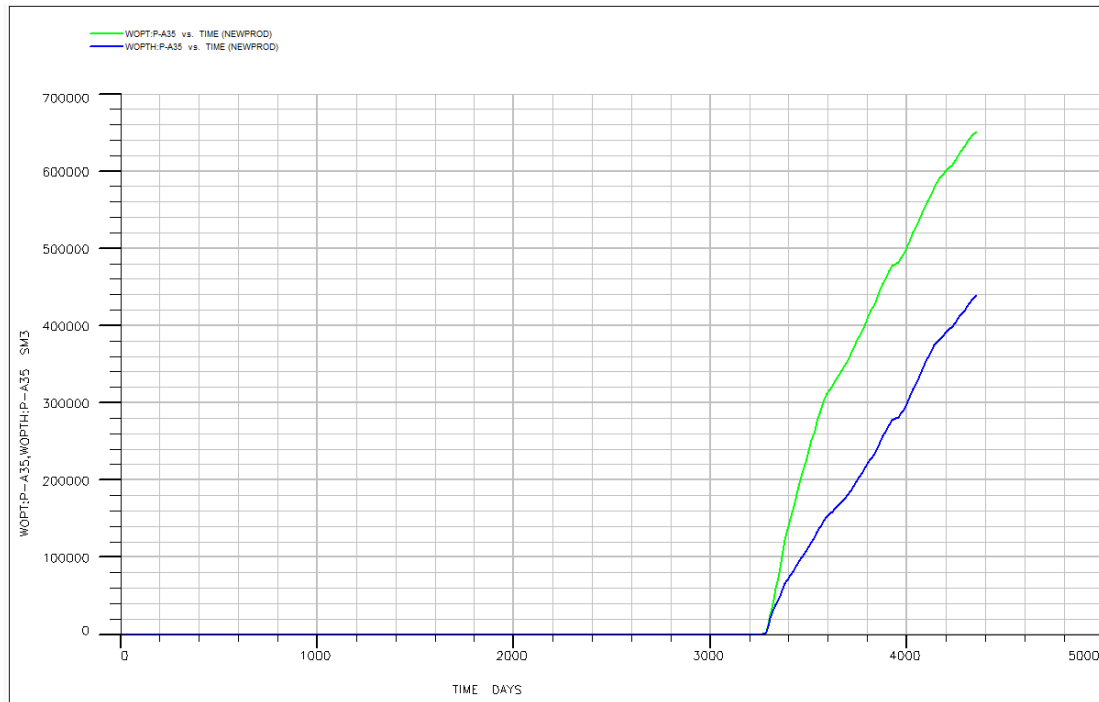
Figure 50: P-A35 WOPT. (Recorded history values are exhibited with blue and estimated performance values with green.)

The well starts operating at the later life of the field, at day 3220 and maintains its function until the end of the recorded history. In fact it is the only well to be still functioning, at the last day of the production records and is assumed to have continued producing even beyond that date.
The well P-A35 has exhibited a maximum oil production rate of 920 SM^3/day at the beginning of its life. The respective total cumulative oil production quantity is 440,000 SM^3 until the end of the recording period.

Well P-A35 has an intense watercut history as well. It starts producing with a watercut to have abruptly climbed to a value of almost "0,70" at the early days of its life and reaches the maximum watercut value of "0,86" at almost towards the end of the recordings. The water production rate for the same period is the maximum of the wells history at the level of 1650 SM^3/day.
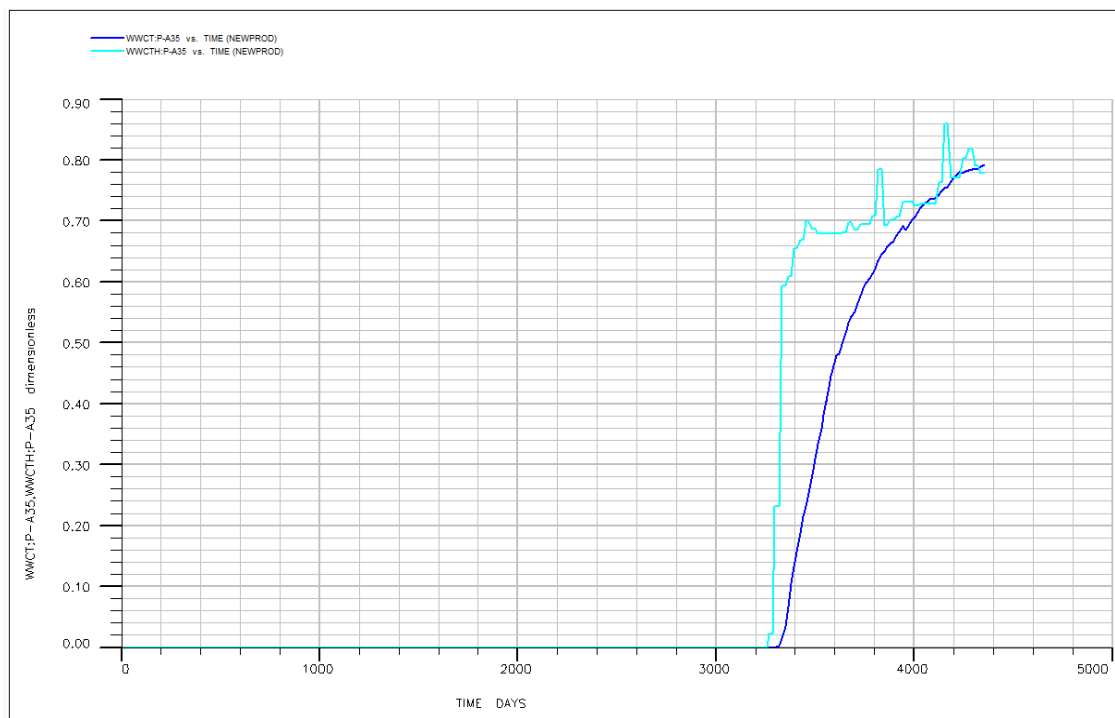
Figure 51: P-A35 WWCT. (Recorded history values are exhibited with light blue, and estimated performance values with dark blue.)
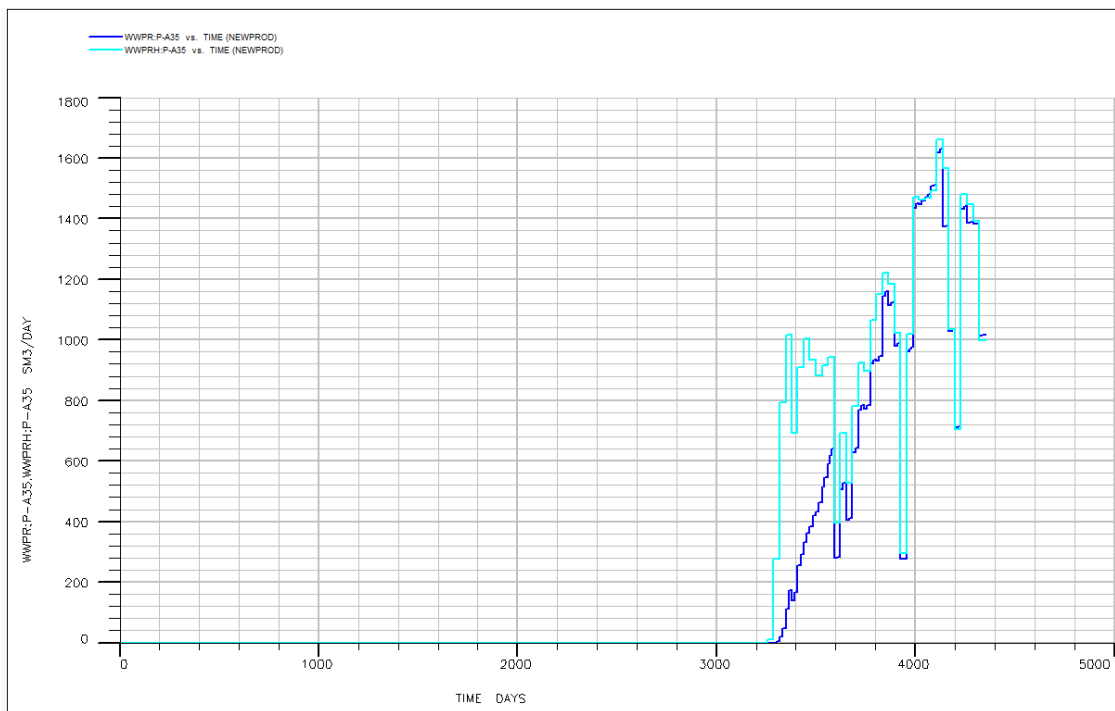
Figure 52: P-A35 WWPR. (Recorded history values are exhibited with light blue, and estimated performance values with dark blue.)

P-A39A

The last well of the field, is well P-A39A. This well has started its operating life, shortly after day 2200, and has been shut down shortly before the end of the recording dates for the entire field.
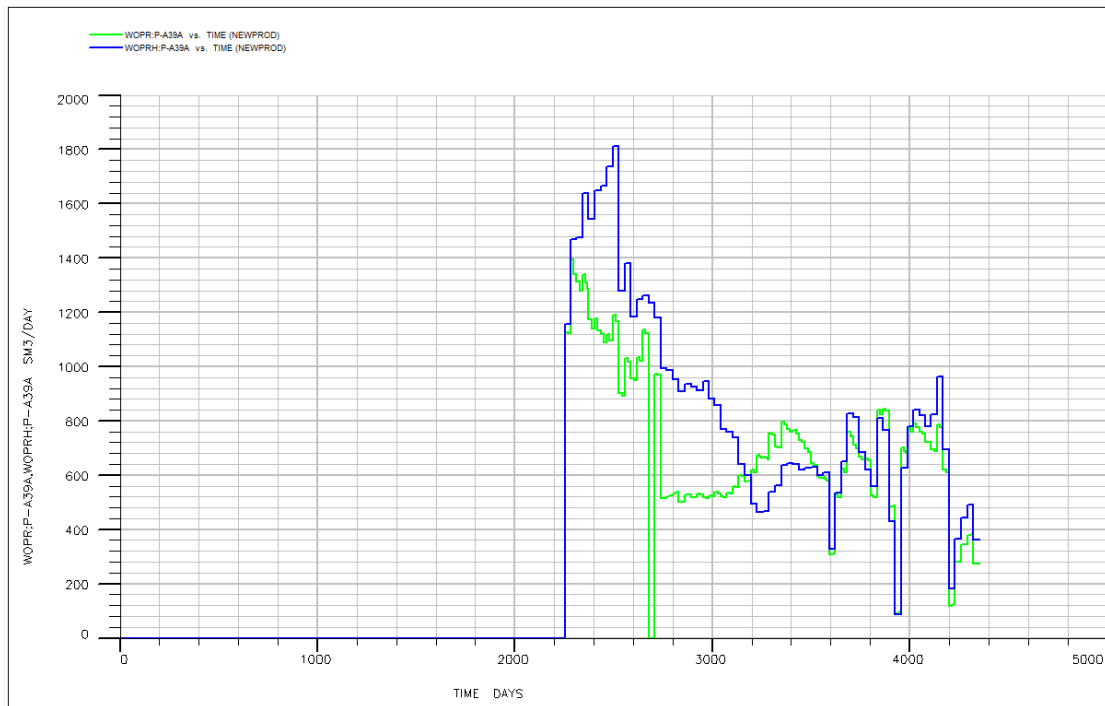
Figure 53: P-A39A WOPR. (Recorded history values are exhibited with blue and estimated performance values with green.)

As It can be told by the relative figures, the wells maximum oil production rate is of the order of 1800 SM^3/day, recorded at day 2500. The total cumulative production oil at the end of its life has a value of 1,680,000 SM^3. The maximum watercut for this well is at the level of "0.74". The respective maximum water production rate, is of the order of 2000 SM^3/day.

Figure 54: P-A39A WOPT. (Recorded history values are exhibited with blue and estimated performance values with green.)

Figure 55: P-A39A WWCT. (Recorded history values are exhibited with light blue, and estimated performance values with dark blue.)
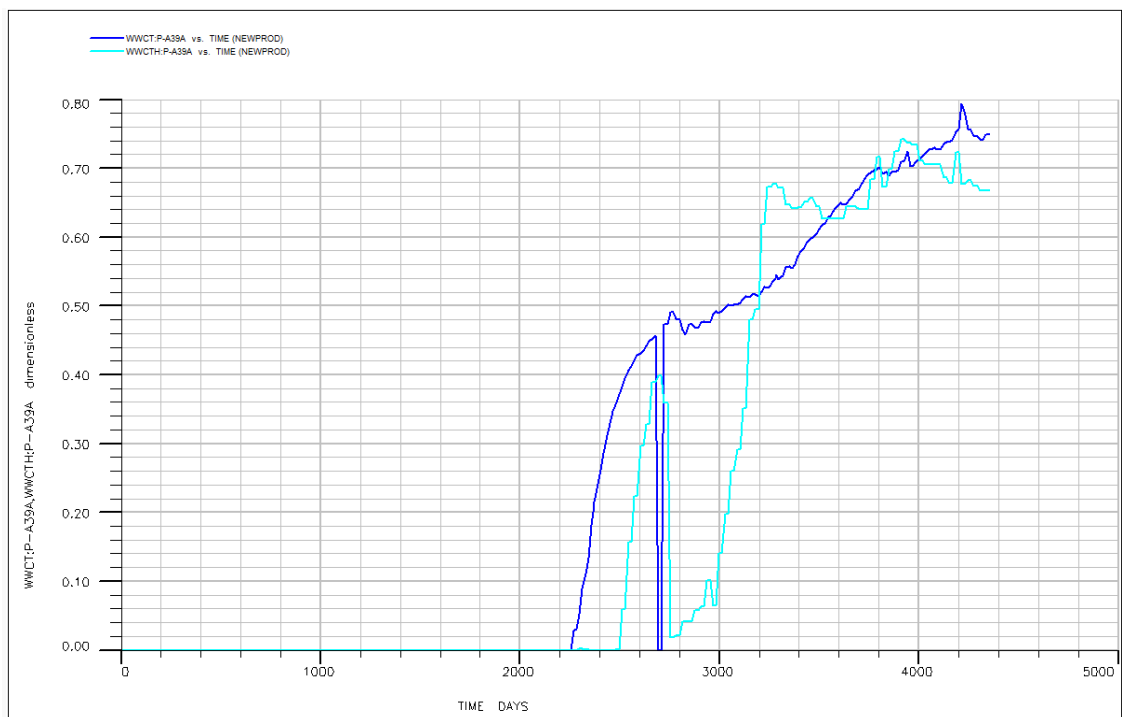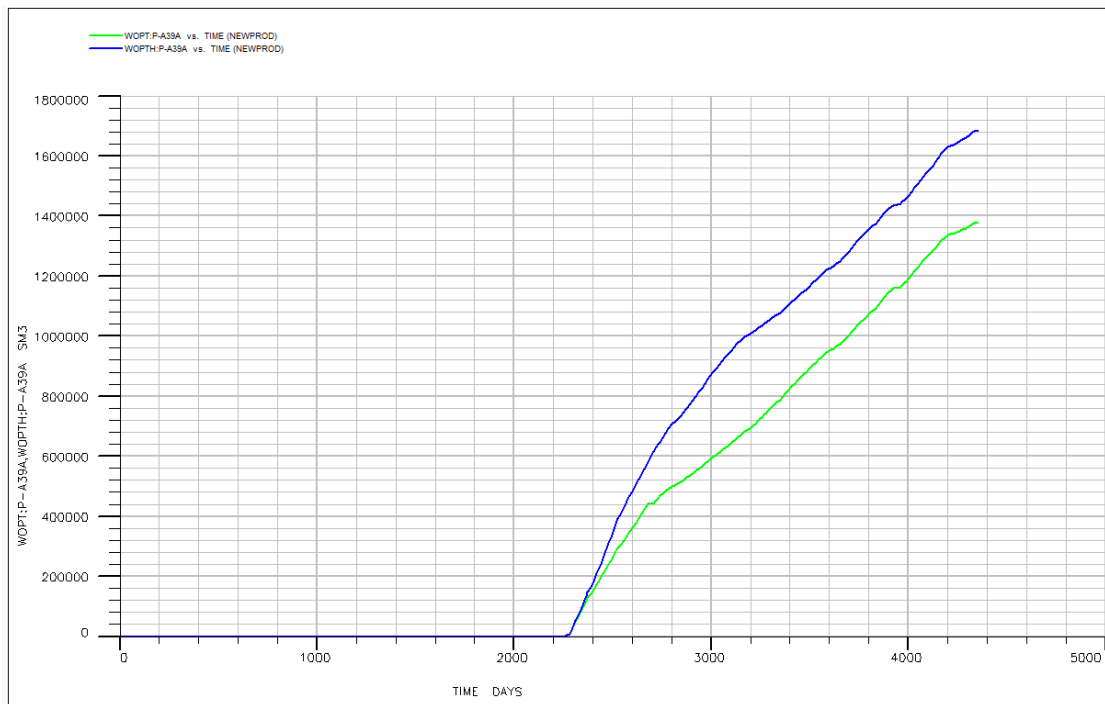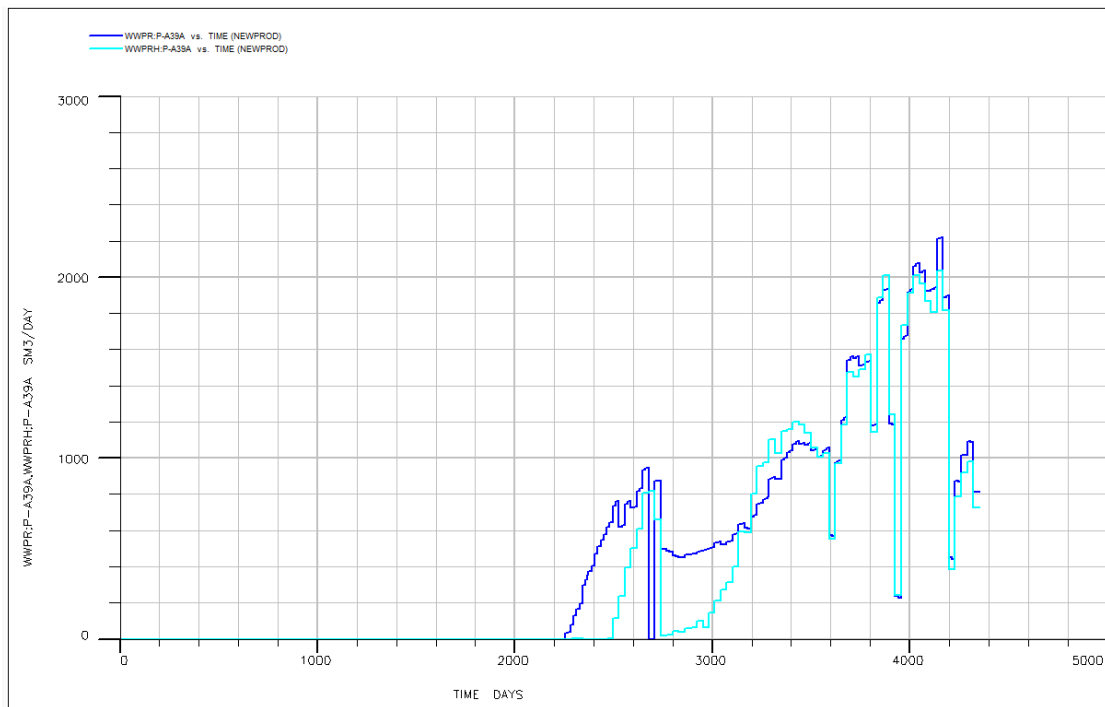
Figure 56: P-A39A WWPR. (Recorded history values are exhibited with light blue, and estimated performance values with dark blue.)

6.4 Matching the parameters

In order for the observed performance of the reservoir to match the one that has been predicted by the simulator, a History Match procedure has to be performed. As it has already been mentioned, the goal of this project is to initially create two models that have been matched under different history records available, as it has been described at the introduction of this chapter.

For the simulated reservoir performance to be matched with the observed one, the reservoir characteristics must be changed in such a way, in order for the simulation outcome to agree with the recorded reservoir performance. As described in a previous chapter, there are quite many options of reservoir characteristics to be changed. However, in this thesis project, for simplicity reasons, the main size to be altered is the transmissibility to specific locations of the reservoir. The modification of the values, has been accomplished through the application of the "**MULT**" command in the eclipse syntax. The selection of the area in which the transmissibility will be altered, has been performed by the use of the "**BOX**" command in the eclipse syntax as well.

The "BOX" command

The "BOX" command allows the selection of a specific group of blocks of the reservoir grid to be selected. The selection is made by declaring the coordinates of the corner blocks that surround the desired sector of the reservoir grid, in which a specific action will take place. The command must end with an "ENDBOX" at the end of the coordinate declaration.

The "MULT" command

The "MULT" command is the transmissibility multiplier. When applied, it multiplies the transmissibilities of the grid blocks selected, by a "BOX" command as described above, by a value that it is specified in the command section. The direction of the flow, for which the transmissibility value will be altered, can be selected. The "MULT" commands can be entered in the form of 6 different formats, thus selecting six different directions respectively. These formats are the following : "MULTX", "MULTX-", "MULTY", "MULTY-" , "MULTZ", "MULTZ-". Each one of the following command formats declares that the direction of the transmissibility to be altered follows the direction towards the positive X axis, the negative X axis, the positive Y axis, the negative Y axis, the positive Z axis and the negative Z axis, respectively.

In the following, the areas selected during the several matching attempts, are to be presented, as well as the modification that has been applied to that area. In a subchapter to follow, the error estimation for each attempt will be analyzed.

Matching evaluation (error calculation)

For evaluating the overall error for each of the matching attempts, an error calculation method will be introduced. The error calculation is based on an infinite norm application and it estimates an error value based on the maximum distance between the observed behavior line and the estimated behavior by the simulator line on the same chart. The error is calculated for every

measured size (WOPT, WOPR, WWCT and WWPR) and for every production well. The overall error value for the entire history matched model is based upon creating a weighted average error value by modifying each sizes error value with an appropriate weighting factor. The definition of each wells weight factor is based on the relative duration of the wells' life, compared to the total duration of the fields' performance.

Error Formulation

The formulation of the error estimation procedure that has been described above, is to explained in the following.

For every matched model an average error index "E" is calculated. Error index "E" is calculated as explained bellow.

For every well and for each of the four measured sizes, WOPT, WOPR, WWCT and WWPR, the maximum error value between the estimated and the observed performance is measured. The error is taken as the maximum distance, thus an arithmetical error, between the observed and the simulated behavior lines on the sizes' chart. The maximum error is then taken as $|x_i|$ for the specific size and for the specific well. The measured error is then normalized by dividing it to the maximum value of the observed value in the same chart. The normalization creates then a dimensionless relative error value X_i of the size in discussion for the well in discussion. The error calculation for every size is then based on the creation of a weighted mean average. The dimensionless error calculated above is used to calculate the weighted error index "e" of the size in discussion, for the entire matched model. The weight factor w_i for each well is nothing but the ratio of the days the well has been active in the models' schedule, divided by the total duration of the model itself in days. Once the "e" error value has been calculated, the entire models' average error "E" can be estimated. Error "E" is the average mean of the "e" errors of the four well related sizes in the model.

The Field related sizes are not taken into account in the error calculation, since they are derived as the summation of the well related sizes in each simulation model.

The error formulation described above, is presented in mathematical terms bellow.

$$E = \frac{\sum_{i=1}^{D} e_i}{D}$$

where:

$D = number \ of \ sizes \ in \ the \ model$

$$e = \frac{\sum_{i=1}^{F}(X_i * w_i)}{\sum_{i=1}^{F} w_i}$$

where :

$$w_i = \frac{\Delta t_i^w}{\Delta T_{total}}$$

And

$$X_i = \frac{|x_i|}{y_i^{max}} \text{ (normalized)}$$

And

$$F = number \ of \ production \ wells$$

6.5 Full 4300-days History matching

For the 4300 day model, many history matching attempts were performed. Among them, 3 were the most representative.

On each attempt, the objective of the creation of the BOXES was to manipulate the flow of the hydrocarbons and/or the water, in such a way that the simulated lines will have the tendency to match the observed production.

The transmissibility modification can be translated in many ways. An increase in the transmissibility could have a meaning of an increase absolute permeability, which can bare the meaning of increased difference in the relative permeabilities of the fluids of the reservoir.

Bellow, the evaluation of the matched models will be presented. The selection of the best model will be based on the least error index

6.5.1 Full 4300-day History matched model error

For the above described matched models, an error calculation has taken place in order for the models to be able to be compared to one another. The calculations are to be presented in the following paragraphs. More over the selection of the best fitted model is to be justified.

The validity of the matched models will be assessed by taking into consideration the matching of the total field cumulative oil production and by the error index, as described above.

6.5.1.1 Attempt 1

The first matching attempts' Cumulative Field Oil Production chart Vs the respectful observed one, can be seen bellow.
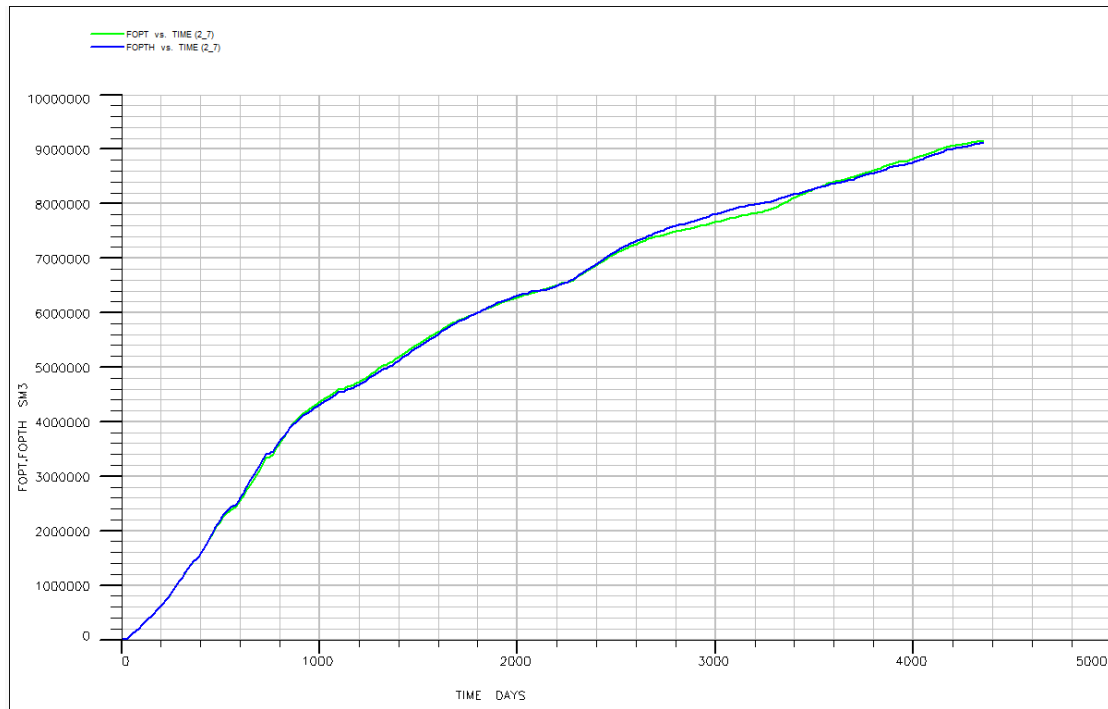
Figure 57: '4300 model' Field Oil Production Total (FOPT) (Recorded history values are exhibited with blue and estimated performance values with green.)

The error estimation for this model, using the formulation as described above, is as follows:

$$e_i^{WOPT} = 0.105$$
$$e_i^{WOPR} = 0.2203$$
$$e_i^{WWPR} = 0.243$$
$$e_i^{WWCT} = 0.257$$

Thus the overall error index is: $E = 0.2063$

6.5.1.2 Attempt 2

In the second attempt, more BOXES were added, both as general reservoir property modifications but also as near wellbore rock property modification multipliers. The result can be seen bellow.
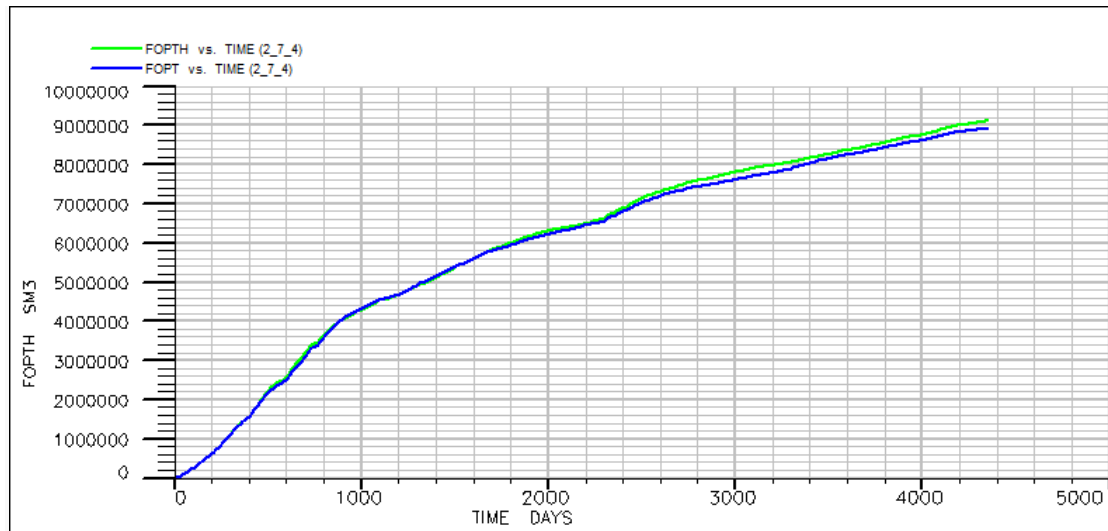
Figure 58: '4300 model' Field Oil Production Total (FOPT) (Recorded history values are exhibited with blue and estimated performance values with green.)

As a first look, the results seem to deviate in a higher extent than the previous attempt; however the line trends agree more despite that the final value does not agree to an 100%.
The error calculation for the model is as follows:

$$e_i^{WOPR} = 0.1316$$

$$e_i^{WOPT} = 0.062$$

$$e_i^{WWCT} = 0.183$$

$$e_i^{WWPR} = 0.179$$

Thus the overall error index is: $E = 0.1389$

It is obvious that the error is less in this model, despite the deviation of the FOPT. This is because the error index, takes into consideration the overall performance of all the wells separately and for all the measured sizes. It can therefore be assumed that this model has a more accurate depiction of the reservoir.

6.5.1.3 Attempt 3

In the final model the agreement between the observed and the predicted values is even better.
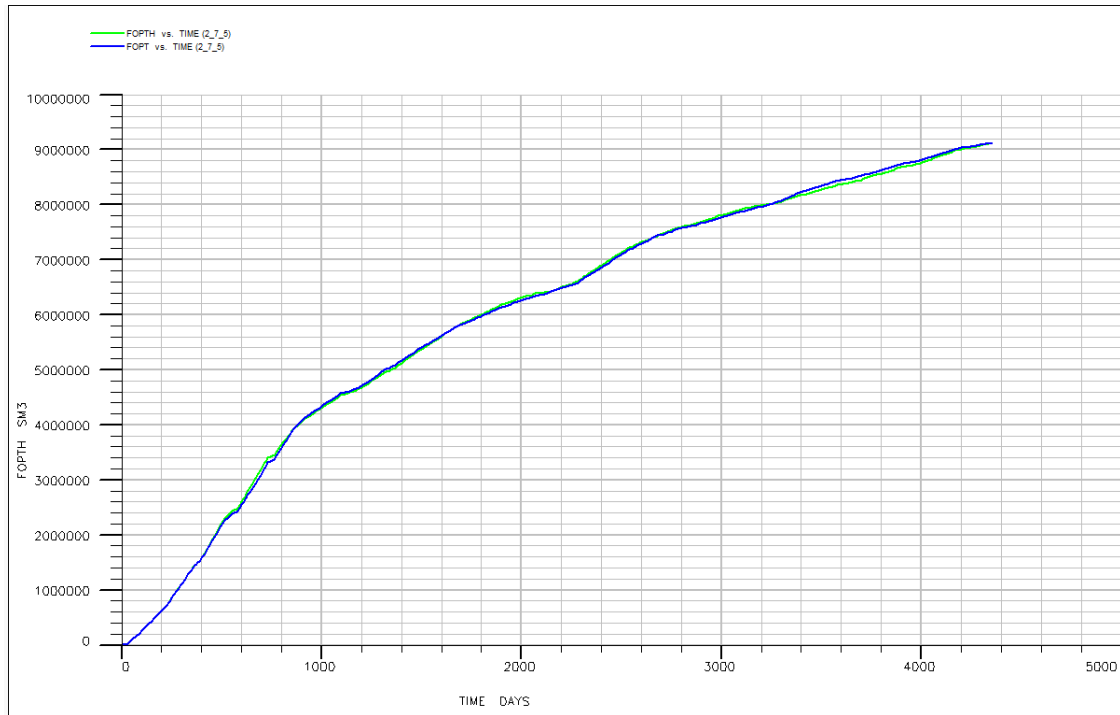
Figure 59: '4300 model' Field Oil Production Total (FOPT) (Recorded history values are exhibited with blue and estimated performance values with green.)

It is obvious that in this model, the accuracy is much better. The cumulative oil production has been successfully matched with the observed one.

The error calculation for this model is as follows:

$$e_i^{WOPR} = 0.116$$
$$e_i^{WOPT} = 0.044$$
$$e_i^{WWCT} = 0.189$$
$$e_i^{WWPR} = 0.173$$

The total error is $E = 0.1305$

The last model is the one to be selected for it has the best fitting of the behavioral trends of the reservoir.

Several attempts have followed, but sadly none of them was able to demonstrate a better fit than the previously presented model.

6.6 Half record (2300 days) history matching

For the half model (2300 days), likewise with the previous model, in order to perform the history matching technique the use of different boxes was selected. This was done in order to achieve

the alteration of the direction of flow and to get a result that is desirable. The 'trial and error' process of history matching is consisted of various attempts, each one different with the previous one. The difference of the attempts lies in boxes that were placed in different places, either obstructing or favoring the flow of the fluids, by altering accordingly the box's transmissibility multipliers. However, for the purposes of presentation, only the three most representative attempts will be presented.

6.6.1 Half record (2300 days) History match model error

The comparison of the attempts' presented hereby will be done mainly through error calculation; this will be further supported by the graph of 'Field Oil Production Total', both for the data of the new attempt and for the history data.

6.6.1.1 Attempt 1
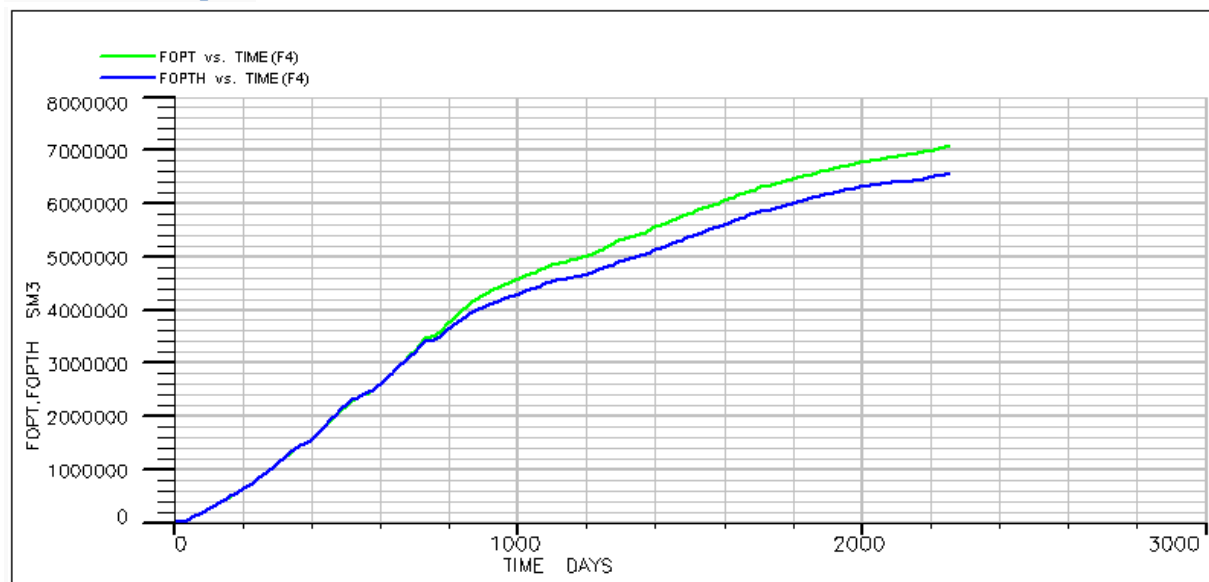
Figure 60: Attempt 1 for '2300 model' History match

The error calculation for the model is as follows:

e_i^{WOPR} = 0.221
e_i^{WOPT} =0.097
e_i^{WWCT} =0.356
e_i^{WWPR} =0.348

The total error is E = 0.256

6.6.1.2 Attempt 2
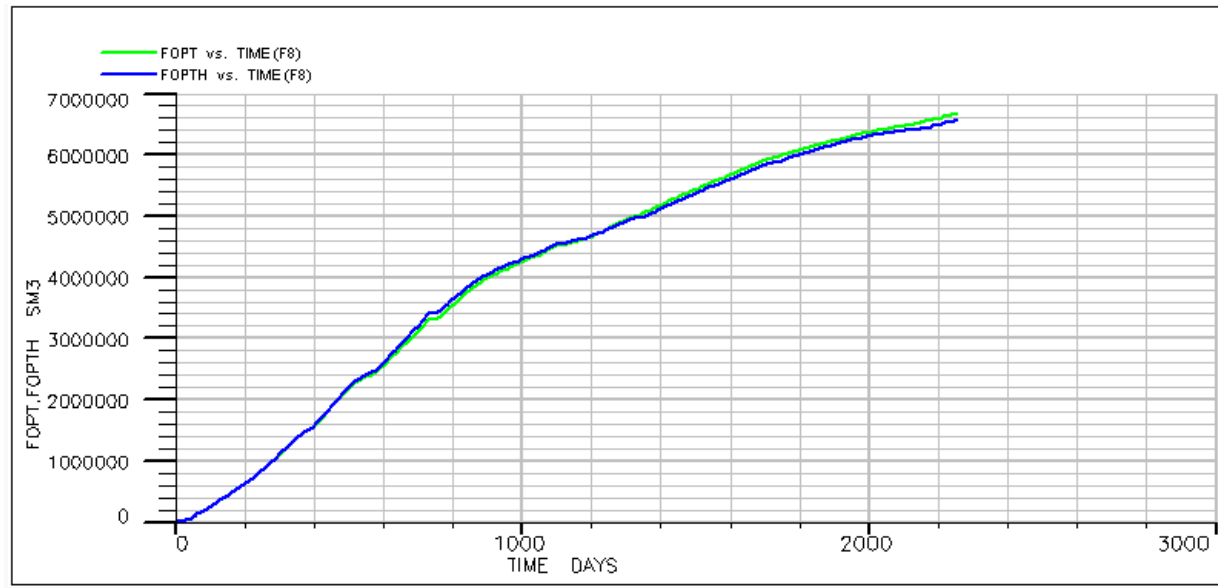
Figure 61: Attempt 2 for '2300 model' History match

For this attempt an additional box has been added compared to the previous one. It can be observed that this resulted in obtaining a different reservoir fluid flow, significantly closer to the flow of the history data.

The error calculation for the model is as follows:

$e_i^{WOPR} = 0.159$

$e_i^{WOPT} = 0.024$

$e_i^{WWCT} = 0.288$

$e_i^{WWPR} = 0.208$

The total error is E = 0.170

6.6.1.3 Attempt 3
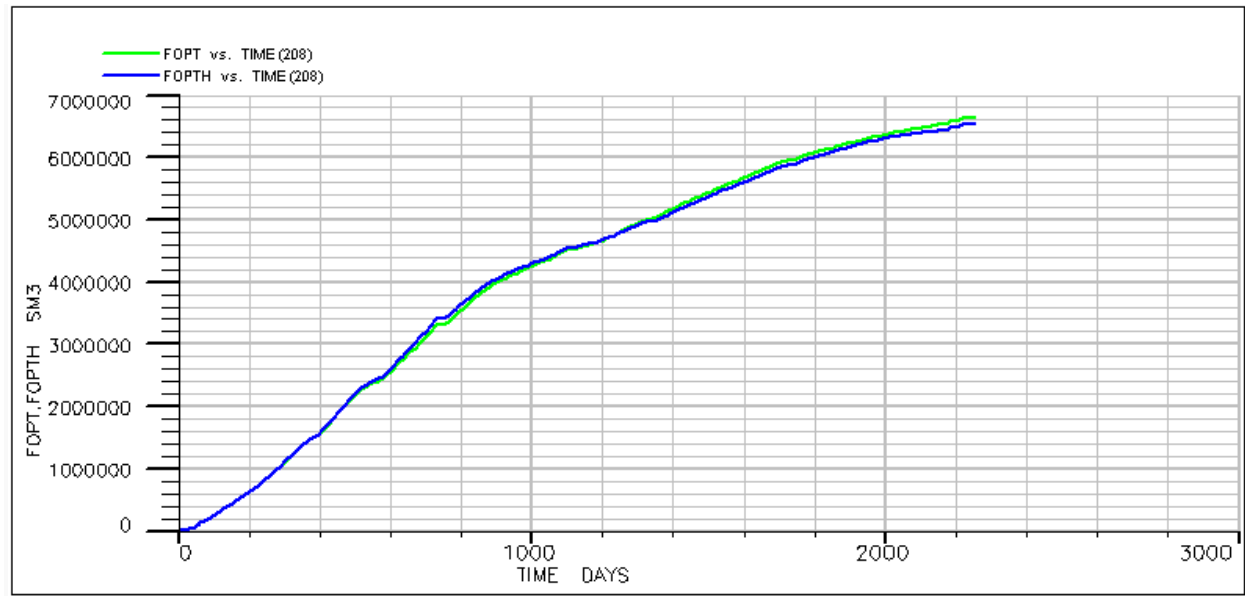
Figure 62: Attempt 3 for '2300 model' History match

For the last attempt presented hereby, the same boxes have been left in place as to the previous attempt, but with altered transmissibility multipliers.
The error calculation for the model is as follows:

$e_i^{WOPR} = 0.145$
$e_i^{WOPT} = 0.026$
$e_i^{WWCT} = 0.232$
$e_i^{WWPR} = 0.208$

The total error is E = 0.153

Solely by the graphical comparison, the two last attempts seem to be very close in terms of result accuracy compared to the line that represents the history data. However, the magnitude of the total error clarifies the situation clearly in favor of the last attempt, which was the one that produced the best results out of all the trials that were attempted.

7) Future prediction using the history matched models

7.1 Simulator controlling parameters

The eclipse simulator has several function modes for controlling the production and injection wells' behavior. In this project, liquid rate control mode has been used for the production wells, and water rate control for the injection wells.

The injection wells function at water rate control for the entire of the simulation schedule. During the recorded production periods, the rates are the ones the wells actually had in the field. During the future prediction runs, the injection rates are being defined in the schedule script by the software user.

The production wells can either be specified as History matching wells or common production wells. In both cases, the wells can function under control of the oil rates, gas rates, water rates or liquid rates. In the last case, the well is controlled by the total liquid production rates which is the summation of oil plus water production rates. If the well is characterized as History matching well, then the simulator is forced to match exactly the controlling parameter which is selected, with the actual History recorded value. In this Thesis project, all wells are History matching wells controlled by liquid production rate.

However, when extrapolating into the future, the production wells must be switched to common well mode, since history record is no longer available for these dates. In that case, the wells are still in liquid control mode, but the rate is now defined by the user. The users' suggestion of liquid rate, acts as a target to be achieved and as a maximum rate limit to not be violated. However it is not guaranteed that the rate will actually be achieved. The simulator will try to satisfy the demand as long as there are no convergence failure issues during the simulation run.

For the injection wells, the water injection control rate is declared, using the definition "RATE" in the control mode selection of the keyword "WCONINJE".
For the production wells, a history matching well is declared by using the keyword "WCONHIST". The liquid rate control mode is defined by using the definition "LRAT" in the control mode selection.

The declaration of an ordinary well is done by using the keyword "WCONPROD". The liquid rate control mode is selected in the same way as in the history matching well.
All the above declarations take place in the schedule script.

7.2 The future prediction

Once a matched model has been obtained, the simulator is set to predict the future performance of the reservoir. As it has already been mentioned, the only well that is still active after the end of the recorded history, is well P-A35. That well will continue to function for the future prediction to come.

For controlling reasons, the control mode of the P-A35 well has been switched to "WCONPROD" mode, with liquid production rate. The injection well I-A38 is the only injection well active at this period of time, and thus it is the only injection well to be active for the future prediction.

At the end of the recorded history, the production schedule is set at 600 SM^3/day of liquid production and the water injection rate is at 2986 SM^3/day, for wells P-A35 and I-A38 respectively.

For the future prediction, the production and injection rates have to be modified properly so several fall outs may be avoided. If the production rate is too fast, then the pressure may fall below bubble point. Since the simulator is using a black oil model for this case, and there are no data available for the dissolved gas properties, the simulator will stop functioning, indicating that the pressure has entered the biphasic region of the fluid. More over if the injection rate is too high, then the simulators' linear solver, may experience convergence fall outs. Therefore, several trials have been attempted, and the production/injection rates, have been modified accordingly. The modifications were revised whenever a new prediction date was added to the script, so that the optimal values would be obtained and with the highest possible oil production rate while at the same time making sure the sustainability of the production.

7.3 The extrapolation results

The extrapolation to the future goes until the 1st of May 2006. Until then, the simulation has lasted for approximately 7100 days. The recorded history is up to 4300 days approximately. That means that the future prediction has been made for 2800 days, which stands for a little less than 8 years.

The future prediction has been executed using the two different history matched models, under the same production schedule and for the same simulation dates. The purpose of this trial is to compare the two different outcomes. By analyzing the error in the "unknown" schedule dates for the second matched model (2300 day record) an estimation of the error in the future predictions of the model can be derived. The knowledge of the error potential can be very useful in determining the possibility of a prediction to be accurate or not.

7.3.1 Full 4300 day model future prediction

The results of the extrapolation, for the full production schedule history matched model, in terms of FOPT and FOPR are to be shown in the following figures.
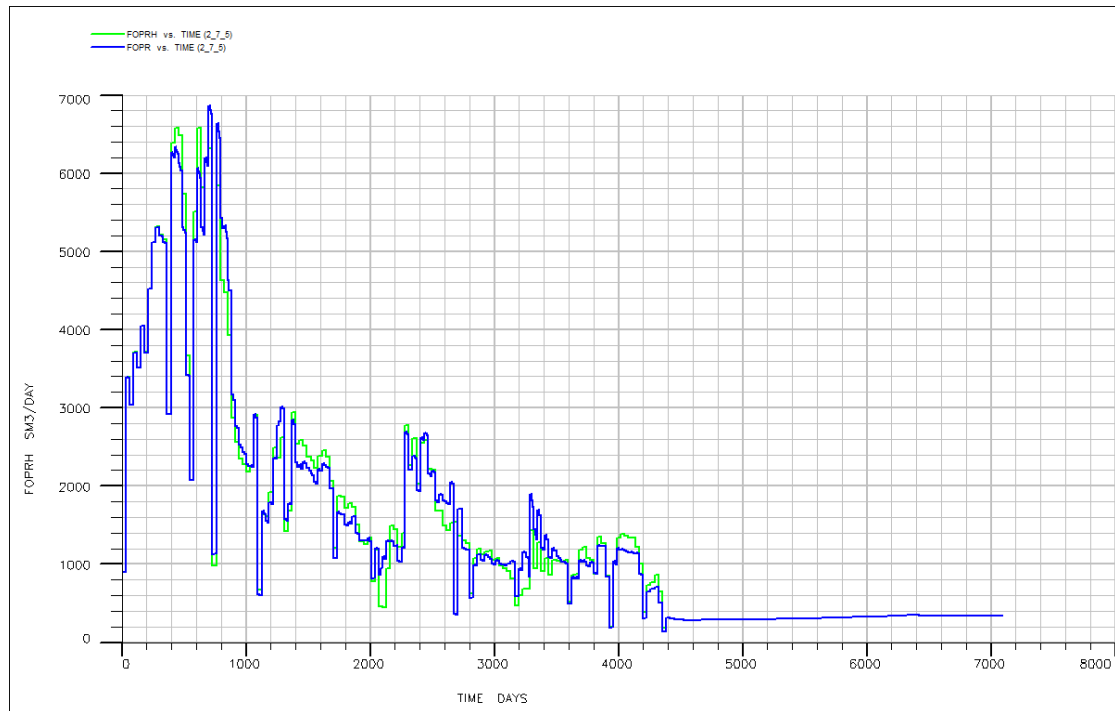
Figure 63: Field Oil Production Rate (FOPR) for the future prediction

As it can be seen, the production rate is rather more smooth and without fluctuations in contrast to the production rate of the recorded history. That is because, in the history schedule, information of well workovers, maintenance, as well as sudden shut downs due to technical reasons are provided. During the future prediction however, the schedule is much simpler, provided only with production and injection rates resulting in this smooth and more stable behavior.

For the prediction mode of the simulation, which is for the days beyond day 4300, the production rate of oil is around 300 SM^3/day and tends to reach 400 SM^3/day. The rate is low enough for field production, but it has to be brought to attention, that only one well operates in the field for that period. It is worth mentioning that the watercut level is of the order of 0.84 with a tendency to decrease, as the simulation advances, to 0.80.

In the cumulative oil production of the field, which can be seen in the figure below, the forecast part of the simulation appears as a linear end of the curve with stable slope. That is because of the almost stable of the production rate. During the 2800 day forecast, it appears that the cumulative oil production has increased by 1 million SM^3, thus reaching a total cumulative oil production of 10 million SM^3.
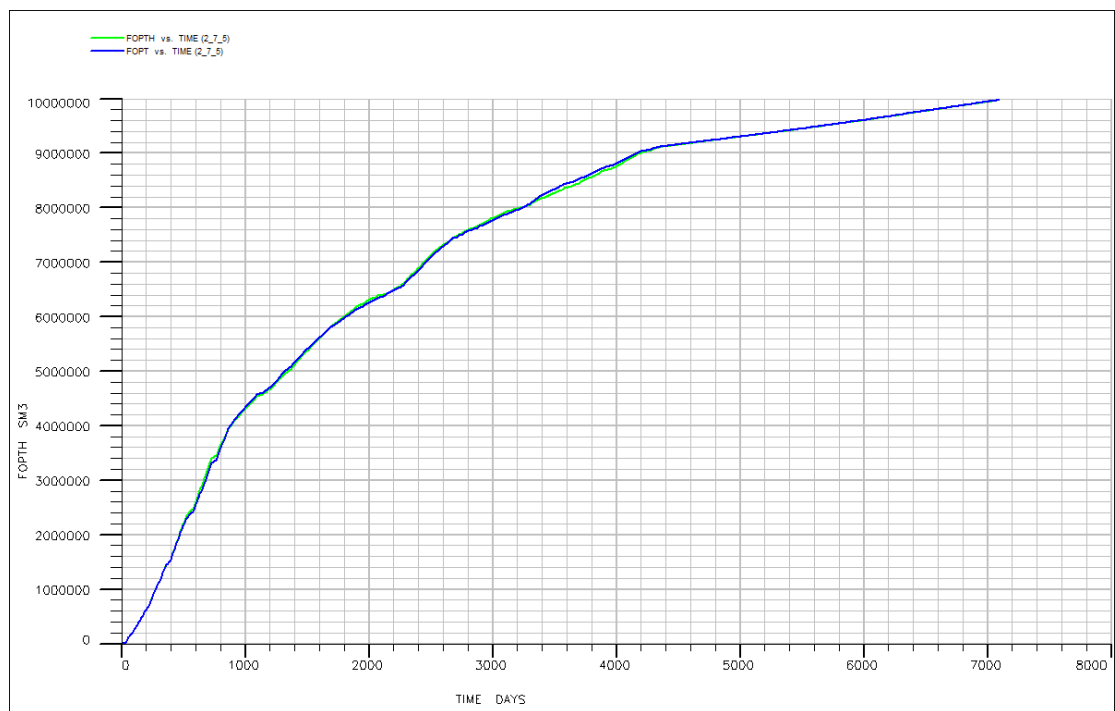
Figure 64: Field Oil Production Total (FOPT) for the future prediction
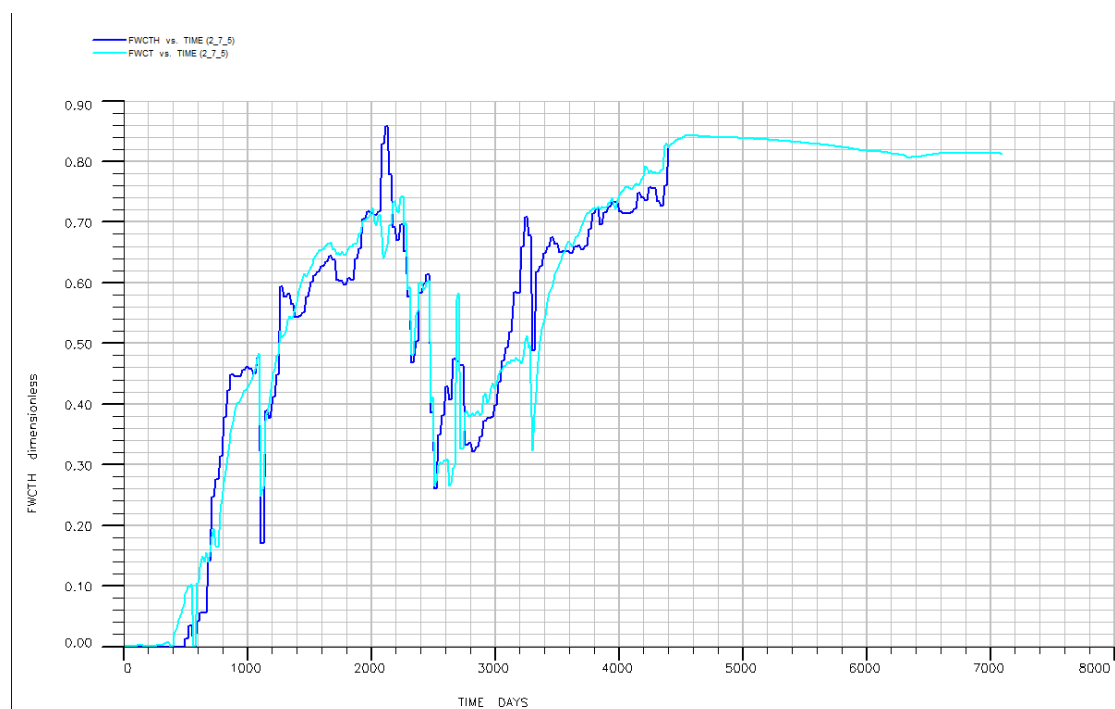
Figure 65: Field Water Cut (FWCT) for the future prediction

7.3.2 Half '2300 day' model future prediction.

The results of the extrapolation, of the 2300 day production schedule history matched model; in terms of FOPT and FOPR, will be now presented.

For this particular model, the available history data will be treated as if the production has stopped at 2300 days. In that way, future prediction will take place not just for a production period beyond the 4300 days and until 7000 days, which is the case for the model that has been presented above; but also for the intermediate period. Therefore, apart from the desired extrapolated predicted production, the degree of accuracy of the results obtained can be also evaluated by simply comparing the predicted production data with the history data that are available, for that particular period of the reservoir's activity.
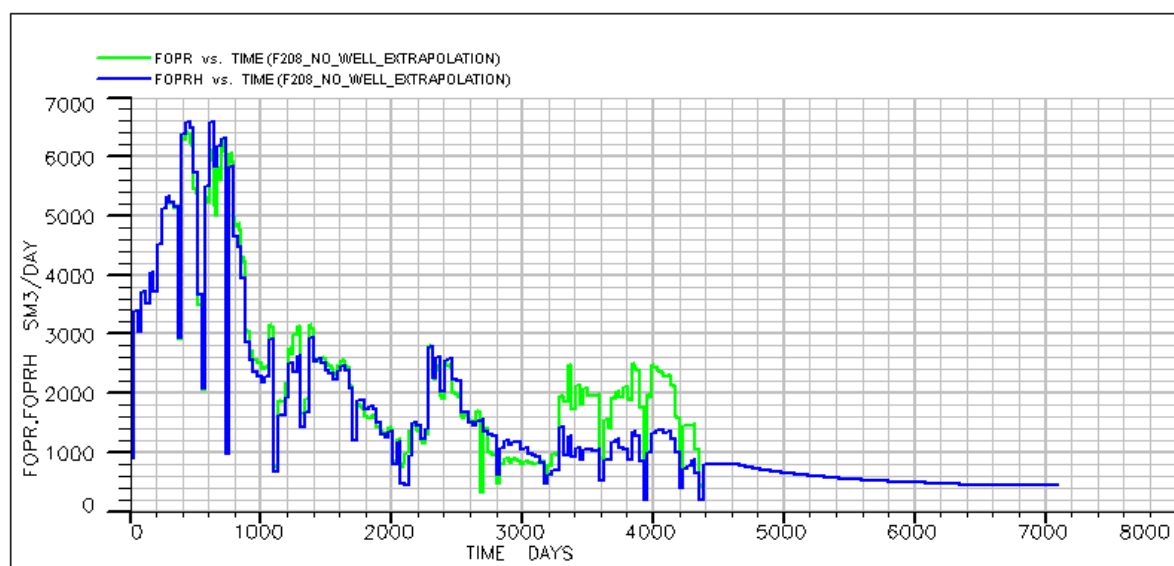
Figure 66 : Field Oil Production Rate (FOPR) for the future prediction

For the initial period of up to 2300 days, the activity of the reservoir in terms of production is comprised by the wells P-A1H, P-A2AH, and P-A17; in other words, the data correspond just to the activity of those wells. After that period, other wells come into play, which are normally included in the schedule of the reservoir production.

For the period in between the 2300 days and the 4300 days the following can be deducted; it is obvious that the overall pattern of the field oil production rate does not present significant changes for the period between 2300 days up to 3150 days, however, above the 3150 days and up to 4300 days, there is a significant discrepancy between the predicted production rate and to that of the history data. This is anticipated to be also observable in the figure 67 of the field oil production total, and to that of the water cut (see figure 67 and figure 68 below).

The explanation lies on the fact that the predicted production is done through a simulation model that has been designed in order to be able to reproduce the characteristics of the reservoir up to a specific date. After that date, divergence of the history data and to the

extrapolated ones is expected to take place beyond some point. Therefore, it can be said that it the predicted data contain some sort of safety up to a certain period, and beyond that they have to be treated with a lot of aloofness.

Initially, after the 2300 days, the production rate is of the order of 2800 SM^3/day, with a declining trend, until after the period of 3200 days, where the order of the production rate is more or less 1200 SM^3/day. After the 4300 days period, the production rate presents a constant but smooth decline dropping to 450-400 SM^3/day.

This kind of divergence can also be observed in the following figure, which depicts the cumulative production, which until the end of the 7000 days period, an increase of about 900 SM^3 takes places, and the total reaches to a production of just about 11.8 SM^3.
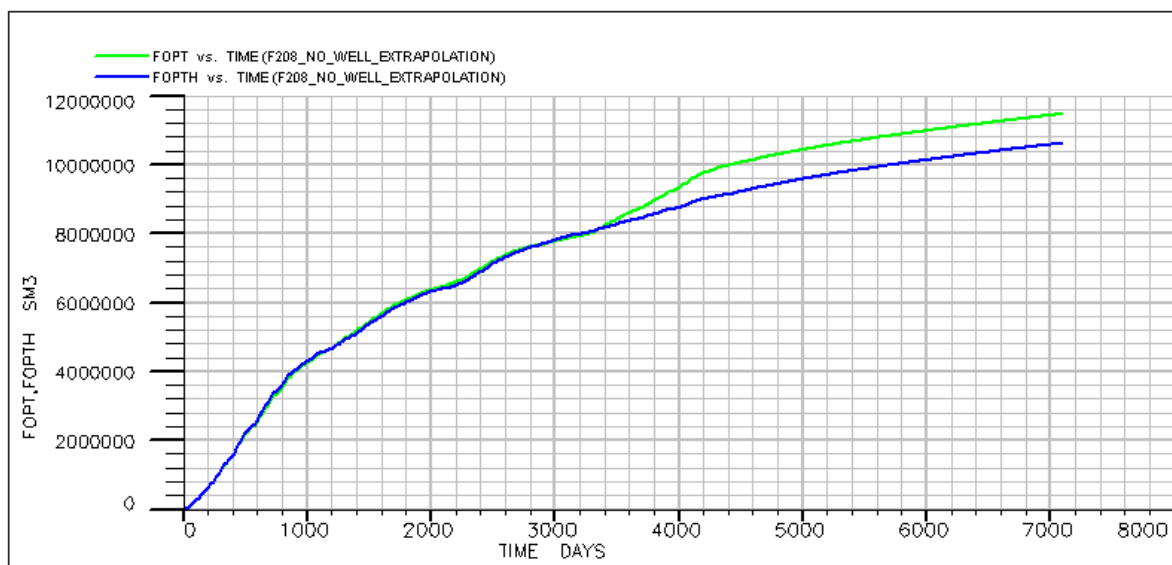
Figure 67: Field Oil Production Total (FOPT) for the future prediction

The water cut rate at the end of the 2300 days period is of the order of about 0.5, initially further dropping to 0.35 and then again rising up to 0.58, which is the point where the model seems to be unable to further predict the behavior of the reservoir with the required reliability needed in the obtained results.

As a matter of fact, the figure of the water cut rate is a very good representation of the failure of the constructed simulation model to carry on the production extrapolation, since the discrepancy observed between the history data and to the extrapolated ones is much more intense compared to the previous figures.
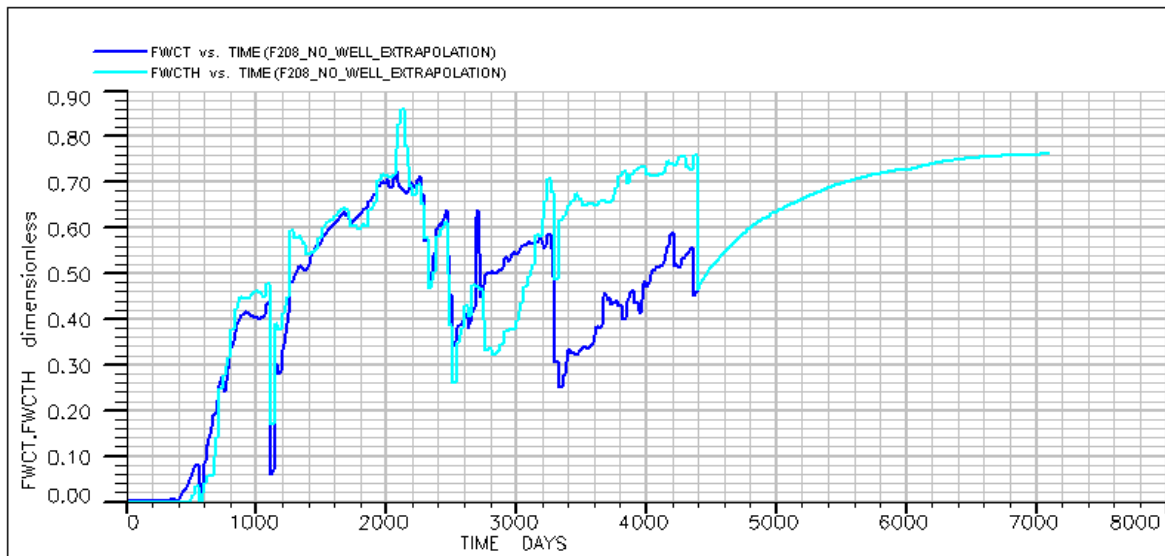
Figure 68: Field Water Cut (FWCT) for the future prediction

7.4 Explanation of outcomes

Taking both history matched model extrapolation runs, we may be able to develop levels of trust or degree of reliability; for the extrapolating capability of the simulator. The time domain from 2300 days until 4300 for the second model, consist of production data against which the model has not been history matched. Therefore, this time period can be considered as extrapolation period for the "2300 day matched model".

So, for the 2nd model and for a period of 1100 days (from day 2300 until 3400) the accuracy in the prediction is excellent. The history and the prediction lines almost match for this time, as if they have been history matched.

From there on, and for a period of 1000 days (up to day 4400), the model begins to overestimate the production with an error that increases with a steady rate. That is due to the history recorded liquid rate that the model is forced to follow, even though these rates have not participated in the history match procedure. It can be seen in the FOPR for this model that the rate prediction, from day 2300 till 3200, is of small relative error.

From day 4200 and on, the mode switches to "WCONPROD" and therefore the simulator follows the suggested rate. However, it has to be mentioned, that in the second model, the rates tend to overestimate the production, in the early days of the forecast, with the tendency to stabilize the oil rate to 400 SM^3/day.

As already mentioned above, it can be observed from the FOPT graphical representation (fig. 67) that the matching achieved between the recorded data (blue line) and to those from the constructed model (green line) is satisfying until reaching 3400 days of the reservoir's operation. However, a safer approach to the setting of the trust factor of the extrapolated data would be to impose to the result obtained a safety factor.

Throughout the reservoir's simulation procedure, there are plenty sources of error that can seriously affect the validity of the outcome. An induced error may be related to the upscaling of the initial fine grid that has been obtained from the geologists, or it can also be related to a defective structured model. The oil industry is a multibillion business, and as much as it is ambitioned to have trustworthy results for the greater period possible, it is also desired not to go astray with the future predictions due to overoptimistic expectations, since that may seriously jeopardize the viability of the project. This way, the errors induced to the results can be accounted for with the imposition of the safety factor mentioned above.

According to figure 67, a period of 1100 days is giving very good extrapolated results, however, by imposing to that day period a safety factor slightly higher than ¼ of its size, the trustworthy period with the safety factor embodied can then be retrieved. Therefore:

1100*0.725 = 797.5 ≈ 800 days

From the above data, it can be concluded, that an average "good trust" sector for an extrapolation model, of the order of 2300 days, is found to be 800 days. Therefore the "trust" factor for this model is of "0.35" as a result of the 800 days relative to the total 2300 days.

$$\frac{800}{2300} = 0.35 \qquad \text{trust factor for 2300 day model}$$

That factor is to be applied to all the extrapolation attempts. The application of the "trust" factor is necessary in order to ensure the validity of a potential decision making plan, based on the simulator outcomes.
Taking the previous factor into consideration, for the full 4300 day matched model, the "trust" area for that model's forecast is up until day 5800 (4300 * 0.35 = 1500, 4300+1500 = 5800) and a FOPT of 9,600,000 SM^3 and a rate of around 350 SM^3/day.

The rate in this case, is smooth however, because of the participation of only one well in the production. The case might have been completely different, if multiple wells were to participate in the production at the same time. Since the "trust" factor was derived based on data collected from simulating a more complex schedule with multiple wells functioning at the same time, thus it can be considered as 'safe' to be applied on a simpler case such as the full 4300 model extrapolation.

8) Simulation runs with additional injection wells

8.1 Well location proposals

The purpose of performing this Thesis project is to identify the optimal location of a new injection well placement. In order to do that an amount of potential location suggestions need to be presented. The locations have been chosen after taking into consideration, the production schedule available, locations of the reservoir which are highly saturated with oil and have not been swept by the water flooding until the end of the history record and water-flooding pattern geometry.

Taking the production schedule into account, it can be told that the production activity is transferred successively towards the right-hand edge of the reservoir, (towards the edge closer to the wells P-A39 and P-A35).

All the wells that have been shut by this time were due to high water-cut values, which imply a high water saturation level in those areas. However, areas with high oil saturation values were located among the water-flooded areas. A potential enhancement of these areas however, would imply to re activate one of the already shut wells. This was avoided, and the following of the already schedule was decided. As a result, the locations suggested were aiming to enhance the sweeping efficiency of this area, and/or to mobilize the amount of oil that had not been mobile up to that moment.

For every well location that has been suggested, the simulation was run with both history matched models. With every run, special care was given to the fact that the total amount of injected water, has to remain the same with the original case. This fact is of crucial importance, because the difference in the oil recoverability needs to be estimated, as a function of the injection well location solely. Thus the injection rates were modified accordingly, so as the total injection rate for the entire field would remain unaltered.

The suggested locations for the potential new injection well of the reservoir are to be presented, as well as the justification for their selection.

Location 1

This location was selected under the philosophy of enhancing the water fronts' motion toward the wells P-A2H, P-A39A and P-A17. It is located in line with the injection wells I-A38 and I-A5H. The coordinates for this well are (8 , 16) as it appears on the grid system.
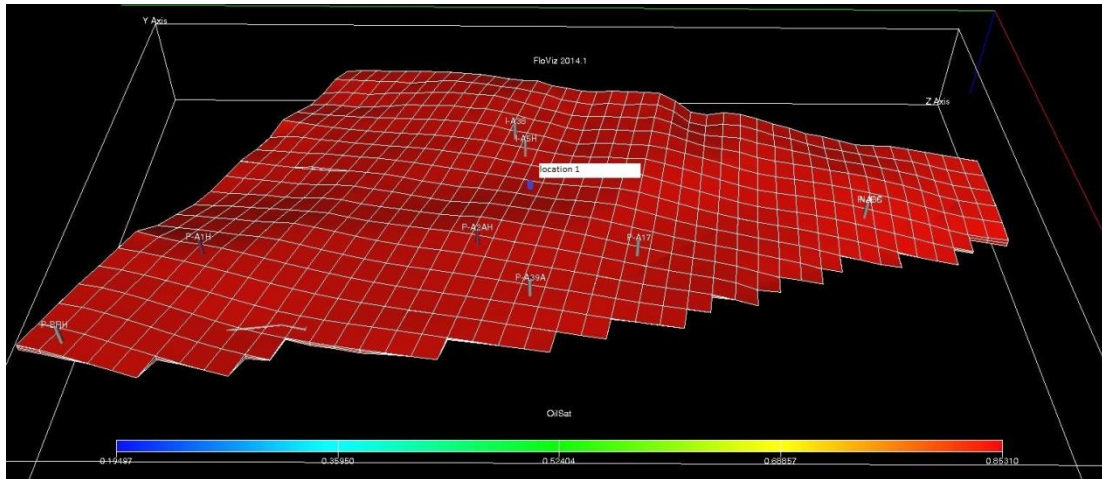
Figure 69: Location 1 on the grid

Location 2

This location was selected under the philosophy of enhancing the water-flood front towards the production wells P-A17 and P-A35. The enhancement is believed to take place, by placing the new well close to the location were the advancement of the front has reached and for the well to be in line with the two production wells at the same time. This location can be seen below.
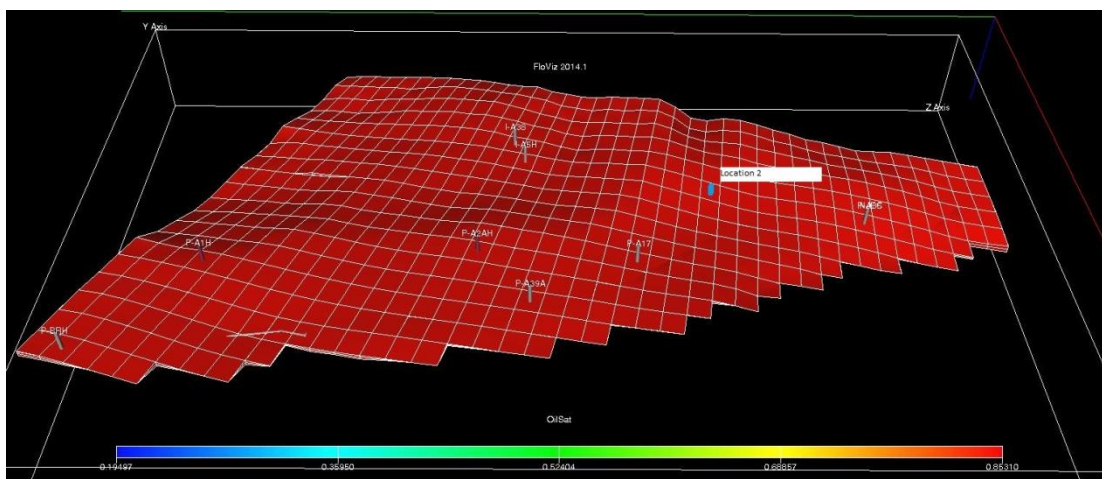
Figure 70: Location 2 on the grid

Location 3

This location was selected in order to enhance the propagation of the water front, and thus the area to be swept, towards the P-A17 production well. The location can be seen below.
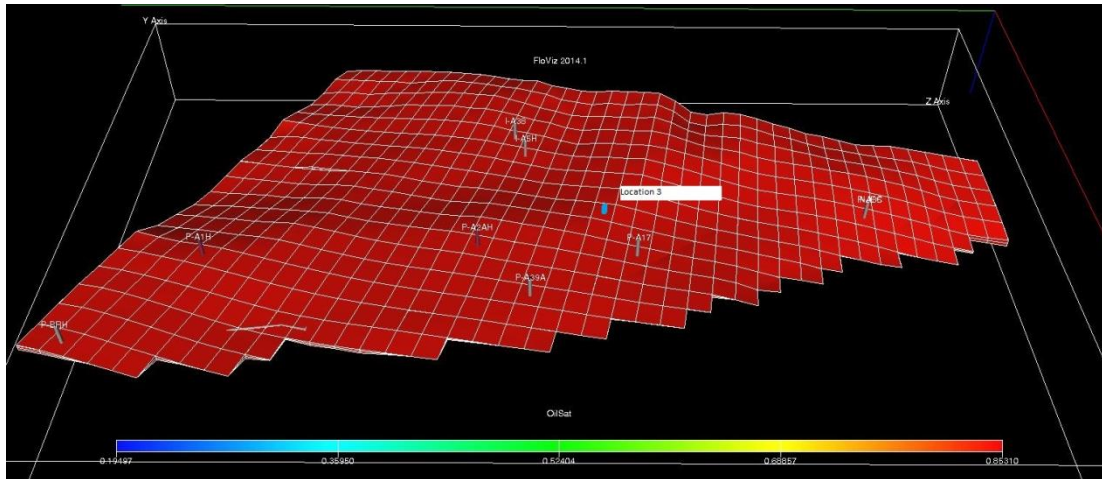
Figure 71: Location 3 on the grid

Location 4

This location aims to mobilize oil quantities that have not been swept by the water-flooding yet in the area behind the well P-A17. Also the mobilization of oil phase towards well P-A35 is intended. The location can be seen below.
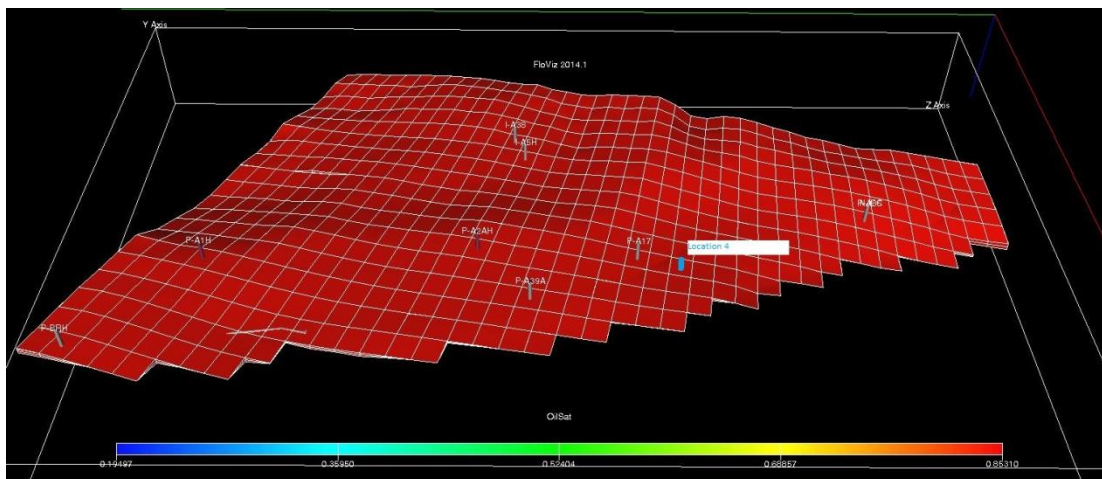
Figure 72: Location 4 on the grid

Location 5

An injection well in location 5 is intended to mobilize oil from the boundaries of the reservoir. This oil has never been in contact with injection water before. To mobilize this amount of oil, will have as a result its propagation towards the well P-A35 which is the only well to be producing at the end of the history and from there on. The location on the grid may be seen below.
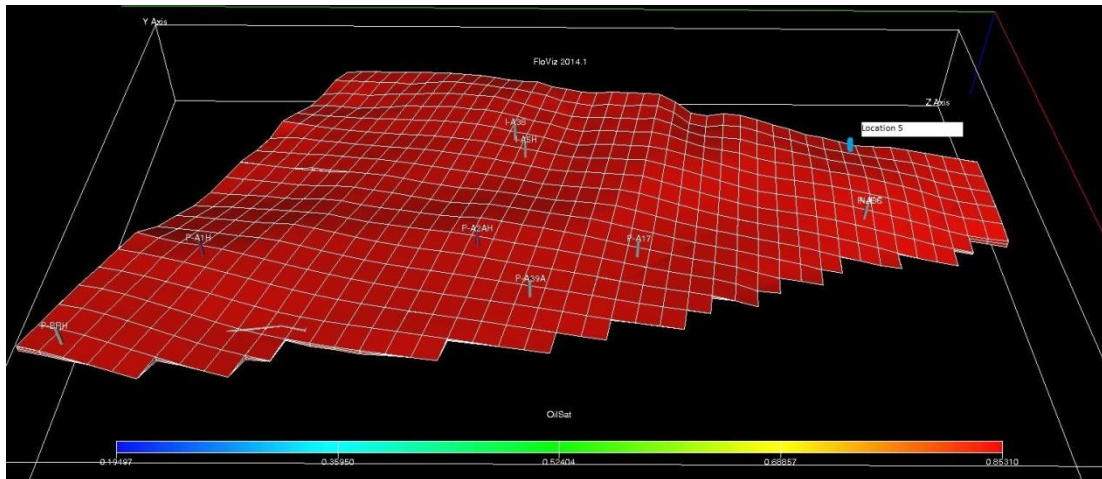
Figure 73: Location 5 on the grid

Location 6

An injection well in this location aims to mobilize any immobilized oil until that period, which lies at the corner end of the reservoir. The injection at this location will sweep oil from an area that has not been swept before and can be considered to be immobile. The location is presented below.
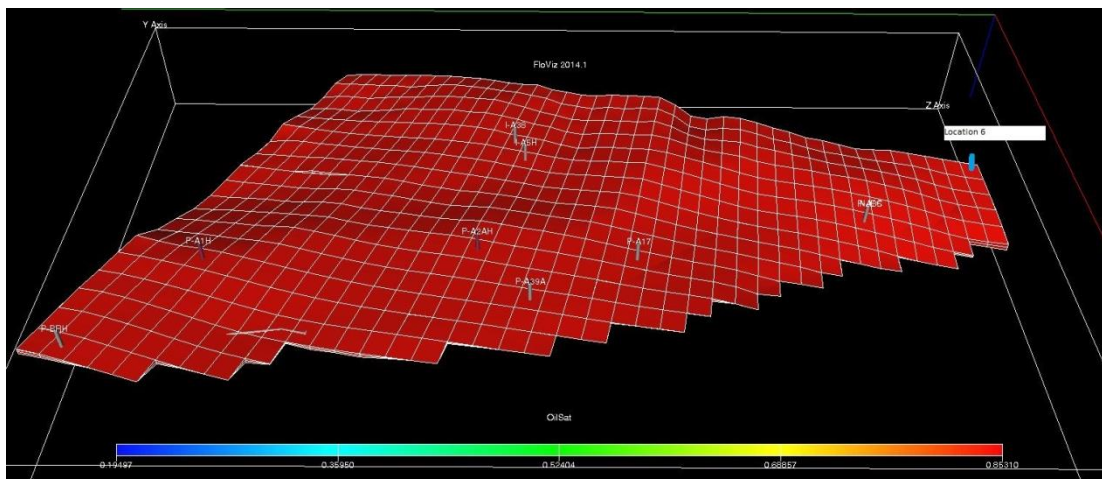
Figure 74: Location 6 on the grid

8.2 Simulation runs with additional injection well

The simulation schedule file is to be updated with the addition of the new injection well in each case. Thus, 6 modifications are to be created, one for each well location as indicated above. The simulation for the reservoir is to be re executed separately for each one of the wells. For each well, the injection schedule has been modified in a way that the total injection rate for the entire field to remain unaltered.

The modified 6 new schedules were executed twice, once for each matched model. The simulation had been performed for the entire history, so that comparison of the total amount of produced oil will be possible.

8.3 Full 4300 day matched model results

The results that have been obtained after the runs with the 4300 matched model are to be presented here. The FOPT and FOPR are to be presented in each case, and they are to be compared with the production forecast which was presented in the previous chapter. The objective of this comparison is to determine whether or not, the new well on each location, may contribute towards an increased oil production for the same production period.

8.3.1 Location 1 results

The results for the first well location turn out to be not in favor of the oil production enhancement. The production rate, despite the fact that it initiates with a higher value than the original model, turns out to be decreased as the production advances in time.

This effect can be seen in the cumulative field production, where the overall oil quantities show lower values than originally presented. The total production even at the end of the future forecast period does not exceed the value of 10M SM^3.
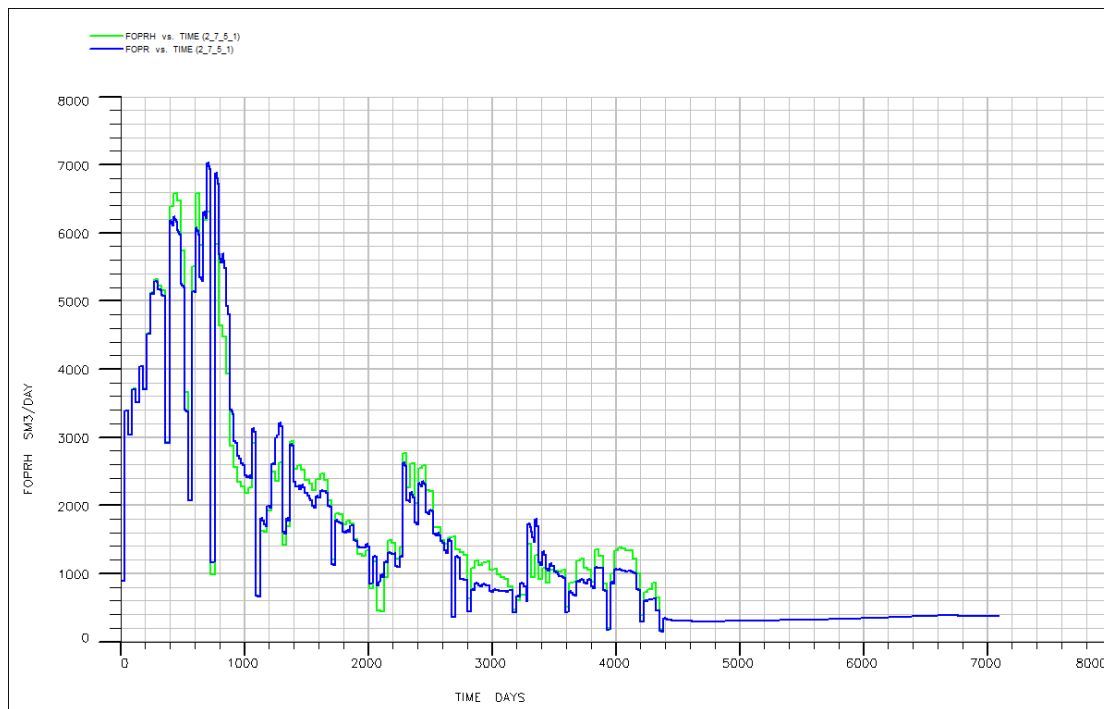
Figure 75: FOPR for well location 1
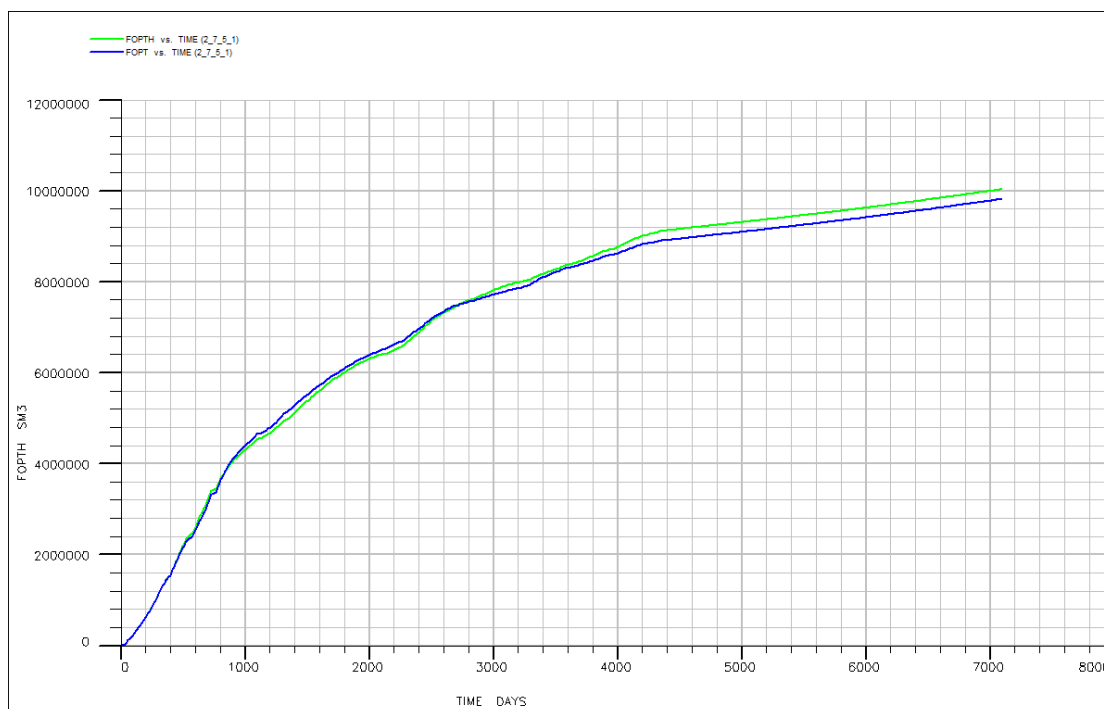
Figure 76: FOPT for well location 1

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8.3.2 Location 2 results

The results for the second location are not the desired ones as well. The oil production rate seems to be significantly lower than the original extrapolation. Low rates such as the observed ones, lead to a cumulative production that is even lower than the initially recorded. This indicates a highly insufficient solution. It is more than clear that a potential injection well on this location will not enhance the productivity of the field.
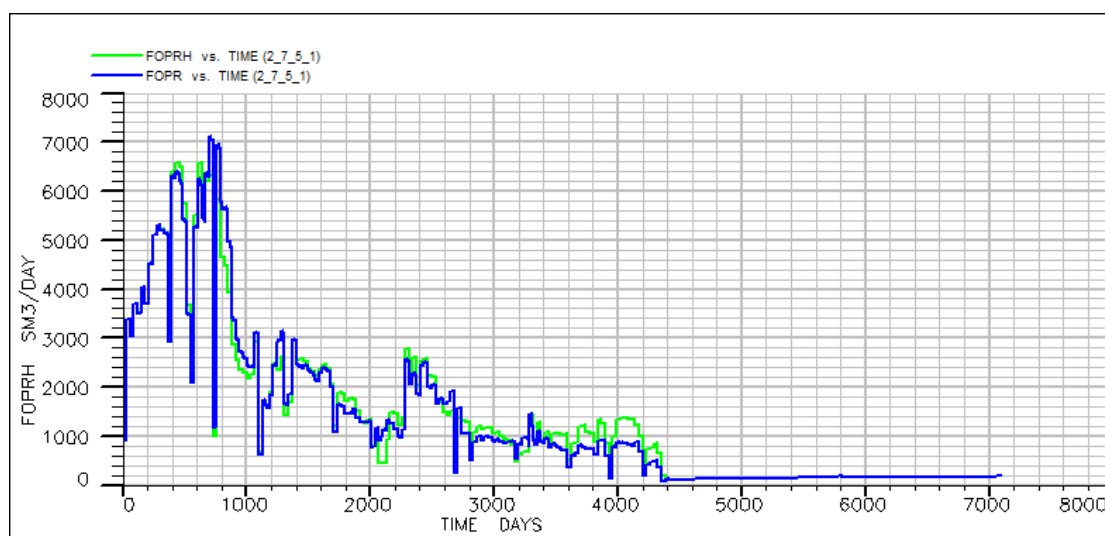
Figure 77: FOPR for well location 2
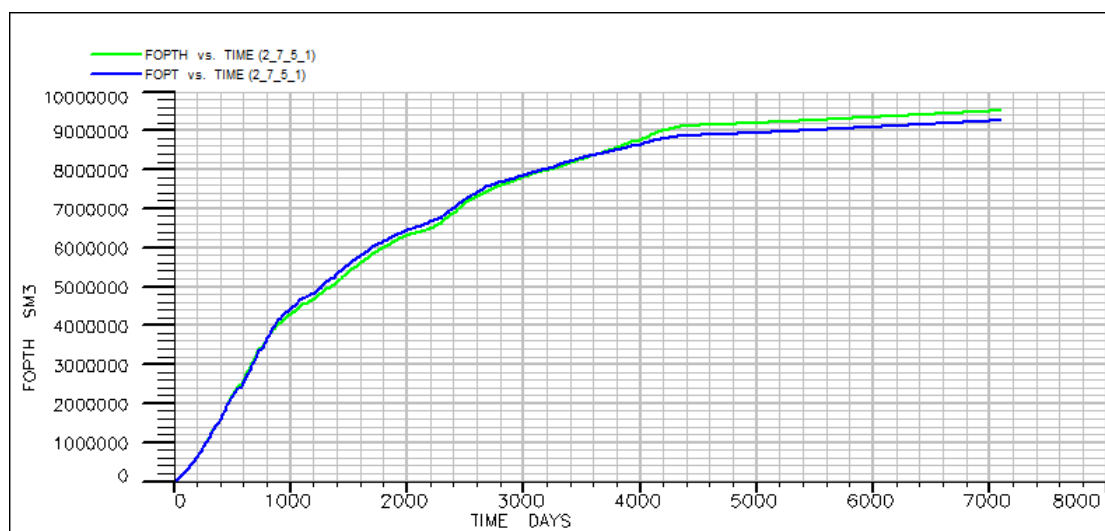
Figure 78: FOPT for well location 2

8.3.3 Location 3 results

The cumulative oil production for the third prospect location has again fallen below the initially recorded values. In this case the production has been significantly suppressed and the total cumulative oil production does not reach 10M SM^3.
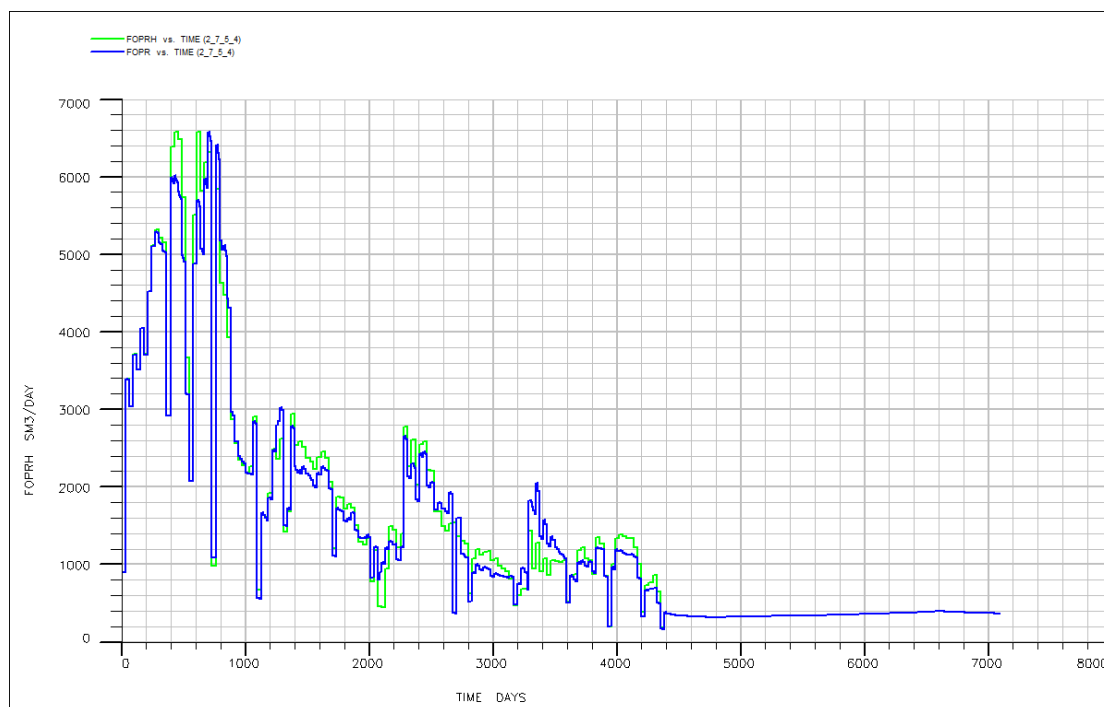
Figure 79: FOPR for well location 3
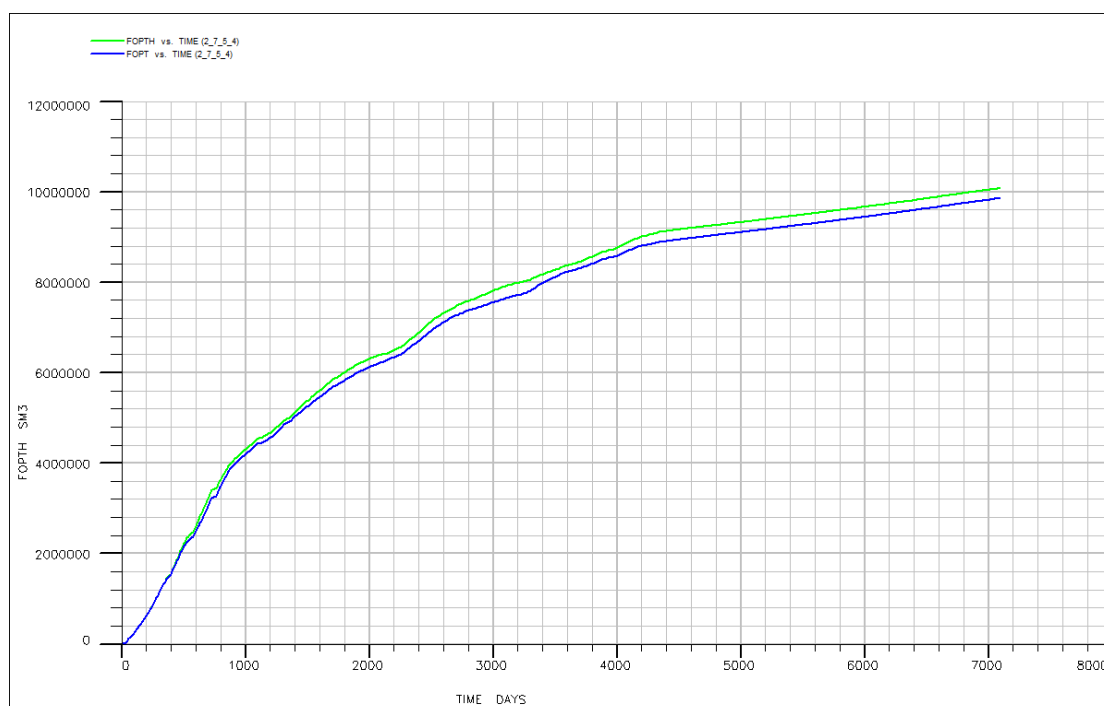
Figure 80: FOPT for well location 3

8.3.4 Location 4 results

Despite the fact that the extrapolated production rate seems to increase abruptly and the early cumulative production seems to have been positively optimized, the overall cumulative production can barely exceed the point of 9M SM^3 of oil, making this attempt the least productive of all the attempts that have been carried out.
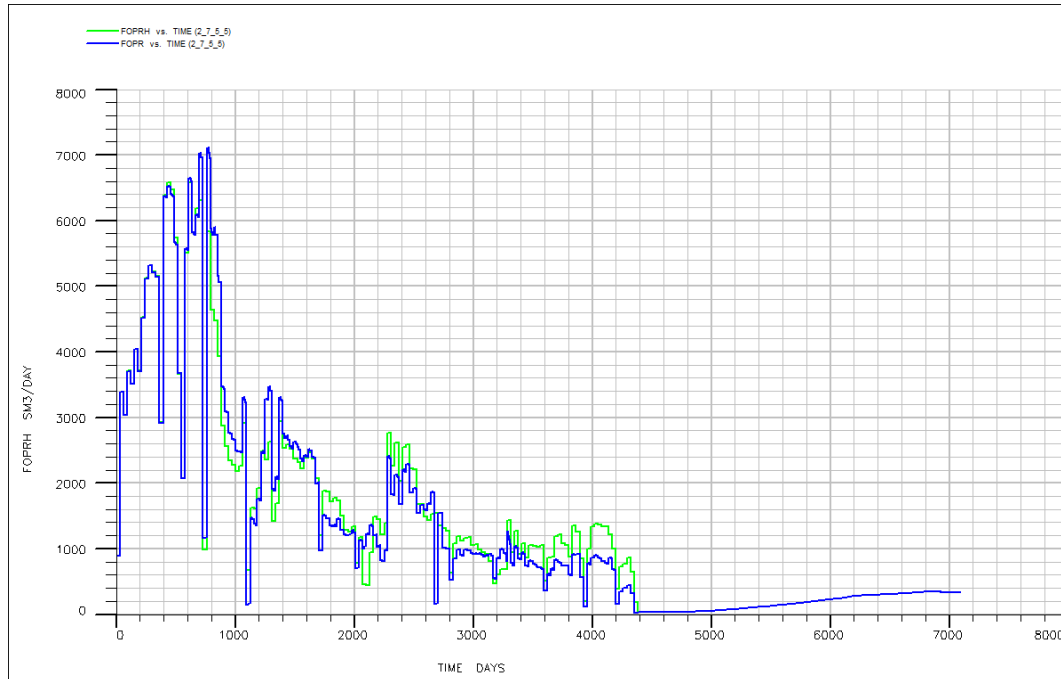
Figure 81: FOPR for well location 4
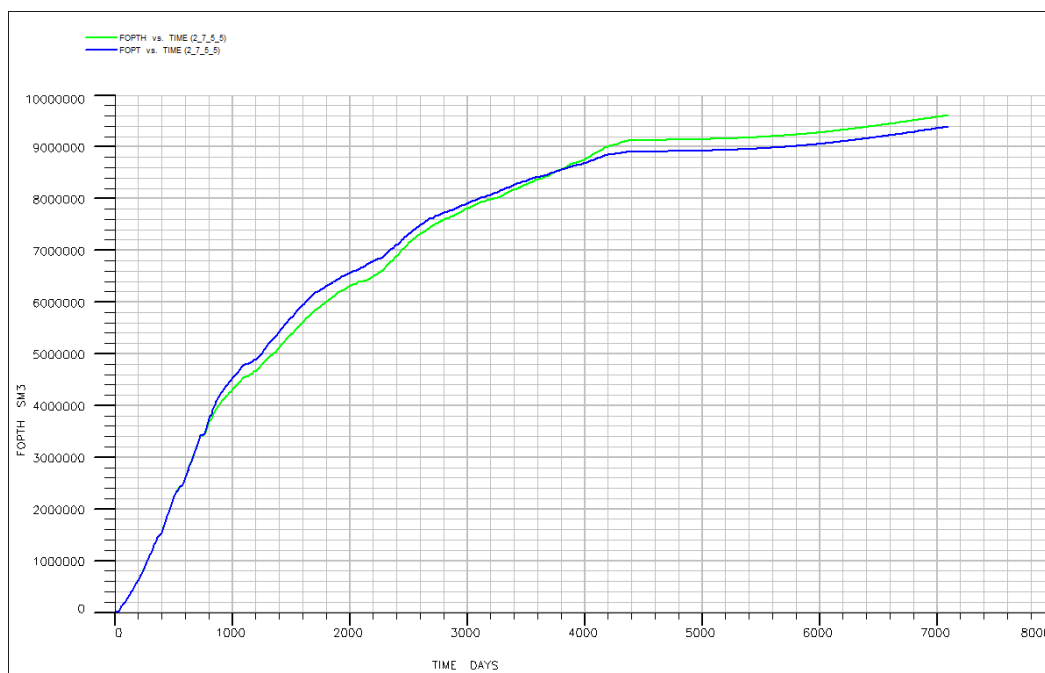
Figure 82: FOPT for well location 4

8.3.5 Location 5 results

This attempt is the first one to have a clearly positive effect on the production optimization procedure. The production rates have a sufficiently higher value in almost all aspects of the production. This results in a cumulative production that excesses the recorded production by far during the entire duration of the simulation. The total cumulative oil production seems to be of higher value than the original one by around 100,000 SM^3 of produced oil.
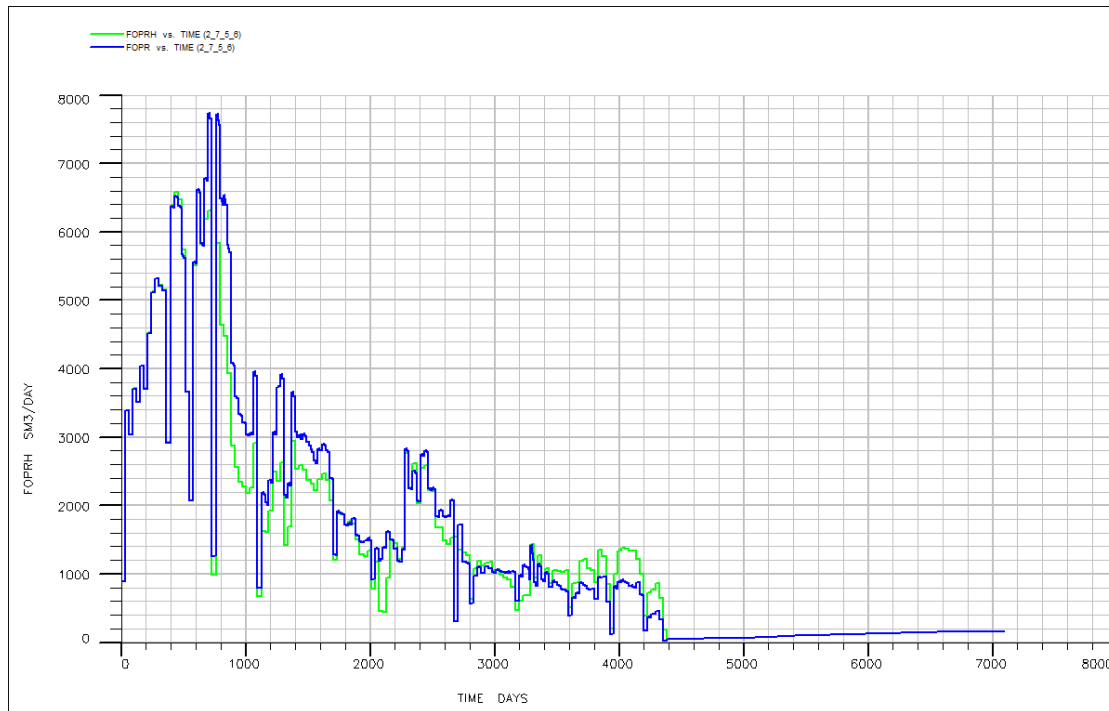
Figure 83: FOPR for well location 5
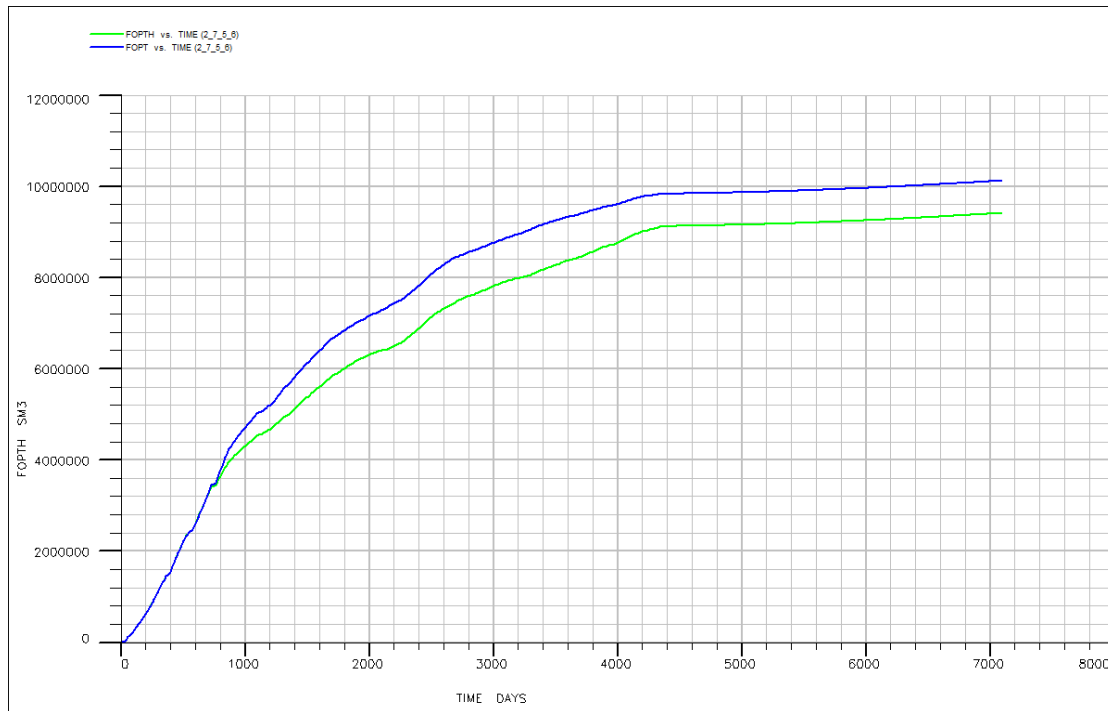
Figure 84: FOPT for well location 5

8.3.6 Location 6 results

The location number six, is the second one to give positive results as far the improvement of the oil production is regarded. The production rate is substantially higher, resulting in a cumulative oil production of around 100,000 SM^3 higher than the originally predicted.
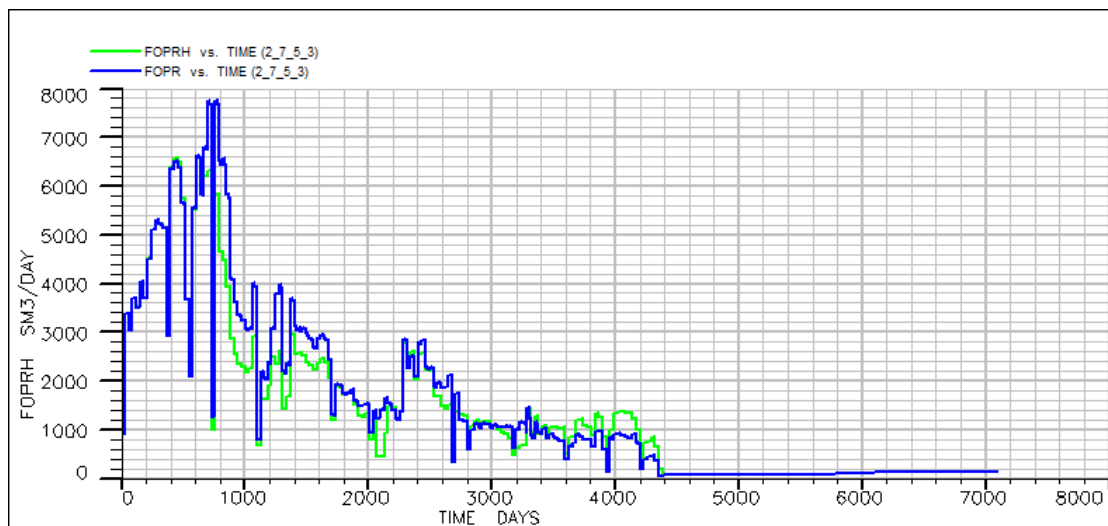
Figure 85: FOPR for well location 6
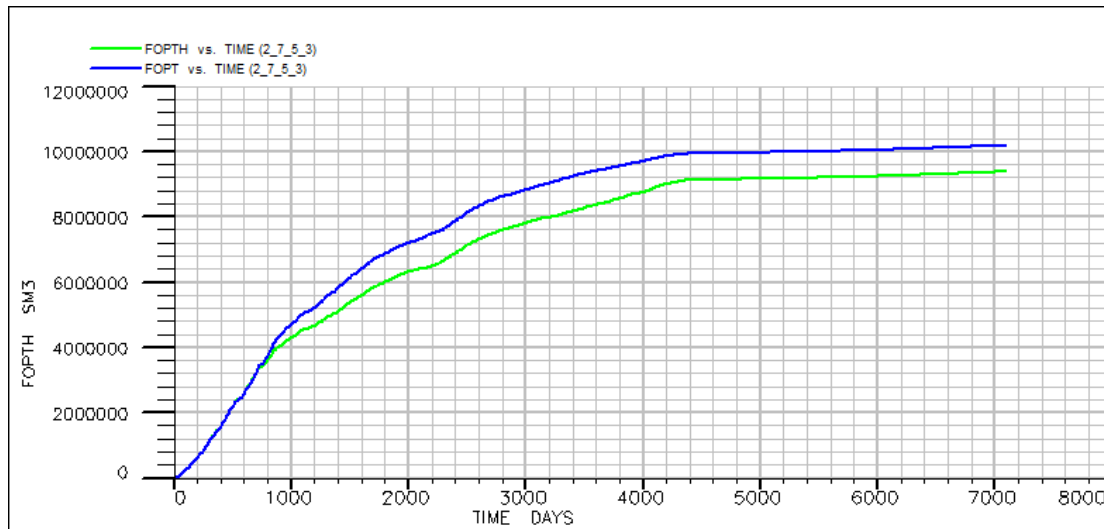
Figure 86: FOPT for well location 6

8.4 Forecasting with additional injection well to be created after the recorded History

After the entire schedule has been executed for each of the suggested locations under the equal injected water constrain, an extrapolation forecast will be executed using the wells that have showed the best results in both models. The extrapolation will re execute the entire model, however in this case the new injection well will begin to operate after the 4300 days of the recorded history. The objective is to show whether or not, these location will benefit the production of oil.

8.4.1 Trial with full 4300 day matched model

The best well locations for the 4300 day model were the two last cases, that is for the wells to be placed in the locations 5 and 6.

In both of these cases, the injection rate was the same at any moment, thus resulting in an equivalent injection water quantity, so that the results may be comparable.

For these two locations, the extrapolation prediction is about to be executed. Bellow the results are presented.

8.4.1.1 Well on location 5

This trial returns the result of a stable production rate of about 400 SM^3/day for the extrapolation period. This results in a linearly increased cumulative production of oil for the entire field. The total cumulative production value reaches 10,200,000 SM^3 of oil.
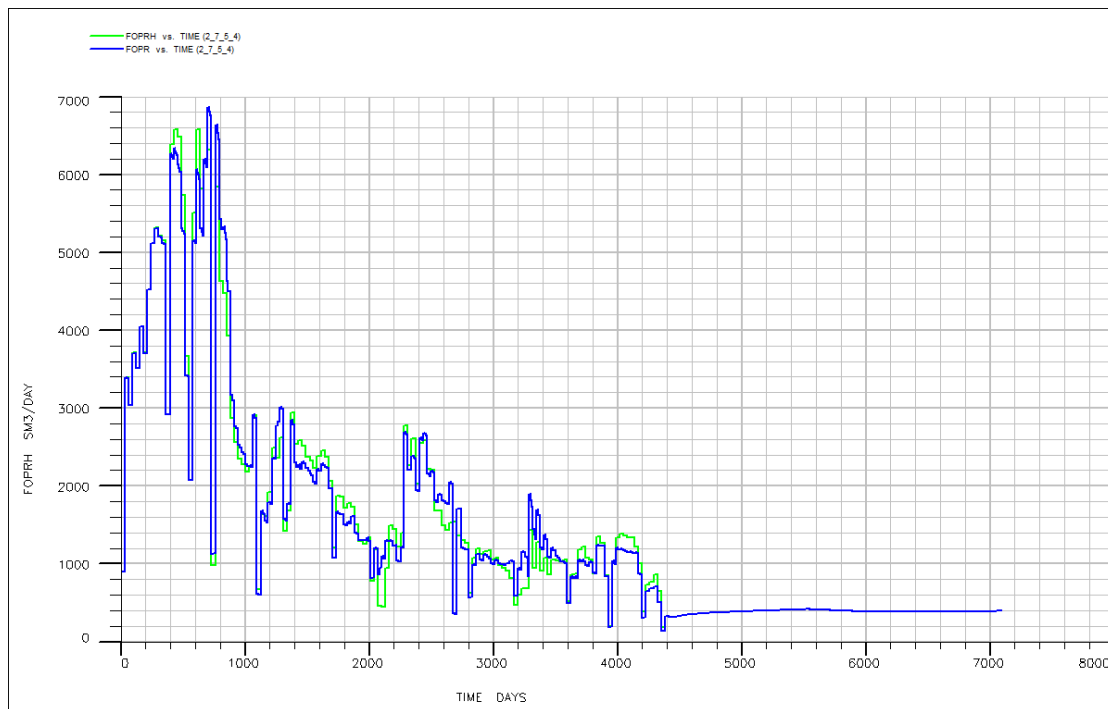
Figure 87: FOPR for well location 5 (injection after history end)
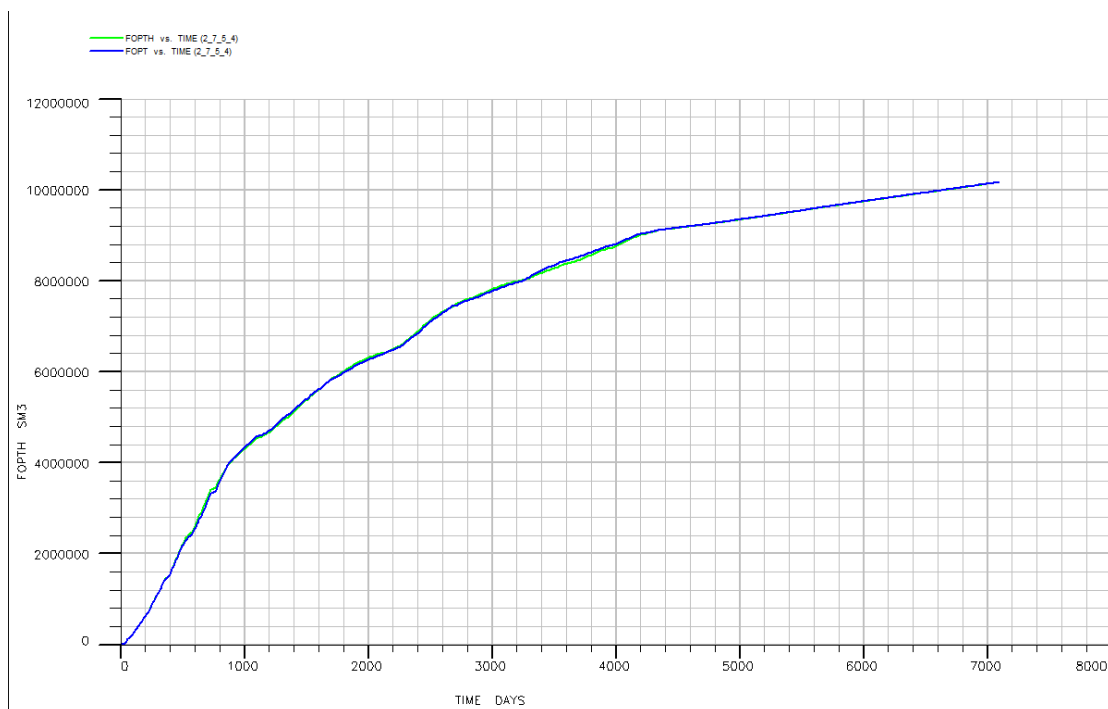
Figure 88: FOPT for well location 5 (injection after history end)

8.4.1.2 Well on location 6

Similar results appear on the trial with the injector to be placed on location 6. The production rate for the extrapolation period is stable and exhibits a value of 400 SM^3/day as well.

The overall cumulative oil production for the entire field is again 10,200,000 SM^3 of oil.
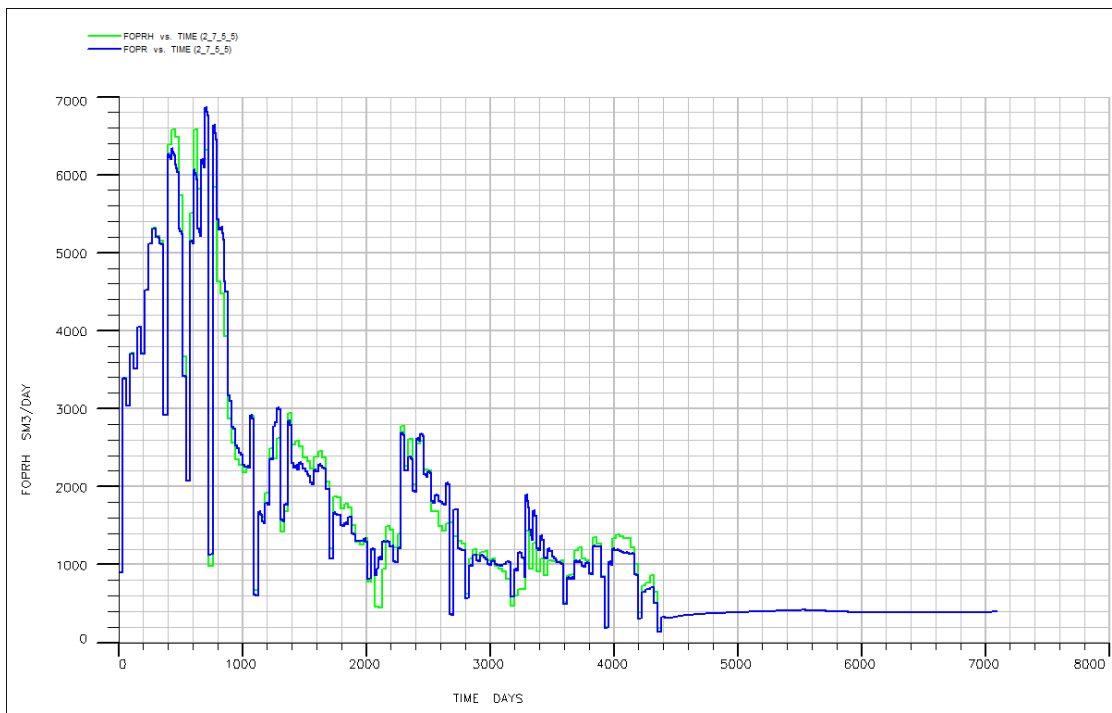
Figure 89: FOPR for well location 6 (injection after history end)
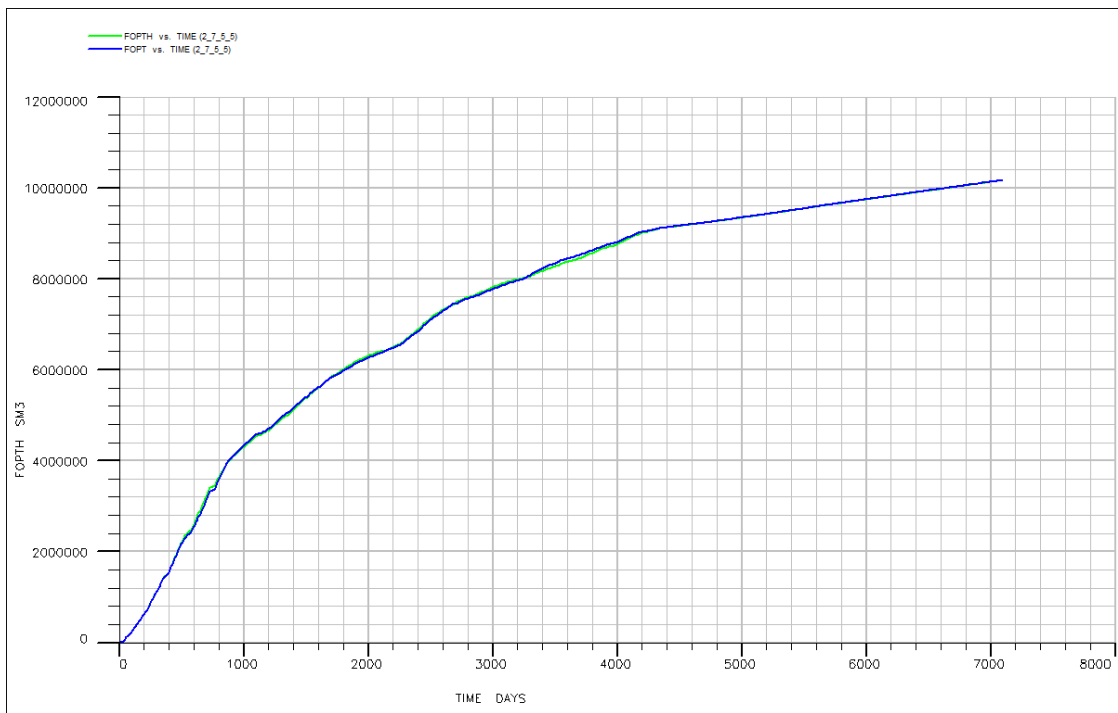
Figure 90: FOPT for well location 6 (injection after history end)

8.5 2300 day history matched model results with the additional well

Hereunder, the results obtained for the 6 new injection wells will be presented. The field oil production rate (FOPR) and the field oil production total (FOPT) are the diagrams according to which the comparison on the wells' output is going to take place. Furthermore, an additional comparison of the FOPT of the new wells, the ones that presented better performance, is then going to be contrasted against the extrapolated FOPT that was produced in chapter 5. In that way a more spherical view will be gained, in terms of the quality effect each well can have in the increase of the oil production.

8.5.1 1st well diagrams
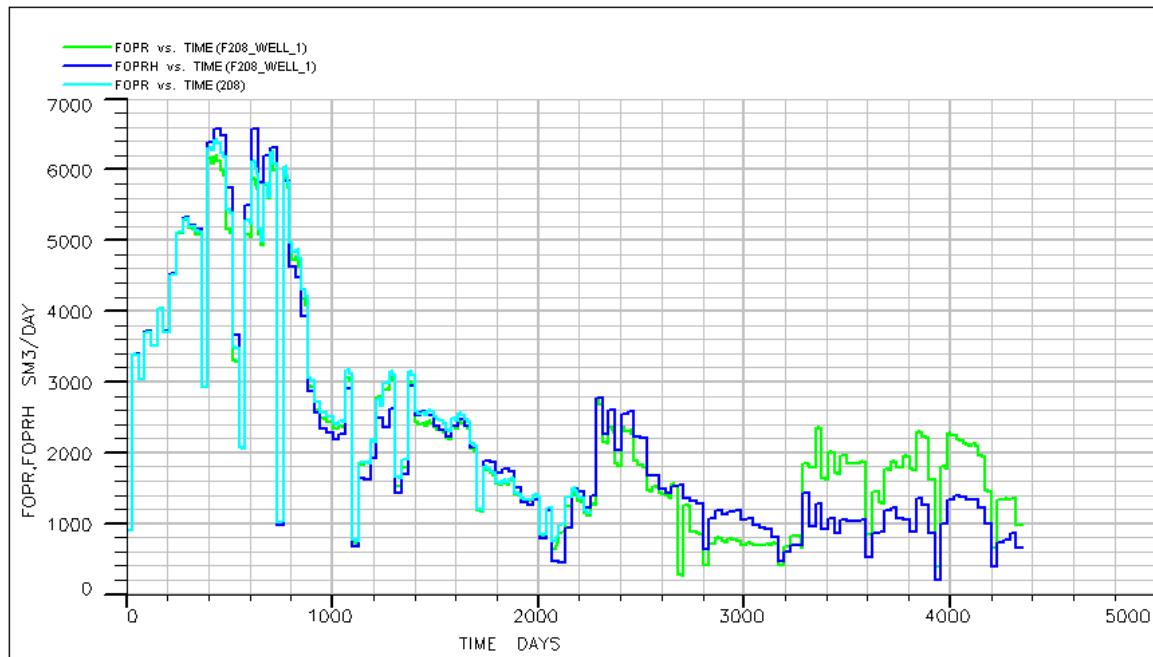
Figure 91: FOPR for 1ˢᵗ well's extrapolated injection
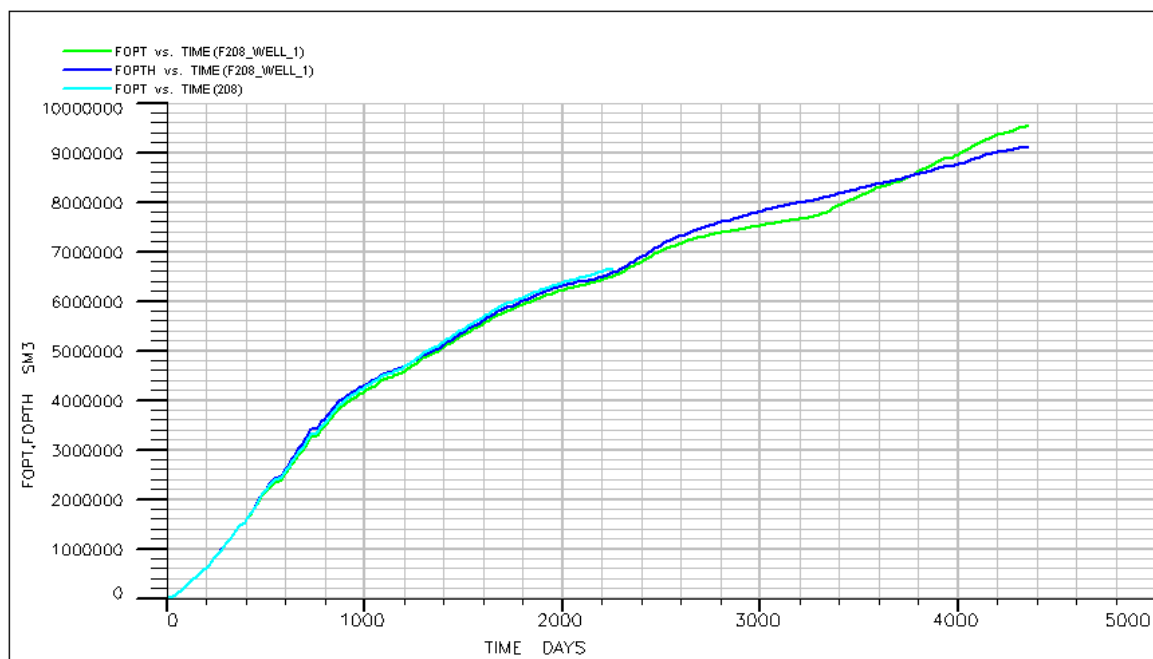
Figure 92: FOPT for 1ˢᵗ well's extrapolated injection

From the diagram of the FOPR it is relative obvious, even without looking at the FOPT diagram, that the case of 1st well is probably a moderate one. For most of the time the oil production rate for well number 1 is below the production rate that corresponds to the history. After exceeding 3150 days the production rate for well 1 becomes higher than that of the history for the remaining interval.

The results obtained can better be observed in the FOPT diagram, where the cumulative oil production of the 1st well, does not present a positive divergence; and at the end of the period it finishes with an excessive production, and in between the time frame of 2400 and 3600 days is well below the cumulative production of oil that corresponds to the history. It's just after the 3600 days that the total production becomes higher. In total the produced oil is around 9,550,000 SM^3, which is about 450,000 SM^3 higher than the total oil produced according to the history line.

8.5.2 2nd well diagrams
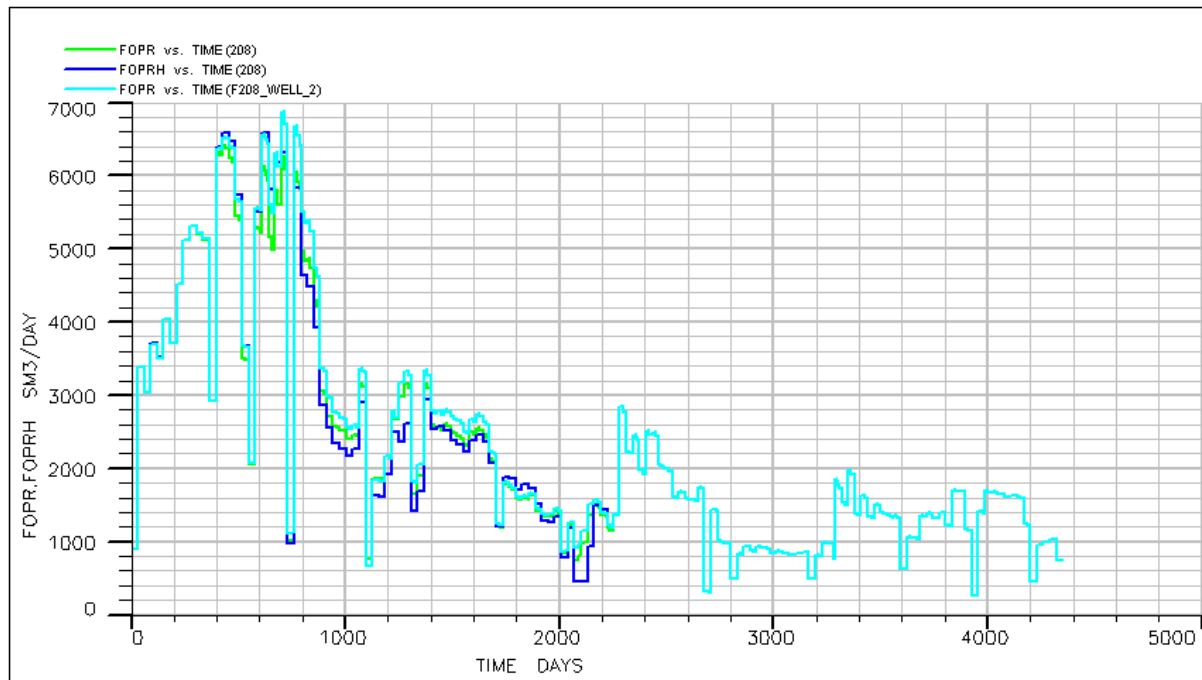
Figure 93: FOPR for 2nd well's extrapolated injection
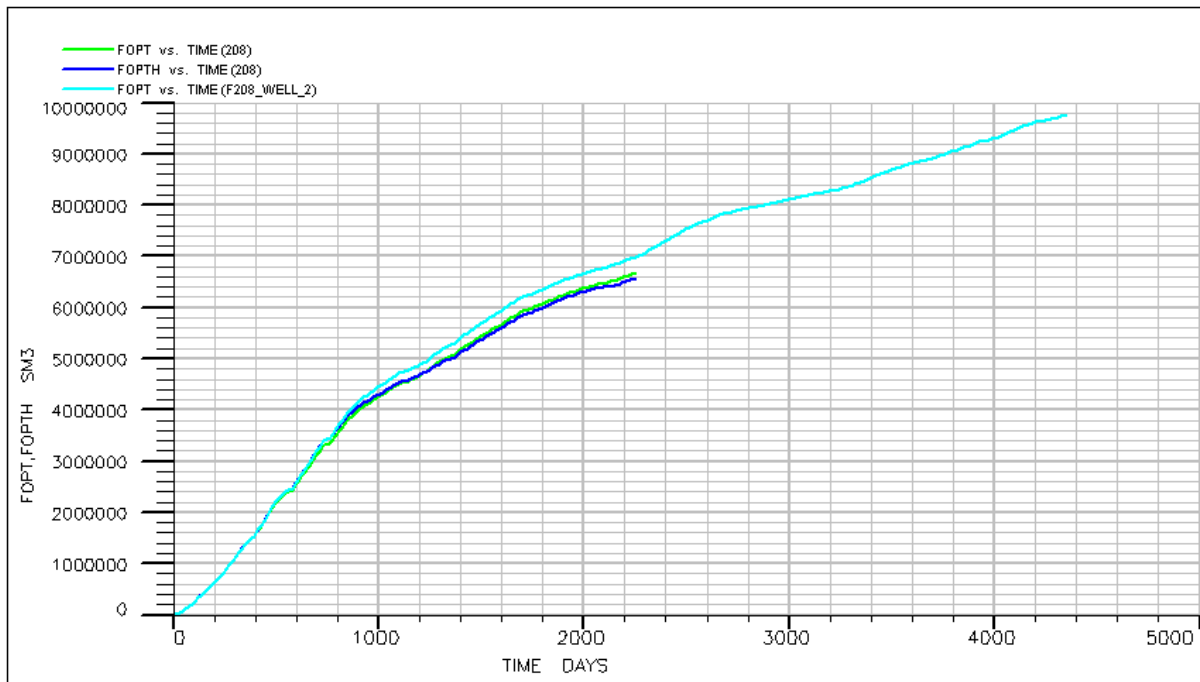
Figure 94: FOPT for 2nd well's extrapolated injection

Again the 2nd well does not present very good results; equally moderate in quality to the results obtained from the 1st well. The production rate is throughout the time period at the same level with that of history's production. The FOPT diagram offers a better demonstration of the results. The final cumulative oil production for the 2nd well is now about 975,000 SM^3. In essence there seems to be no significant difference in the effect the 1st well has compared to that of the 2nd well, and both of them are regarded as ineffective.

8.5.3 3rd well diagrams
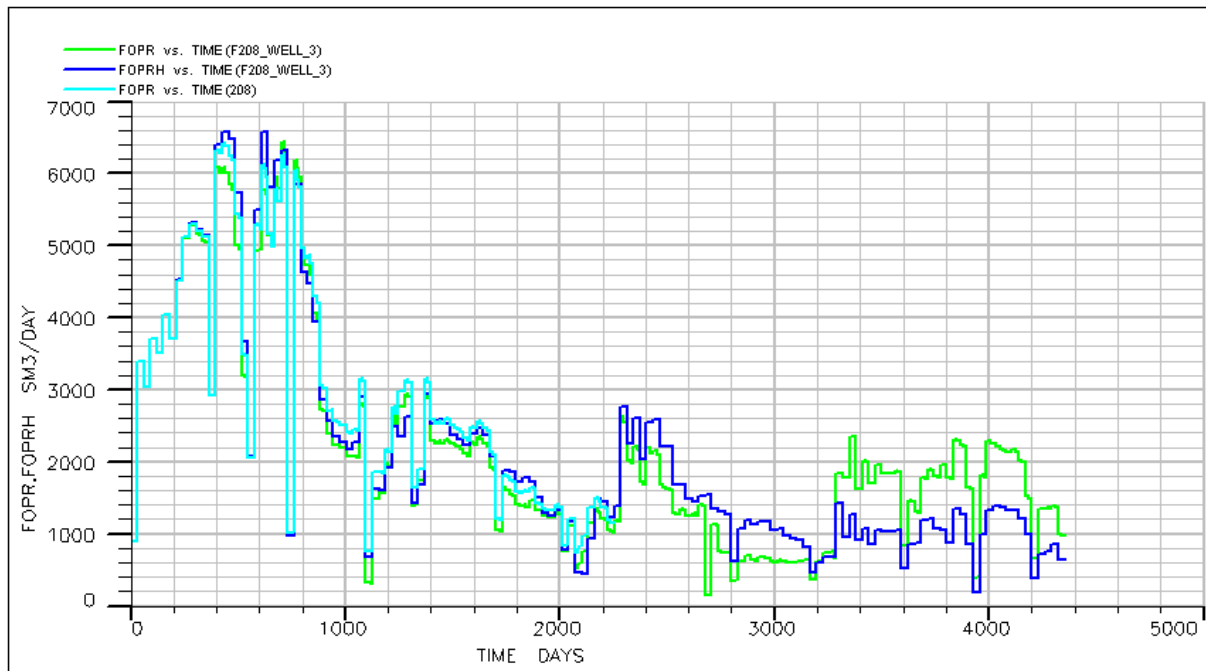
Figure 95: FOPR for 3rd well's extrapolated injection
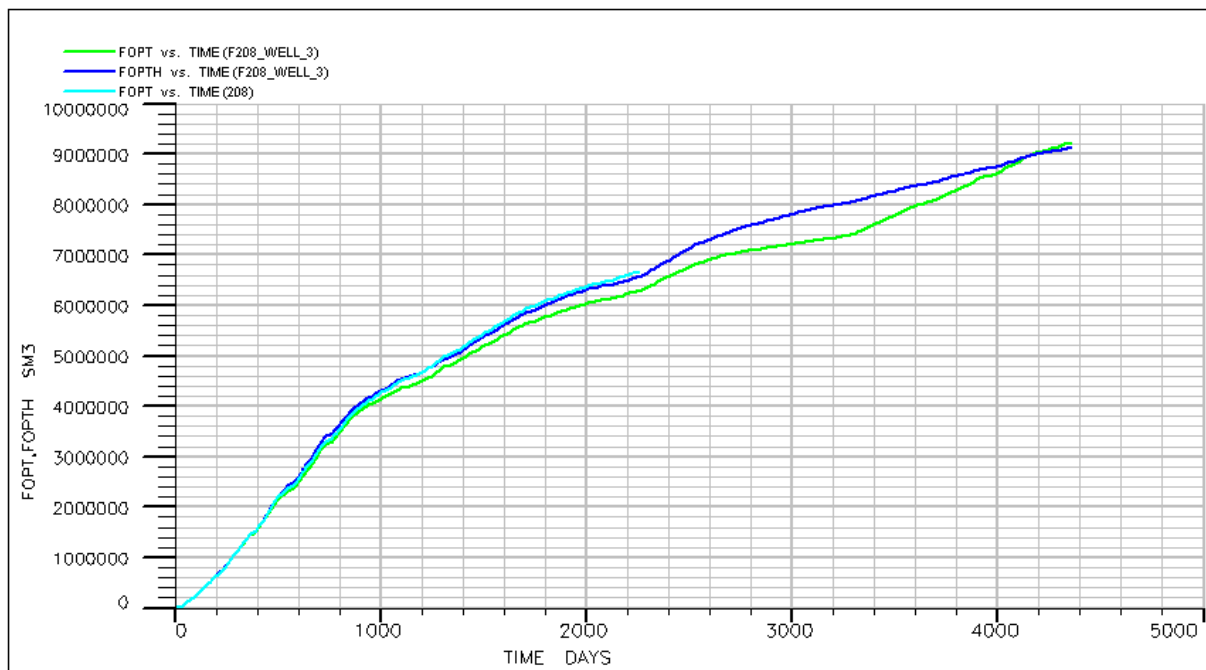
Figure 96: FOPT for 3rd well's extrapolated injection

In this case the production rate foreshadows the unsuitability of the 3rd well. The results obtained are slightly worse than the second's case results. The production rate is constantly below that of history's production, and only after the 3150 days, it becomes higher. However, that is not adequate in order for this trial to be considered as successful. This can also be seen at the FOPT diagram, where the oil cumulative production is 9,400,000 SM^3, and barely exceeds

that of history's total production. The total oil produced in this case is by 400,000 SM^3 less than the previous case.

8.5.4 4th well diagrams
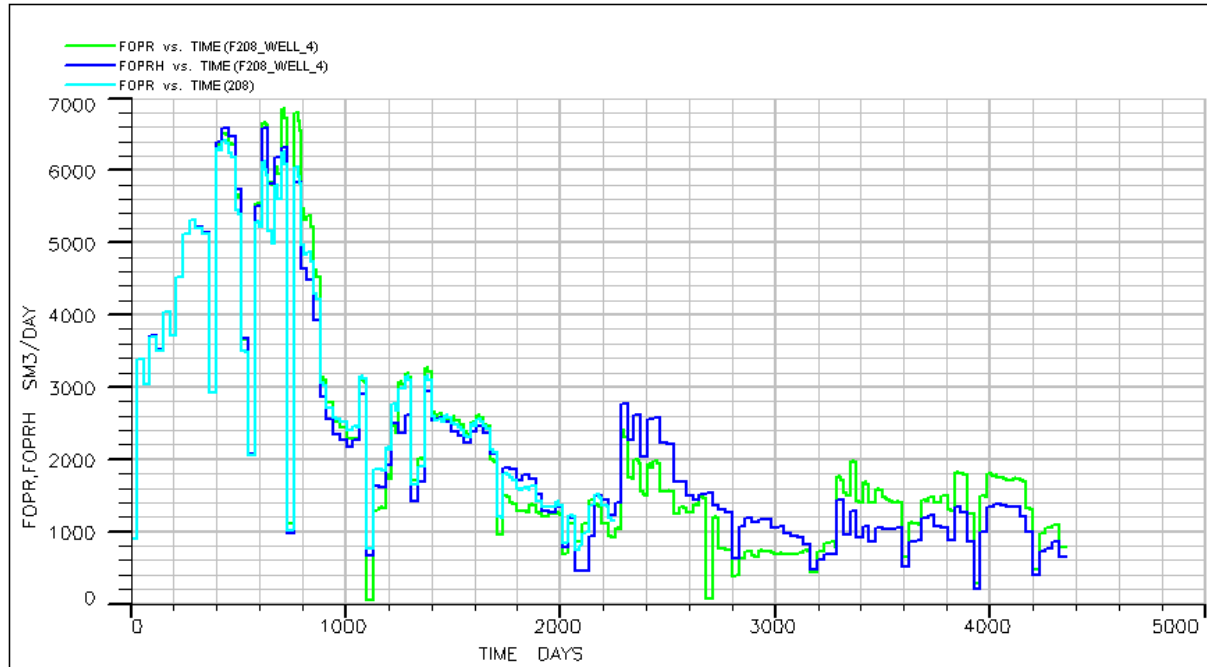
Figure 97: FOPR for 4th well's extrapolated injection
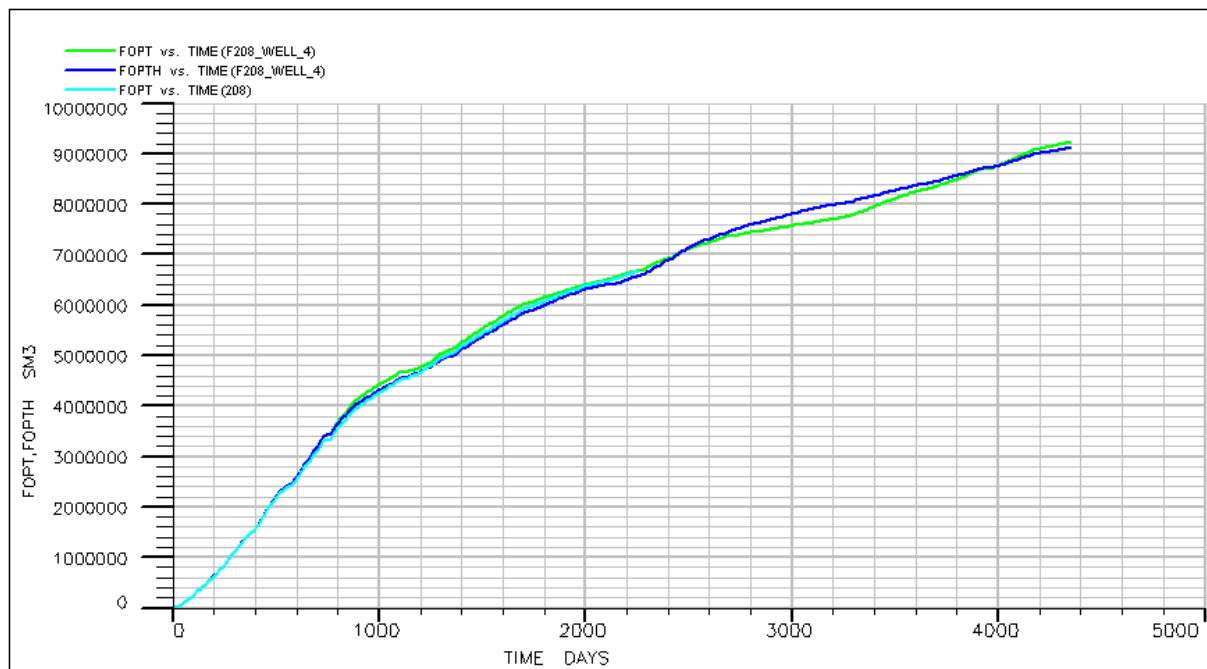
Figure 98: FOPT for 4th well's extrapolated injection

As in the case of well 3, well 4 does not present any better results than the cases so far carried out. Well's 4 production rate is lower and only towards the end it exceeds that of history's production rate. The total cumulative production of well 4 is slightly higher than that of history's cumulative production, and it scarcely exceeds a total production of 9,400,000 SM^3.

8.5.5 5th well diagrams
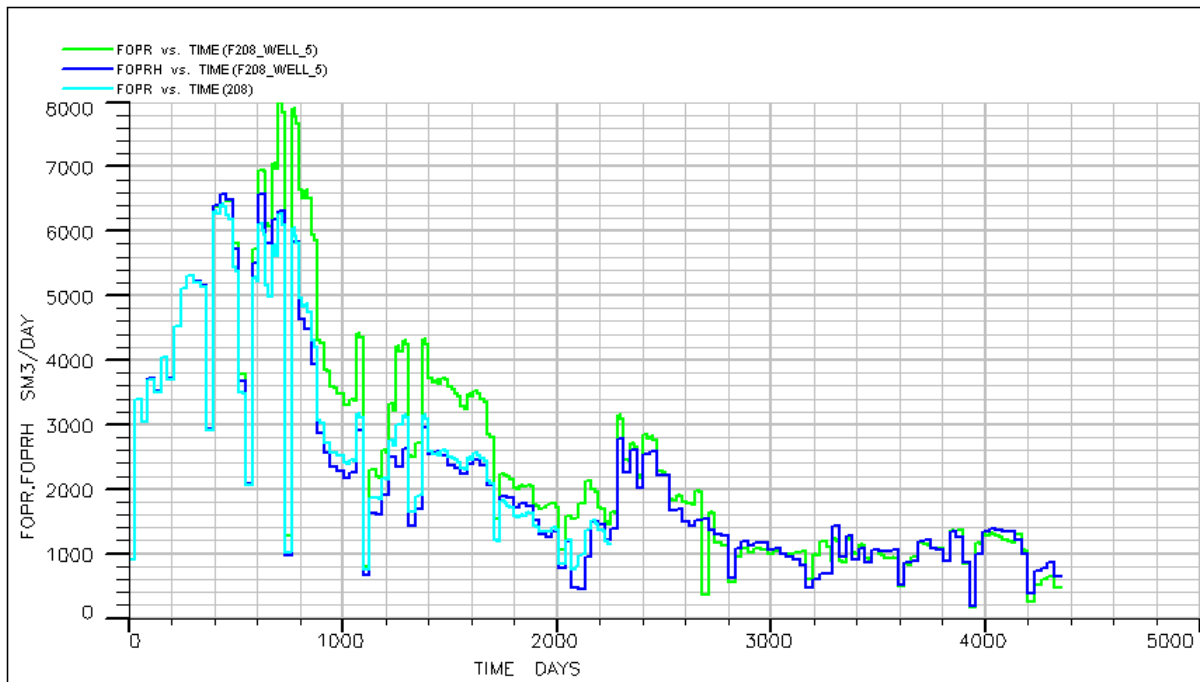
Figure 99: FOPR for 5th well's extrapolated injection
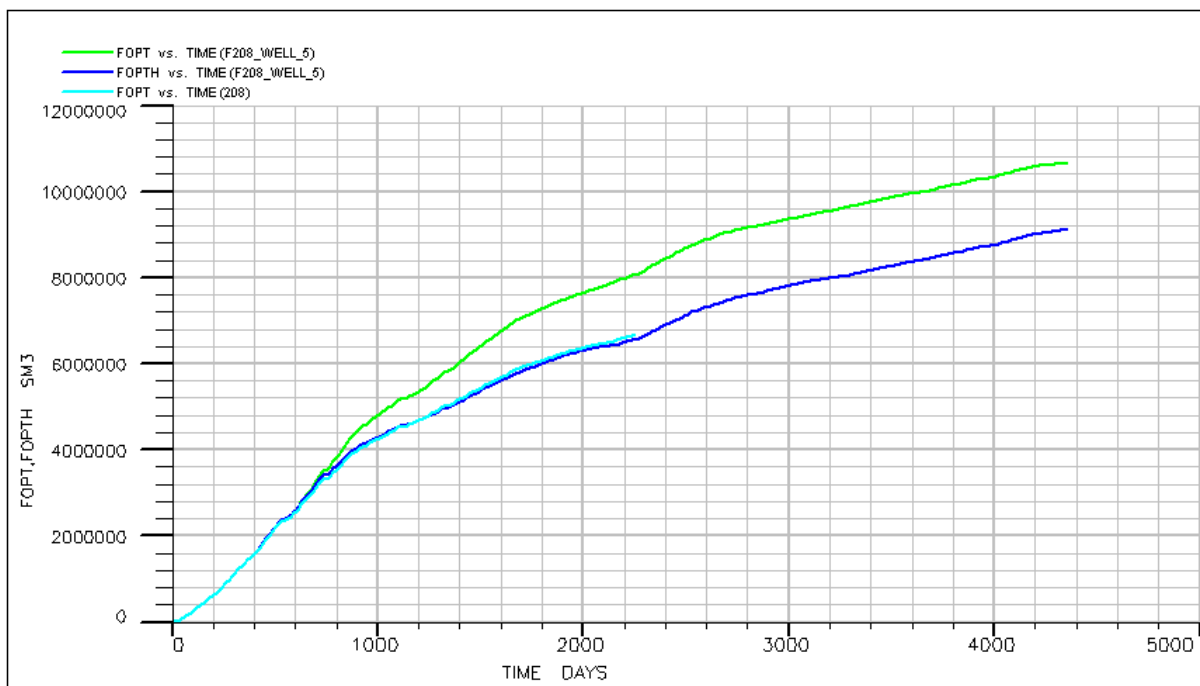
Figure 100: FOPT for 5th well's extrapolated injection

The oil production rate of well 5 predisposes the reader of an excellent trial, in terms of the effect to the total oil production this particular well has. Well's five production rate is almost constantly higher than that of history's production rate and only after 3000 days have passed the production rates seem to get equalised. The superiority of well's 5 oil total production, compared to that of history, is better illustrated by the FOPT diagram. The total oil production reaches to 10,750,000 SM^3 which is higher by almost 1,600,000 SM^3 from the history's total oil

production, and almost 1,000,000 higher, compared to the best so far results obtained from the previous cases.

8.5.6 6th well diagrams
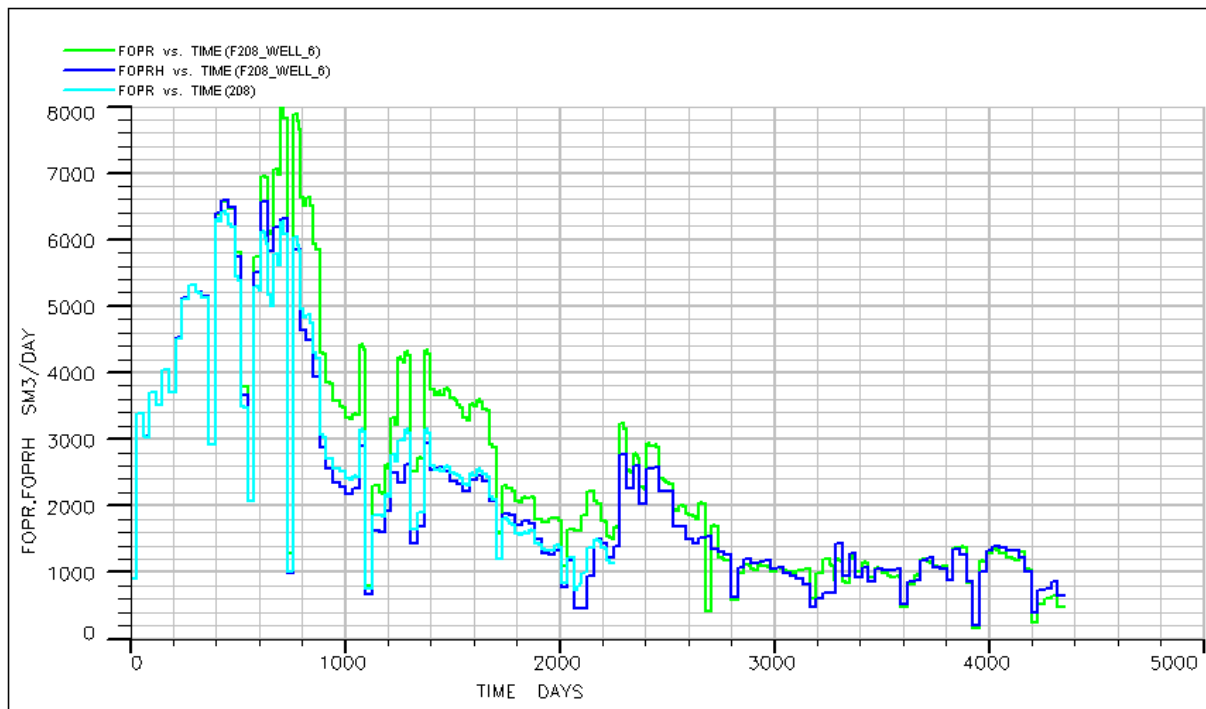
Figure 101: FOPR for 6th well's extrapolated injection
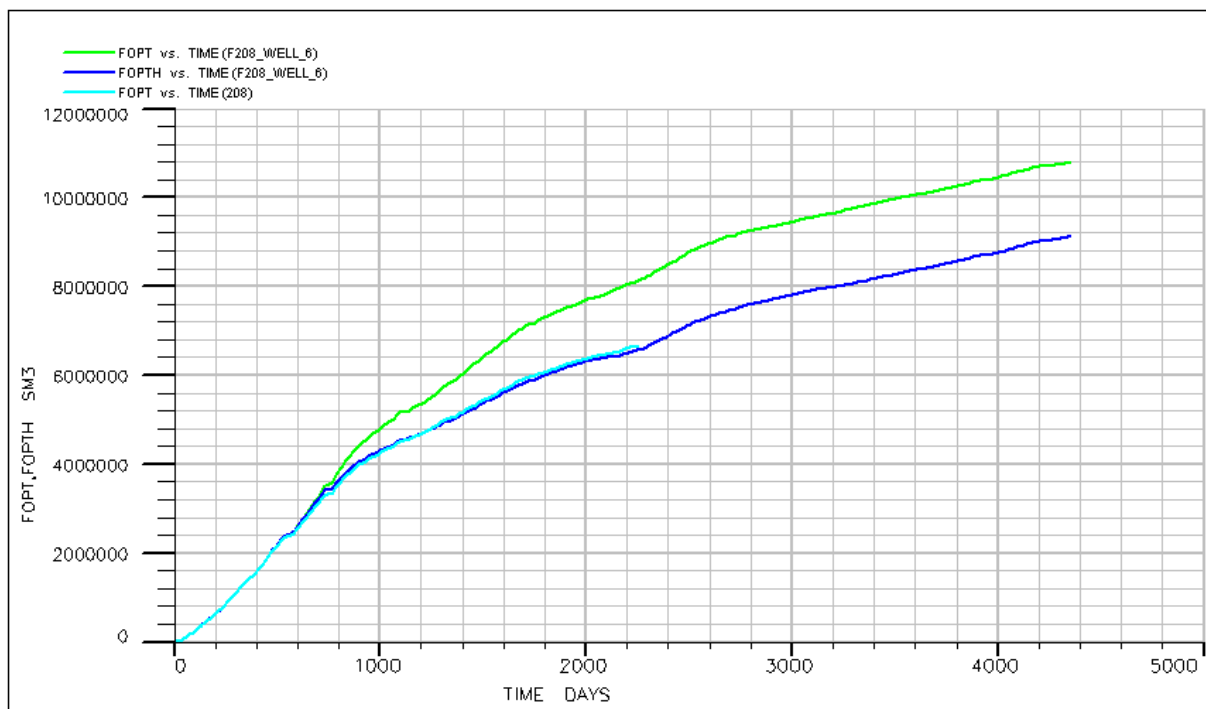
Figure 102: FOPT for 6th well's extrapolated injection

Once more, the predisposition by looking to the production rate is a positive one. The production rate of well 6 is most of the time higher than that of history's production rate.

Furthermore, the achieved oil cumulative due to the addition of well 6, reaches to 10,800,000 SM^3, whereas the history's oil total production goes only up to about 9,100,000 SM^3.

8.6 Forecasting with additional injection well to be created after the recorded History

Likewise the previous model, for the 2300 days history matched model, after the execution of the entire schedule for each of the suggested locations; with the constraint of equal injection water, the previously best performed wells will be used for an extrapolation forecast. So as with the previous case, the extrapolation will be executed on the entire model, with the new injection well's operation to commence after the 4300 days of the recorded history. As already mentioned above, the objective of this execution is to determine whether the additional well, at the specified locations, will increase the production of oil.

8.6.1 Trial with 2300 day history matched model

Amongst the 6 attempted well locations presented above, those that produce the best results will be chosen. The worse results derived are those from the well 3 and 4. There is a significant resemblance to the results obtained from well 1 and 2, and also to the results obtained from well 5 and 6. However, well 1 and 2 do not produce satisfactory results, and therefore they are rejected. So the results that are regarded as successful are being derived from wells 5 and 6, since the achieved increase in the total production is compelling. Consequently these two wells will undergo the scenario in which the additional well becomes operational only after 4300 days have passed.

Likewise with the previous model, in both wells the injection rate was constant at all times, thus resulting in an equivalent injection water quantity, so that the results may be comparable.

8.6.1.1 Well 5 operational after 4300 days
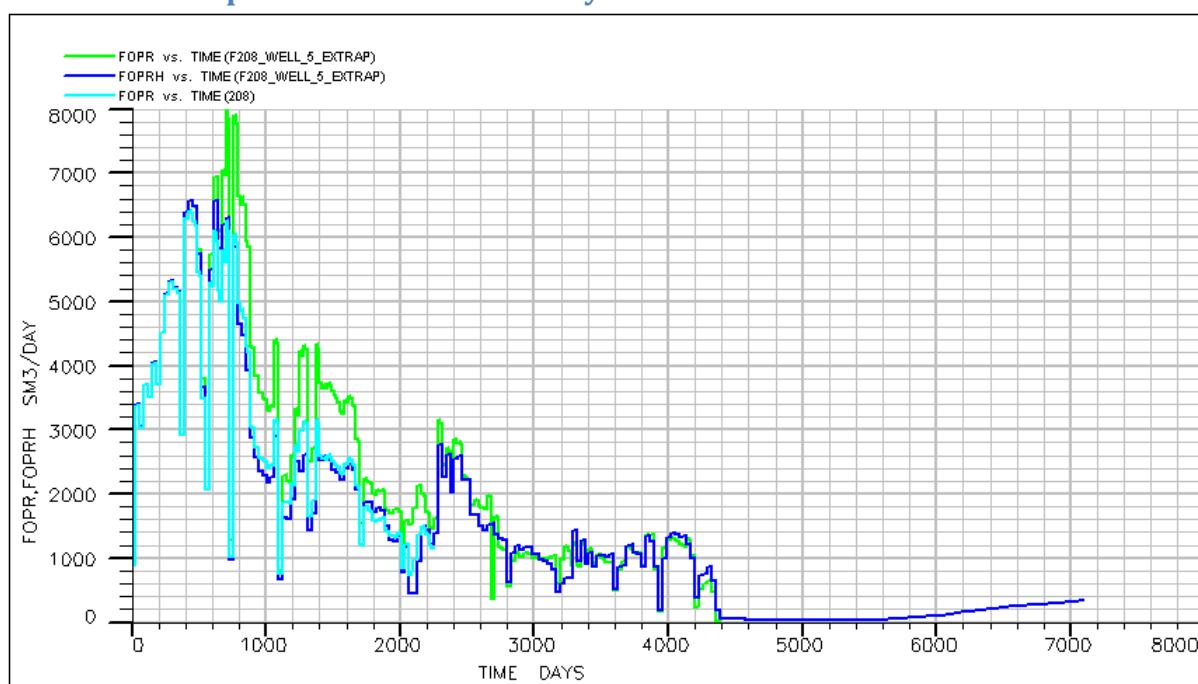
Figure 103: FOPR for 5th well's extrapolated injection after history end

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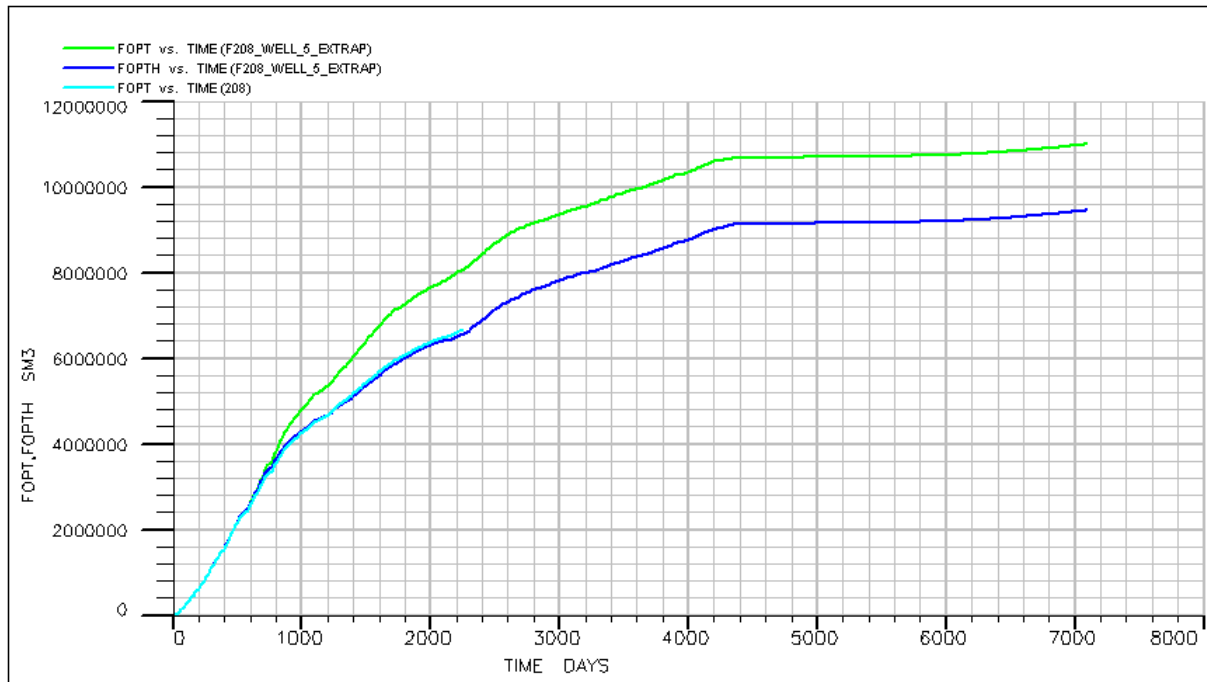
Figure 104: FOPT for 5ᵗʰ well's extrapolated injection after history end

After the 4300 days, the production rate nearly drops to zero, which is also depicted at the FOPT diagram, since for as long as the production rate was that low, the oil cumulative production remained stable. Only after the 5000 days, when the production rate had an upwards slope, the FOPT presented an increase. In general, the total oil production for well 5 has risen up to 11,000,000 SM^3, which makes it about 800,000 SM^3 higher than history's achieved total production.

8.6.1.2 Well 6 operational after 4300 days
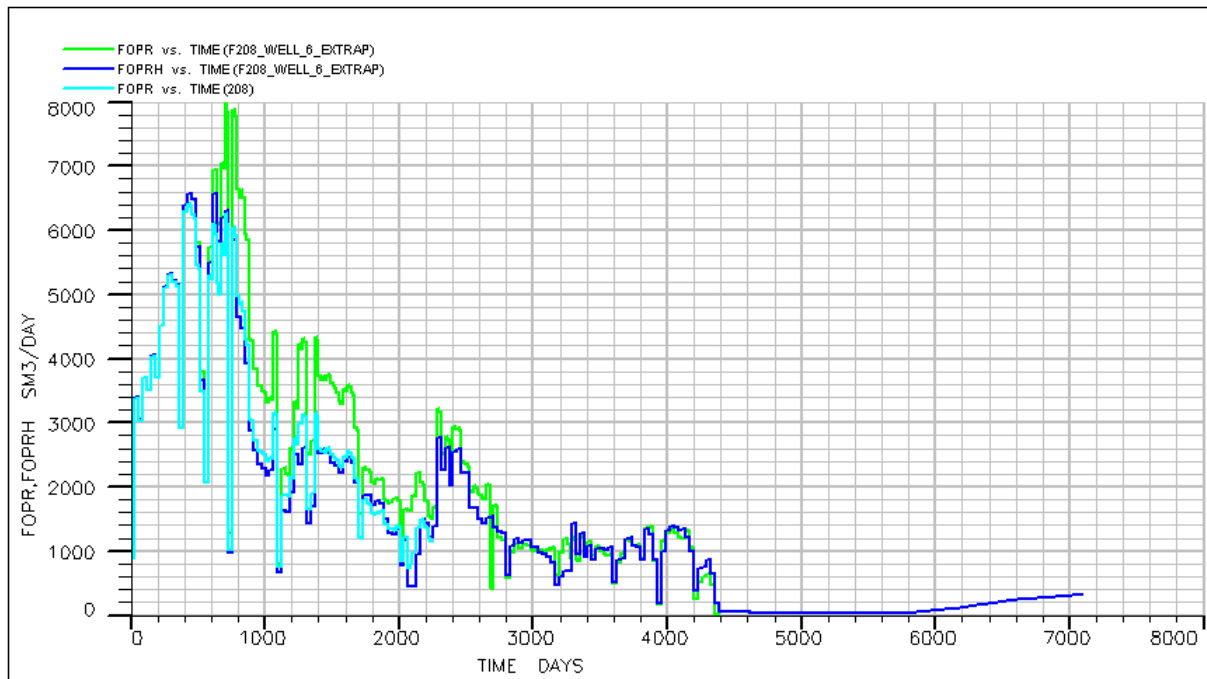
Figure 105: FOPR for 6ᵗʰ well's extrapolated injection after history end
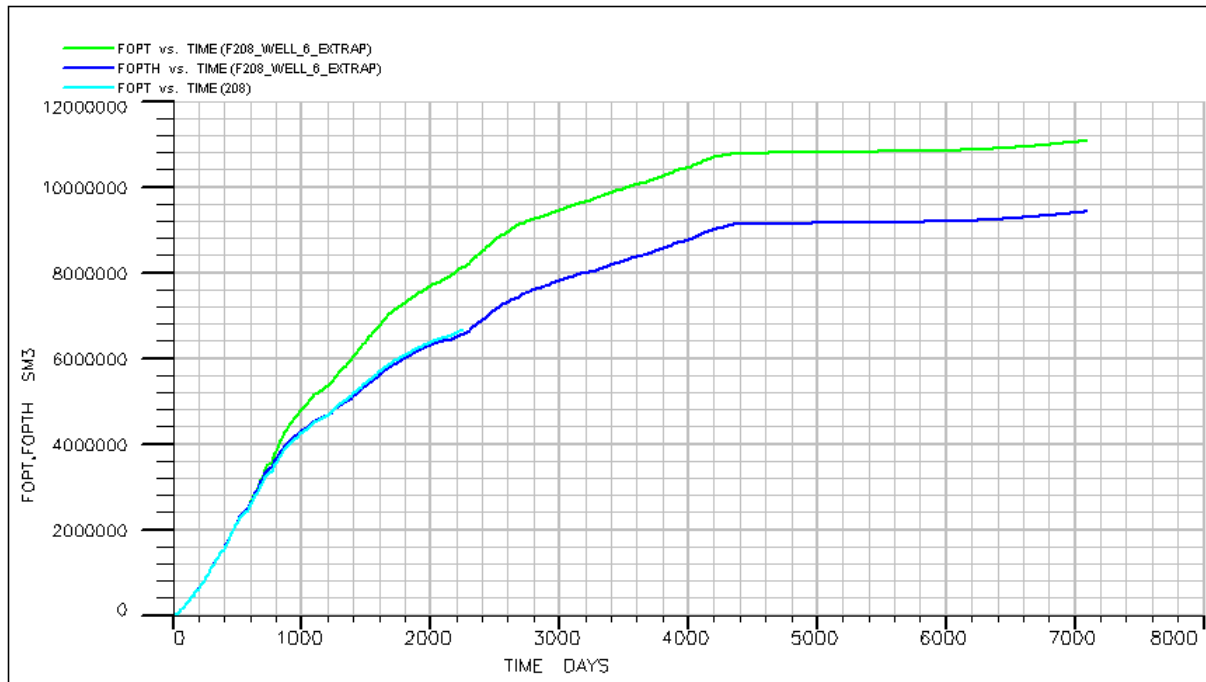
Figure 106: FOPT for 6th well's extrapolated injection after history end

Likewise, the production rate drops almost to zero, and after 5000 days it starts getting positive again. No significant difference in this trial compared to the one previously seen. More specifically, the total oil production for well 6 has reached 11,100,000 SM^3, which is slightly higher than the total production of well 5.

8.7 Model comparison and optimal well location suggestion

As far the 4300 day history matched model is concerned, it can be said that wells 5 and 6 gave the best results. The production had the best incremental percentages for these two locations. The increase in oil production is close to 100,000 SM^3 for the total field oil production for both of these well locations. The amount of oil cannot be negligible due to the fact that only one production well is operational for the time period after the overall recorded history.

As far as the 2300 days history matched model is concerned, it can be concluded that there has been achieved a significant increase in the field oil production total with the wells 5 and 6, when they became operational after 4300 days. The best results have been produced by well 6, which returned a total production of 11,100,000 SM^3. For the 6 trials that took place throughout the recorded history, the one the produced the best results was again well 6, with a total cumulative of 10,800,000 SM^3. This compensates for an overall 300,000 SM^3 increase in the field oil production total.

According to the recorded history, the total oil production would reach up to 9,100,000 SM^3. With the interventions stated above, by placing a well to location number 6, which is at the corner end of the reservoir, an increase of the order of 1,700,000 SM^3 is accomplished, which

accounts for 1,700,000/9,100,000 x 100 = 18.7% of the total production. In order for the reference point to be further understood, it has to be said that the reservoir with the initial settings has to be operational for a period of around 420 days, or 1.15 years for the production to reach a total of 1,700,000 SM^3. Hence, the interventions that were examined in this Thesis, ultimately lead to an improvement of the total oil production which is not at all negligible.

Taking all the above into consideration, it can be concluded that the best location for a new injection well to be placed, is location 6. This particular location may result is a wider sweeping effect due to the geometry of the area. Thus it is the location best suggested for improving the oil recovery. Further improvement can be achieved by activating more production wells, and/or the initiation of tertiary recovery techniques (EOR).

Conclusions

If we were to guess the best possible position of a new injection well, with respect to the oil productivity prospects, then most probably we would place it at some place where the reservoir fluids have little space to maneuver.

Indeed, the main findings of this thesis advocate in favor of choosing such a location, amongst all the different locations that have been tested. This could be at a corner edge of the reservoir, as for location number 6, since it allows for the otherwise trapped hydrocarbon quantities, to be mobilized by the additional injected water towards the production wells.

However, apart from clarifying the new optimal well location, an economic analysis regarding the investment needs to be done; both in the short and in the long term period. Such an analysis will dictate the viability of the investment and whether its potential profits can compensate for the definite investment and maintenance costs.

Of course the increase in productivity could be further enhanced by combining the placement of new injection well, with the placement of a new production well. Moreover, the development of new wells can be also combined with the deactivation of existing wells, or with the activation of previously deactivated wells, according to the movement of fluids inside the reservoir.

To conclude with, it has to be said that the entire production has resulted in large quantities of oil being trapped inside the reservoir, due to the decrease in the oil saturation, thus resulting in the remaining oil to be immobile as residual. These amounts, or at least a percentage of them, may be possible to be extracted through EOR techniques.

Suggestions for further study

1) Productivity analysis of production increase due to the placement of a new production well.
2) Future forecast by applying EOR procedures.
3) Simulation study of production behavioral change due to reservoir pressure drop, bellow bubble point.

Bibliography

Chin, W. (2002). *Quantitative methods in reservoir engineering*. Amsterdam: Gulf Professional Pub.

Dake, L. (1978). *Fundamentals of reservoir engineering*. Amsterdam: Elsevier.

Dake, L. (2001). *The practice of reservoir engineering*. Amsterdam: Elsevier.

ECLIPSE reservoir simulation software Reference Manual, Version 2014.1. (2014). Schlumberger.

Ertekin, T., Abou-Kassem, J. and King, G. (2001). *Basic applied reservoir simulation*. Richardson, Tex.: Society of Petroleum Engineers.

Fanchi, J. (2006). *Principles of applied reservoir simulation*. Amsterdam: Gulf Professional Pub.

Fayers, F. (1981). *Enhanced oil recovery*. Amsterdam: Elsevier Scientific Pub. Co.

Holstein, E. and Lake, L. (2007). *Petroleum engineering handbook Vol. 5*. Richardson, TX: Society of Petroleum Engineers.

Jelmert, P., Chang, N. and НГЕіer, L. (2010). Comparative Study of Different EOR Methods. *NTNU, Department of Petroleum Engineering, Norwegian University of Science & Technology, Trondheim, Norway*.

Koederitz, L. (2005). *Lecture notes on applied reservoir simulation*. Singapore: World Scientific Pub. Co.

Lyons, W. and Zaba, J. (1996). *Standard handbook of petroleum & natural gas engineering*. Houston, Tex.: Gulf Pub. Co.

Pettersen, Г. (2006). *Basics of Reservoir Simulation with the Eclipse Reservoir Simulator*. Bergen, Norway: Department of Mathematics, University of Bergen.

Reservoir Simulation. (2005). Edinburgh, Scotland, UK: Heriot Watt University, Institute of Petroleum Engineering.

Whitson, C. and BruleM⬚, M. (2000). *Phase behavior*. Richardson, Tex.: Henry L. Doherty Memorial Fund of AIME, Society of Petroleum Engineers.

Yaghi, H. (1999). *Petroleum reservoir simulation using 3-D finite element method with parallel implementation*.

Yaghi, H. (2013). *Petroleum Reservoir Simulation*. SaarbruM⬚cken: LAP LAMBERT Academic Publishing.

Zemel, B. (1995). *Tracers in the Oil Field*. San Diego: Elsevier Science [Imprint].

H.M. Ånes, O. Haga, R. Instefjord and K.G. Jakobsen: "*The Gullfaks Lower Brent Waterflood Performance*" paper presented at The 6th European Symposium on Improved Oil Recovery, 21-23 May 1991 in Stavanger, Norway.

Fossen H. & Hesthammer J: "Structural Geology of the Gullfaks Field, northern North Sea", In Coward M.P., Daltaban T.S. & Johnson H. (editors) Structural Geology in Reservoir Characterization. Geological Society, London, Special Publications, 127, 231-261.

Samsonsen B., Jacobsen B.G., Skagestad T. & Kerr S., Statoil a.s.: "Drilling and Completing a High Angle Well with Coiled Tubing Technology" paper SPE 48941 presented at the 1998 SPE Annual Technical Conference and Exhibition held in New Orleans, Louisiana 27-30 September.

Bale A., Owren K., and Smith M.B.,: "Propped Fracture as a Tool for Sand Control and Reservoir Management" SPE 24992, presented at EUROPEC, Cannes, France 16-18 November 1992.

Agustsson H., Stroenen L.K., and Solheim, O.A.,: "The Gullfaks Field: "Creating Value by means of a Multidisciplinary Reservoir Management Approach", paper OTC 10739 presented at the 1999 Offshore Technology Conference, Houston, Texas, 3-6 May 1999.

Ahmed, Tarek H. Reservoir Engineering Handbook. Amsterdam: Gulf Professional Pub., 2010. Print.

Ahmed, Tarek, and Paul D. McKinney. Elsevier Inc., 2005. Print.

Ahr, Wayne M, and Wayne M Ahr. Geology Of Carbonate Reservoirs. Somerset: Wiley, 2011. Print.

Batchelor, G. K, H. K Moffatt, and M. G Worster. Perspectives In Fluid Dynamics. Cambridge: Cambridge University Press, 2000. Print.

Danesh, Ali. PVT And Phase Behaviour Of Petroleum Reservoir Fluids. Amsterdam: Elsevier, 1998. Print.

Dikkers, A. J. Geology In Petroleum Production. Amsterdam: Elsevier, 1985. Print.

Firoozabadi, Abbas. Thermodynamics Of Hydrocarbon Reservoirs. New York: McGraw-Hill, 1999. Print.

McCain, William D. The Properties Of Petroleum Fluids. Tulsa, Okla.: PennWell Books, 1990. Print.

Websites

Anon, (2015). [online] Available at: http://www.treccani.it/portale/opencms/handle404?exporturi=/export/sites/default/Portale/sito/altre_aree/Tecnologia_e_Scienze_applicate/enciclopedia/inglese/inglese_vol_1/pag031-64ING3.pdf.

Asu.edu, (2015). *Arizona State University | A top ranked research university | ASU*. [online] Available at: http://www.asu.edu.

Bairdusa.com, (2015). *BPI Baird Petrophysical International*. [online] Available at: http://bairdusa.com.

Encyclopedia Britannica, (2015). [online] Available at: http://www.britannica.com .

Gly.uga.edu, (2015). [online] Available at: http://www.gly.uga.edu.

Informit.com, (2015). *InformIT: The Trusted Technology Source for IT Pros and Developers*. [online] Available at: http://www.informit.com.

Ogj.com, (2015). *Oil & Gas Journal- Oil and Gas News, Prices, Oil Drilling, Exploration and Production*. [online] Available at: http://www.ogj.com.

Petroleum.co.uk, (2015). *Petroleum | Information on Petroleum and Crude Oil*. [online] Available at: http://www.petroleum.co.uk.

Petrowiki.org, (2015). *Fluid flow through permeable media* -. [online] Available at: http://petrowiki.org/Fluid_flow_through_permeable_media.

Petrowiki.org, (2015). *Gridding in reservoir simulation* -. [online] Available at: http://petrowiki.org/Gridding_in_reservoir_simulation.

Petrowiki.org, (2015). *High performance computing and reservoir simulation* -. [online] Available at: http://petrowiki.org/High_performance_computing_and_reservoir_simulation.

Petrowiki.org, (2015). *PEH:Reservoir Simulation* -. [online] Available at: http://petrowiki.org/PEH%3AReservoir_Simulation.

Petrowiki.org, (2015). *PEH:Well-To-Well Tracer Tests* -. [online] Available at:

http://petrowiki.org/PEH%3AWell-To-Well_Tracer_Tests.

Petrowiki.org, (2015). *Reservoir simulation* -. [online] Available at: http://petrowiki.org/Reservoir_simulation.

Petrowiki.org, (2015). *Reservoir simulation applications* -. [online] Available at: http://petrowiki.org/Reservoir_simulation_applications.

Petrowiki.org, (2015). *Reservoir simulation linear equation solver* -. [online] Available at: http://petrowiki.org/Reservoir_simulation_linear_equation_solver.

Petrowiki.org, (2015). *Upscaling of grid properties in reservoir simulation* -. [online] Available at: http://petrowiki.org/Upscaling_of_grid_properties_in_reservoir_simulation.

Sepmstrata.org, (2015). *Home - SEPMStrata*. [online] Available at: http://www.sepmstrata.org.

Spec2000.net, (2015). *Crain's Petrophysical Handbook - Home Page*. [online] Available at: http://www.spec2000.net.

Statoil.com, (2015). *Statoil β€" a leading energy company in oil and gas production*. [online] Available at: http://www.statoil.com.

Wikipedia, (2015). *ECLIPSE (reservoir simulator)*. [online] Available at: https://en.wikipedia.org/wiki/ECLIPSE_(reservoir_simulator).

Wikipedia, (2015). *Finite volume method*. [online] Available at: https://en.wikipedia.org/wiki/Finite_volume_method.

Appendix

1) 4300 day model final script

```
--
==========================================================
======
-- SIMULERINGSMODELL BLOKK 34/10 OSTLIG DEL GULLFAKS FELTET
--
-- H1 SEGMENT NEDRE BRENT
--
==========================================================
======
-- KOMMENTARER TIL MODELLEN:
-- BASIS TILFELLE MED 7 LAG
--
----------------------------------------------------------
------------------
-- 15.07.1997
--
==========================================================
======
RUNSPEC
TITLE
  Sekvensstratigrafisk modellering av Nedre Brent
DIMENS
--NX NY NZ
  20 40 13 /
OIL
WATER
METRIC
START
--DAY MONTH YEAR
  1 'DEC' 1986 /
WELLDIMS
--NWMAXZ NCWMAX NGMAXZ NWGMAX
  15    20    2     10 /
--NOSIM
ENDSCALE
2* 3 /
ROCKCOMP
 'HYSTER'  1 /
TABDIMS
  1  3* 8 /
UNIFIN

UNIFOUT

GRIDOPTS
YES 0 3 /

--NOSIM
NSTACK
 110  /


TRACERS  --OIL  WATER  GAS  ENV    FLS
           0    3    0    0    'DIFF' /


GRID
==========================================================
--      I DENNE SEKSJONEN SPESIFISERES GRIDDETS GEOMETRI OG
--      BERGARTS PARAMETRENE PERMEABILITET OG POROSITET.
--      RUTENETTET ER KONSTRUERT V.H.A RESVIEW
----------------------------------------------------------
---------
-- GRID DIM.: 20 X 40 X 13  (global grid)
--NOGGF
GRIDFILE
2/
NOECHO
INIT
NEWTRAN
--
MESSAGES
2* 10000 1000 4* 10000 1000 /
----------------------------------------------------------
-----------
-- INKLUDERER COORD, ZCORN FOR HELE MODELLEN
INCLUDE
  '../../INCLUDE/GRID/GRID-13-REV.GRDECL'  /

-- ELIMINERER ALLE BLOKKER MED TJUKKELSE MINDRE ENN 0.1 M
PINCH
0.30 2* 'ALL' /

RPTGRID
'ALLNNC'   /
----------------------------------------------------------
-----------
-- SETTER BLOKKER UTENFOR HOVEDFORKASTNINGER INACTIVE
INCLUDE
  '../../INCLUDE/GRID/ACT-13-REV' /
----------------------------------------------------------
------------
-- OPPSKALERT PERM FRA STORM
INCLUDE
  '../../INCLUDE/GRID/upsc_zone6_perm'  /

-- OPPSKALERT POROSITET FRA STORM
INCLUDE
  '../../INCLUDE/GRID/upsc_zone6_poro'  /

-- PETROFYSIKK FOR BROOM (LAG 13)
--INCLUDE
--  '/project/gf_h1_nb/ECLIPSE/INCLUDE/GRID/broom.param'  /
----------------------------------------------------------
---------
INCLUDE
  '../../INCLUDE/GRID/wblck_param_z6ff'  /
```

```
----------------------------------------------------------
---------
BOX
  1 20 1 40 1 13  /
COPY
  'PERMX' 'PERMY' /
  'PERMX' 'PERMZ' /
/

ENDBOX
----------------------------------------------------------
---------
INCLUDE
  '../../INCLUDE/GRID/multz_zone6_m2'  /
----------------------------------------------------------
----------
-- INKLUDERER NTG FOR HVERT LAG
EQUALS
  'NTG' 0.19 1 20 1 40  1  2 /
  'NTG' 0.96 1 20 1 40  3  3 /
  'NTG' 0.98 1 20 1 40  4  5 /
  'NTG' 0.90 1 20 1 40  6  6 /
  'NTG' 0.96 1 20 1 40  7  9 /
  'NTG' 1.00 1 20 1 40 10 10 /
  'NTG' 0.90 1 20 1 40 11 13 /
/
----------------------------------------------------------
------------
-- KORRIGERER VERTIKAL PERMEABILITET
--- KV/KH = 0.1
--MULTIPLY
--  'PERMZ'  0.1 /
--/
--------------------------------------------------




----------------------------------------------------------
-----------------

EDIT
==========================================================
--      I DENNE SEKSJONEN GIS INSTRUKSJONER FOR MODIFIKASJONER

BOX
1 5 11 21 1 12 /

MULTX
660*0.5 /

MULTX-
660*1.7 /

MULTY
660*100 /

MULTY-
660*0.1 /

ENDBOX

BOX
6 8 11 21 1 12 /

MULTX
396*0.7 /

MULTX-
396*2.5 /

MULTY
396*100 /

MULTY-
396*0.1 /

ENDBOX

BOX
1 8 1 9 1 4 /

MULTX
288*15 /

--MULTY
--288*0 /

MULTY-
288*80 /

MULTZ
288*0 /

ENDBOX

BOX
14 17 2 5 3 7 /

MULTX
80*10 /

MULTY
80*0 /

MULTY-
80*120 /

MULTZ
80*10 /

ENDBOX

BOX
18 19 2 5 3 7 /

MULTX
40*10 /
```

```
MULTY
40*0 /

MULTY-
40*120 /

MULTZ
40*10 /

ENDBOX


--------P-A17----------

BOX
10 12 21 23 9 12 /

MULTZ-
36*0 /

MULTZ
36*0 /

MULTY-
36*0.5 /

MULTX
36*0.5 /

ENDBOX


BOX
10 12 21 23 5 6 /

MULTZ-
18*0 /

MULTZ
18*0 /

MULTX
18*0.5 /

ENDBOX


BOX
4 6 18 21 9 11 /

MULTY-
36*500 /

MULTZ-
36*0 /

MULTZ
36*0 /

ENDBOX


BOX
4 11 19 21 9 11 /

MULTX
72*500 /

MULTY
72*0 /

MULTY-
72*500 /

MULTZ-
72*0 /

MULTZ
72*0 /

ENDBOX

BOX
10 13 15 21 5 6 /

MULTY-
56*0.25 /

ENDBOX

BOX
6 8 15 22 5 6 /

MULTY-
48*1.3 /

ENDBOX

BOX
5 11 21 23 5 6 /

MULTX
42*1.3 /

ENDBOX

BOX
12 13 15 22 9 11 /

MULTY-
48*0 /

ENDBOX

BOX
1 11 22 24 9 12 /

MULTX
132*1.5 /
```

```
ENDBOX

BOX
11 11 22 22 5 6 /

MULTX
2*2 /

MULTX-
2*2 /

MULTY
2*2 /

MULTY-
2*2 /

MULTZ
2*2 /

MULTZ-
2*2 /

ENDBOX

BOX
11 11 22 22 9 12 /

MULTX
4*0.01 /

MULTX-
4*0.01 /

MULTY
4*0.01 /

MULTY-
4*0.01 /

MULTZ
4*0.01 /

MULTZ-
4*0.01 /

ENDBOX


------------P-A2AH--------

BOX
5 14 12 15 6 12 /

MULTX
280*0.2 /

ENDBOX


--------P-A35---------
BOX
5 7 28 32 1 12 /

MULTX
180*2 /

MULTX-
180*5 /

MULTY
180*20 /

MULTY-
180*70 /

MULTZ
180*0 /

MULTZ-
180*0 /

ENDBOX


BOX
1 6 32 34 9 12 /

MULTX
72*0.01 /

MULTY-
72*0.01 /

ENDBOX


BOX
6 6 33 33 3 6 /

MULTX
4*0.2 /

MULTX-
4*0.2 /

MULTY
4*0.2 /

MULTY-
4*0.2 /

MULTZ
4*0.2 /

MULTZ-
4*0.2 /

ENDBOX

BOX
6 6 33 33 9 12 /
```

```
MULTX
4*0.1 /

MULTX-
4*0.1 /

MULTY
4*0.1 /

MULTY-
4*0.1 /

MULTZ
4*0.1 /

MULTZ-
4*0.1 /

ENDBOX


--------------P-A39A----------

BOX
15 17 10 13 10 12 /

MULTY-
36*0.05 /

MULTY
36*0.05 /

MULTX
36*2.5 /

MULTX-
36*0.05 /

ENDBOX

BOX
14 16 9 19 11 12 /

MULTY-
66*8 /

MULTY
66*8 /

MULTX-
66*200 /

MULTX
66*200 /

ENDBOX


------------------------------------------------------------
----------------

PROPS
============================================================
--      I DENNE SEKSJONEN DEFINERES RELATIVE PERMEABILITETER,
--      INITIELL VANNMETNINGER, KAPILLARTRYKK OG PVT-
EGENSKAPER
--      TIL RESERVOARFLUIDENE.
--      REFERANSE:
------------------------------------------------------------
---------
-- KURVEFORM BASERT P□ A3H KJERNENE:
-- RANNOCH: aw=4.81,bw=-2.75, ao=5.76,bo=-2.52
-- ETIVE: aw=1.36,bw=1.02, ao=5.96,bo=-3.85
------------------------------------------------------------
---------
-- RELATIV PERMEABILITETS KURVER
INCLUDE
  '../../INCLUDE/PROPS/RELP1.HIST'    /
------------------------------------------------------------
---------
-- ENDPUNKTSSKALERING I OLJESONEN
SCALECRS
  'NO' /
------------------------------------------------------------
-----------
-- OPPSKALERT VANNMETNINGER FRA STORM
--INCLUDE
-- '/project/gf_h1_nb/ECLIPSE/INCLUDE/GRID/upsc_zone6_sw' /

--MAX VANNMETNIGER FOR INMOBILT VANN
BOX
  1 20 1 40 1 13 /
SWCR
 10400*0.15 /
ENDBOX
------------------------------------------------------------
-----------
--MIN VANNMETNINGER (I OLJESONEN)
COPY
  'SWCR' 'SWL' /
/
------------------------------------------------------------
------------
-- MAX OLJEMETNINGER FOR INMOBIL OLJE
BOX
  1 20 1 40 1 13 /
SOWCR
 10400*0.20 /
ENDBOX
------------------------------------------------------------
-----------
-- MAX VANNMETNINGER I VANNMETNINGS TABELLER

EQUALS
--     KONSTANT IX1  IX2  JY1  JY2  KZ1  KZ2
'SWU'    1.0    1    20   1    40   1    13   /
/
------------------------------------------------------------
------------
-- ENDEPUNKT RELATIV PERMEABILITET TIL VANN
-- KRWR(SORW) = (1-SORW)^4-0.1SORW
```

```
BOX
  1 20 1 40 1 13 /
KRWR
 10400*0.41 /
ENDBOX
------------------------------------------------------------
------------
-- ENDEPUNKT RELATIV PERMEABILITET TIL OLJE
BOX
  1 20 1 40 1 13 /
KRORW
 10400*1.00 /
ENDBOX
------------------------------------------------------------
------------
-- INKLUDERER PVT, ROCKTAB

INCLUDE
    '../../INCLUDE/PROPS/PVTH.HIST' /

TRACER
 'IW1' 'WAT' 'Mbq' /
 'IW2' 'WAT' 'Mbq' /
 'IW3' 'WAT' 'kg' /
 /

--TRACTVD

RPTPROPS
8*0 0 1 /


REGIONS
============================================================
--      REGIONS-SEKSJONEN DEFINERER HVORDAN GRIDET ER DELT INN
I
--      REGIONER OG TILORDNER FORSKJELLIG KURVESETT FOR
METNINGER TIL
--      BLOKKENE.
------------------------------------------------------------
---------
--BOX
--  1 20 1 40 1 7 /
--SATNUM
--  800*1 1600*2 2400*3 /
--ENDBOX

--INCLUDE
--   '../../INCLUDE/GRID/SATNUM-13' /

--TRACER

TNUMFIW1
 10400*1 /
TNUMFIW2
 10400*1 /
TNUMFIW3
 10400*1 /

BOX
  1 20 1 40 1  13 /
PVTNUM
 10400*1 /
SATNUM
 10400*1 /
ENDBOX

BOX
  1 20 1 40 1 13 /
ROCKNUM
 10400*1 /
ENDBOX
------------------------------------------------------------
---------
-- INKLUDERER FIPNUM PR FORMASJON OG BLOKK
BOX
  1 20 1 40 1 13 /
FIPNUM
 1600*1 1600*2 1600*3 1600*4 1600*5 2400*6 /
ENDBOX

BOX
  1 20 1 40 1 13 /
EQLNUM
 10400*1 /
ENDBOX

--TRACER

RPTREGS
 19*0 1 /


SOLUTION
============================================================
--     SOLUTION-SEKSJONEN DEFINERER DEN INITIELLE TILSTAND
TIL HVER
--     BLOKK I RESERVOARET.(TRYKK,METNINGER OG GASS/OLJE
VERDIER)
--
------------------------------------------------------------
---------
-- SPESIFIKASJON AV TRYKK OG KAPILLARTRYKK VED KONTAKTENE
--
-- DATUM  DATUM   OWC    OWC     GOC     GOC   RSVD RVVD SOLN
--  DYP   TRYKK   DYP    PCOW    DYP     PCOG  TAB  TAB  METH
--  (M)   (BARS)  (M)    (BARS)  (M)     (BARS)
EQUIL
   1850   310.0  1947    0  4* 0      /
------------------------------------------------------------
---------
-- UTSKRIFT AV INITIELL OLJEVOLUM
--RPTSOL
-- 6*0 2 3  /

--TRACER
TVDPFIW1
3000.0   0.0
6000.0   0.0  /
/

TVDPFIW2
3000.0   0.0
```

```
6000.0  0.0 /
/
TVDPFIW3
3000.0  0.0
6000.0  0.0 /
/
SUMMARY
=================================================================
--       DENNE SEKSJONEN SPESIFISERER HVILKE DATA SOM SKAL
SKRIVES TIL
--       SUMMARY-FILENE OG SOM SENERE KAN PLOTTES I GRAF.
---------------------------------------------------------------
----------
INCLUDE
  '../../INCLUDE/SUMMARY/SUMIW3.HIST'  /

  --TRACER
RPTSMRY
1 /

WLPR
/
WLPT
/
FLPR
FLPT


SCHEDULE
=================================================================
--       SCHEDULE-SEKSJONEN DEFINERER OPERASJONER SOM SKAL
SIMULERES
-- INKLUDERER BRØNN OG HISTORISKE DATA

TUNING
1.0  20 /
 /
2* 100 /
-- UTSKRIFT AV DJUPN TIL RFT PLOTT
RPTSCHED
6*0 2 3*0 3 2*0 1 3 /

--RPTRST
--'BASIC=4'  /

--GRUPTREE
--'UB-H'  'U-BRENT'  /
--'UB-I'  'U-BRENT'  /
--'UB-I1' 'U-BRENT'  /
--'LB-H'  'L-BRENT'  /
--'LB-I'  'L-BRENT'  /
--'LB-I1' 'L-BRENT'  /
--'UB-HN' 'UB-H'     /
--'UB-HS' 'UB-H'     /
--'LB-HN' 'LB-H'     /
--'LB-HS' 'LB-H'     /
--/

INCLUDE
 '../../INCLUDE/SCHEDULE/schednewprod.sched1' /

END
```

2)   2300 day model final script

```
—–
================================================
============
-- SIMULERINGSMODELL BLOKK 34/10 OSTLIG DEL GULLFAKS
FELTET           --
-- H1 SEGMENT NEDRE BRENT
--
================================================
============
-- KOMMENTARER TIL MODELLEN:
-- BASIS TILFELLE MED 7 LAG
--
================================================
------------------------
-- 15.07.1997
--
================================================
============
RUNSPEC
TITLE
  Sekvensstratigrafisk modellering av Nedre Brent
DIMENS
--NX NY NZ
  20 40 13 /
OIL
WATER
METRIC
START
--DAY MONTH YEAR
  1 'DEC' 1986 /
WELLDIMS
--NWMAXZ NCWMAX NGMAXZ NWGMAX
  16    21     3     11 /
--NOSIM
ENDSCALE
2* 3 /
ROCKCOMP
 'HYSTER'  1 /
TABDIMS
  1  3* 8 /
UNIFIN

UNIFOUT

  --NOSIM
  NSTACK
```

```
 110  /


TRACERS  --OIL  WATER  GAS  ENV     FLS
            0     3     0    0    'DIFF' /

GRID
=================================================================
======
--       I DENNE SEKSJONEN SPESIFISERES GRIDDETS GEOMETRI
OG
--       BERGARTS PARAMETRENE PERMEABILITET OG POROSITET.
--       RUTENETTET ER KONSTRUERT V.H.A RESVIEW
---------------------------------------------------------------
---------------
-- GRID DIM.: 20 X 40 X 13  (global grid)
--NOGGF
GRIDFILE
2/
NOECHO
INIT
NEWTRAN
--
MESSAGES
2* 10000 1000 4* 10000 1000 /
---------------------------------------------------------------
-----------------
-- INKLUDERER COORD, ZCORN FOR HELE MODELLEN
INCLUDE
  '../../INCLUDE/GRID/GRID-13-REV.GRDECL'  /

-- ELIMINERER ALLE BLOKKER MED TJUKKELSE MINDRE ENN 0.1 M
PINCH
0.30 2* 'ALL' /

RPTGRID
'ALLNNC'   /
---------------------------------------------------------------
-----------------
-- SETTER BLOKKER UTENFOR HOVEDFORKASTNINGER INACTIVE
INCLUDE
  '../../INCLUDE/GRID/ACT-13-REV'  /
---------------------------------------------------------------
------------------
-- OPPSKALERT PERM FRA STORM
INCLUDE
  '../../INCLUDE/GRID/upsc_zone6_perm'  /

-- OPPSKALERT POROSITET FRA STORM
INCLUDE
  '../../INCLUDE/GRID/upsc_zone6_poro'  /

-- PETROFYSIKK FOR BROOM (LAG 13)
--INCLUDE
--  '/project/gf_h1_nb/ECLIPSE/INCLUDE/GRID/broom.param'
/
---------------------------------------------------------------
---------------
INCLUDE
  '../../INCLUDE/GRID/wblck_param_z6ff'  /
---------------------------------------------------------------
---------------
BOX
  1 20 1 40 1 13  /
COPY
  'PERMX' 'PERMY' /
  'PERMX' 'PERMZ' /
/


ENDBOX
---------------------------------------------------------------
---------------
INCLUDE
  '../../INCLUDE/GRID/multz_zone6_m2'  /
---------------------------------------------------------------
----------------
-- INKLUDERER NTG FOR HVERT LAG
EQUALS
  'NTG' 0.19 1 20 1 40  1  2 /
  'NTG' 0.96 1 20 1 40  3  3 /
  'NTG' 0.98 1 20 1 40  4  5 /
  'NTG' 0.90 1 20 1 40  6  6 /
  'NTG' 0.96 1 20 1 40  7  9 /
  'NTG' 1.00 1 20 1 40 10 10 /
  'NTG' 0.90 1 20 1 40 11 13 /
/
---------------------------------------------------------------
------------------
-- KORRIGERER VERTIKAL PERMEABILITET
--- KV/KH = 0.1
--MULTIPLY
--  'PERMZ'  0.1 /
--/
------------------------------------------------
--BOX
--BOX
--2 8 1 8 1 12 /
--MULTX
--672*3 /
--ENDBOX
--/

--BOX4
BOX
1 5 3 20 1 6 /
MULTX
540*0.1 /
ENDBOX
/

BOX
1 5 3 20 1 6 /
MULTY
540*0.1/
ENDBOX
/
BOX
1 5 3 20 1 6 /
MULTZ
540*0.1 /
ENDBOX
```

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```
/

--BOX5
BOX
7 13 3 13 1 12 /
MULTX
924*4.5 /
ENDBOX
/

--BOX5
BOX
7 13 3 13 1 12 /
MULTY
924*3 /
ENDBOX
/

--BOX5
BOX
7 13 3 13 1 12 /
MULTZ
924*0.5 /
ENDBOX
/
--BOX6
BOX
6 14 19 21 1 2 /
MULTX
54*0.3 /
ENDBOX
/

BOX
6 14 19 21 1 2 /
MULTY
54*0.3 /
ENDBOX
/

BOX
6 14 19 21 1 2 /
MULTZ
54*0.3 /
ENDBOX
/

--BOX2

BOX
2 5 26 38 1 10 /
MULTX
520*1 /
ENDBOX
/

BOX
2 5 26 38 1 10 /
MULTY
520*1 /
ENDBOX
/

BOX
2 5 26 38 1 10 /
MULTZ
520*1 /
ENDBOX
/

--BOX
--2 8 1 8 1 12 /
--MULTX
---672*3 /
--ENDBOX
--/
--BOX2

--BOX
--2 5 26 38 1 10 /
--MULTX
--520*2 /
--ENDBOX
--/

--BOX7

BOX
9 15 8 13 1 12 /
MULTX
504*0.1 /
ENDBOX
/

BOX
9 15 8 13 1 12 /
MULTY
504*0.1 /
ENDBOX
/
BOX
9 15 8 13 1 12 /
MULTZ
504*1 /
ENDBOX
/

--BOX3

BOX
2 9 16 19 1 10 /
MULTX
320*0.3 /
ENDBOX
/

BOX
2 9 16 19 1 10 /
MULTY
320*0.3 /
ENDBOX
```

```
/
BOX
2 9 16 19 1 10 /
MULTZ
320*0.5 /
ENDBOX
/

--BOX16
BOX
4 9 24 26 1 10 /
MULTX
180*0.5 /
ENDBOX
/
BOX
4 9 24 26 1 10 /
MULTY
180*0.5 /
ENDBOX
/
BOX
4 9 24 26 1 10 /
MULTZ
180*0.5 /
ENDBOX
/
--------------------------------------------------------
-----------------------

EDIT
========================================================
==
--      I DENNE SEKSJONEN GIS INSTRUKSJONER FOR
MODIFIKASJONER


--------------------------------------------------------
----------------------

PROPS
========================================================
==
--      I DENNE SEKSJONEN DEFINERES RELATIVE
PERMEABILITETER,
--      INITIELL VANNMETNINGER, KAPILLARTRYKK OG PVT-
EGENSKAPER
--      TIL RESERVOARFLUIDENE.
--      REFERANSE:
--------------------------------------------------------
---------------
-- KURVEFORM BASERT P□ A3H KJERNENE:
-- RANNOCH: aw=4.81,bw=-2.75, ao=5.76,bo=-2.52
-- ETIVE: aw=1.36,bw=1.02, ao=5.96,bo=-3.85
--------------------------------------------------------
---------------
-- RELATIV PERMEABILITETS KURVER
INCLUDE
  '../../INCLUDE/PROPS/RELP1.HIST'     /
--------------------------------------------------------
---------------
--  ENDPUNKTSSKALERING I OLJESONEN
SCALECRS
 'NO' /
--------------------------------------------------------
-----------------
-- OPPSKALERT VANNMETNINGER FRA STORM
--INCLUDE
--
'/project/gf_h1_nb/ECLIPSE/INCLUDE/GRID/upsc_zone6_sw'  /

--MAX VANNMETNIGER FOR INMOBILT VANN
BOX
  1 20 1 40 1 13 /
SWCR
 10400*0.15 /
ENDBOX
--------------------------------------------------------
-----------------
--MIN VANNMETNINGER (I OLJESONEN)
COPY
  'SWCR' 'SWL' /
/
--------------------------------------------------------
------------------
-- MAX OLJEMETNINGER FOR INMOBIL OLJE
BOX
  1 20 1 40 1 13 /
SOWCR
 10400*0.20 /
ENDBOX
--------------------------------------------------------
-----------------
-- MAX VANNMETNINGER I VANNMETNINGS TABELLER

EQUALS
--      KONSTANT IX1  IX2   JY1   JY2   KZ1   KZ2
'SWU'    1.0    1    20    1     40    1     13   /
/
--------------------------------------------------------
------------------
-- ENDEPUNKT RELATIV PERMEABILITET TIL VANN
-- KRWR(SORW) = (1-SORW)^4-0.1SORW
BOX
  1 20 1 40 1 13 /
KRWR
 10400*0.41 /
ENDBOX
--------------------------------------------------------
------------------
-- ENDEPUNKT RELATIV PERMEABILITET TIL OLJE
BOX
  1 20 1 40 1 13 /
KRORW
 10400*1.00 /
ENDBOX
--------------------------------------------------------
------------------
-- INKLUDERER PVT, ROCKTAB

INCLUDE
```

```
   '../../INCLUDE/PROPS/PVTH.HIST' /

TRACER
 'IW1' 'WAT' 'Mbq' /
 'IW2' 'WAT' 'Mbq' /
 'IW3' 'WAT' 'kg' /
 /

--TRACTVD

RPTPROPS
8*0 0 1 /


REGIONS
==========================================================
======
--      REGIONS-SEKSJONEN DEFINERER HVORDAN GRIDET ER
DELT INN I
--      REGIONER OG TILORDNER FORSKJELLIG KURVESETT FOR
METNINGER TIL
--      BLOKKENE.
----------------------------------------------------------
----------------
--BOX
--  1 20 1 40 1 7 /
--SATNUM
--  800*1 1600*2 2400*3 /
--ENDBOX

--INCLUDE
--  '../../INCLUDE/GRID/SATNUM-13' /

--TRACER

TNUMFIW1
 10400*1 /
TNUMFIW2
 10400*1 /
TNUMFIW3
 10400*1 /

BOX
 1 20 1 40 1  13 /
PVTNUM
 10400*1 /
SATNUM
 10400*1 /
ENDBOX

BOX
 1 20 1 40 1 13 /
ROCKNUM
 10400*1 /
ENDBOX
----------------------------------------------------------
----------------
-- INKLUDERER FIPNUM PR FORMASJON OG BLOKK
BOX
 1 20 1 40 1 13 /
FIPNUM
 1600*1 1600*2 1600*3 1600*4 1600*5 2400*6 /
ENDBOX

BOX
 1 20 1 40 1 13 /
EQLNUM
 10400*1 /
ENDBOX

--TRACER

RPTREGS
 19*0 1 /


SOLUTION
==========================================================
======
--      SOLUTION-SEKSJONEN DEFINERER DEN INITIELLE
TILSTAND TIL HVER
--      BLOKK I RESERVOARET.(TRYKK,METNINGER OG
GASS/OLJE VERDIER)
--
----------------------------------------------------------
----------------
-- SPESIFIKASJON AV TRYKK OG KAPILLARTRYKK VED KONTAKTENE
--
-- DATUM  DATUM   OWC    OWC     GOC     GOC    RSVD RVVD
SOLN
-- DYP    TRYKK   DYP    PCOW    DYP     PCOG TAB  TAB
METH
-- (M)    (BARS)  (M)    (BARS)  (M)     (BARS)
EQUIL
    1850   310.0  1947    0  4*  0     /
----------------------------------------------------------
----------------
-- UTSKRIFT AV INITIELL OLJEVOLUM
--RPTSOL
-- 6*0 2 3  /

--TRACER
TVDPFIW1
3000.0   0.0
6000.0   0.0  /
/

TVDPFIW2
3000.0   0.0
6000.0   0.0  /
/
TVDPFIW3
3000.0   0.0
6000.0   0.0  /
/

SUMMARY
==========================================================
======
--      DENNE SEKSJONEN SPESIFISERER HVILKE DATA SOM
SKAL SKRIVES TIL
--      SUMMARY-FILENE OG SOM SENERE KAN PLOTTES I GRAF.
```

```
----------------------------------------------------------
----------------
      INCLUDE
      '../../INCLUDE/SUMMARY/SUMIW3.HIST'  /

    --TRACER
RPTSMRY
1 /

SCHEDULE
==========================================================
======
--      SCHEDULE-SEKSJONEN DEFINERER OPERASJONER SOM
SKAL SIMULERES
-- INKLUDERER BR□NN OG HISTORISKE DATA

TUNING
1.0  20  /
  /
2* 100  /
-- UTSKRIFT AV DJUPN TIL RFT PLOTT
RPTSCHED
6*0 2 3*0 3 2*0 1 3 /

--RPTRST
--'BASIC=4'  /

--GRUPTREE
--'UB-H'  'U-BRENT'  /
--'UB-I'  'U-BRENT'  /
--'UB-I1' 'U-BRENT'  /
--'LB-H'  'L-BRENT'  /
--'LB-I'  'L-BRENT'  /
--'LB-I1' 'L-BRENT'  /
--'UB-HN' 'UB-H'     /
--'UB-HS' 'UB-H'     /
--'LB-HN' 'LB-H'     /
--'LB-HS' 'LB-H'     /
--/


INCLUDE
'../../INCLUDE/SCHEDULE/schednewprod.sched1' /


--WPIMULT
--P-A1H 0 /
--P-A2AH 0 /
--P-A39A 0 /
--P-A17 0 /

--WPIMULT
--IA-38 0 /
--IA-5H 0 /

END
```

3)   Fnal schedule script with well on location 6

```
----------------------------------------------------------
-
--      S C H E D U L E F I L E          -
-
--          Generated by ratsched 4.5          -
-
--          For the ECLIPSE-simulator          -
-
-- Timestamp : 18/ 2-1998  14:28:12 on hamingja   -
-
----------------------------------------------------------
-
--          F I L E S    U S E D          -
-
-- Filetype        Filename
-- --------        --------
--This out-file   PSINJ-REV-A39Aplug.SCHED
--GLOBAL          PSINJ-REV-A39Aplug.GLOB
--WELLACT         PSINJ-REV-A39Aplug.WELLACT
--WELLRATE        PSINJ.RATE
----------------------------------------------------------
-
WELSPECS
'P-A1H' 'LB-HS' 16  5 1* 'OIL' 1*  'N'  'SHUT' 'YES'
1* 'SEG' /
'P-A2AH' 'LB-HS' 12 15 1* 'OIL' 1*  'N'  'SHUT' 'YES'
1* 'SEG' /
'P-A17' 'LB-HS' 11  22 1*  'OIL' 1*  'N'  'SHUT' 'YES'
1* 'SEG' /
'P-A35' 'LB-HS'  6  33 1*  'OIL' 1*  'N'  'SHUT' 'YES'
1* 'SEG' /
'P-A39A' 'LB-HS' 14  19 1*  'OIL' 1*  'N'  'SHUT' 'YES'
1* 'SEG' /
'I-A5H' 'LB-HS'  5 14 1*  'WAT' 1*  'N'  'SHUT' 'YES'
1* 'SEG' /
'I-A38' 'LB-HS'  5 13 1*  'WAT' 1*  'N'  'SHUT' 'YES'
1* 'SEG' /
'P-BRH' 'LB-HS'  1  2 1*  'OIL' 1*  'N'  'SHUT' 'YES'
1* 'SEG' /
'Injec' 'LB-HS'  6 33 1*  'WAT' 1*  'N'  'SHUT' 'YES'
1* 'SEG' /
'I-NEW1' 'LB-HS'  1 40 1*  'WAT' 1*  'N'  'SHUT'  'YES'
1* 'SEG' /

/
COMPDAT
  'P-A1H'     15   4   3   3 'OPEN' 1* 1* .4320 1*  .0 1*  /
  'P-A1H'     15   4   4   4 'OPEN' 1* 1* .4320 1*  .0 1*  /
```

```
'P-A1H'    15   4   5   5   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    10   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A1H'    15   4   6   6   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    11   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*
'P-A1H'    15   4   7   7   'OPEN' 1* 1* .4320 1*  .0 1*  /        /
'P-A1H'    15   4   8   8   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    12   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*
'P-A1H'    16   5   9   9   'OPEN' 1* 1* .4320 1*  .0 1*  /        /
'P-A1H'    16   5  10  10   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    13   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A1H'    16   5  11  11   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    14   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A1H'    16   5  12  12   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    15   2  12  12  'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A2AH'   12  15   6   6   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    16   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*
'P-A2AH'   12  15   7   7   'OPEN' 1* 1* .4320 1*  .0 1*  /        /
'P-A2AH'   12  15   8   8   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    17   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*
'P-A2AH'   12  15   9   9   'OPEN' 1* 1* .4320 1*  .0 1*  /        /
'P-A2AH'   12  15  10  10   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    18   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A2AH'   12  15  11  11   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    19   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A2AH'   12  15  12  12   'OPEN' 1* 1* .4320 1*  .0 1*  /        'P-BRH'    20   2  12  12  'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A17'    11  22   5   5   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1'    1  40   1   1   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A17'    11  22   6   6   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1'    1  40   2   2   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A17'    11  22   9   9   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1'    1  40   3   3   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A17'    11  22  10  10   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1'    1  40   4   4   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A17'    11  23  10  10   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1'    1  40   5   5   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A17'    11  23  11  11   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1'    1  40   6   6   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A17'    11  23  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1'    1  40   9   9   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A17'    12  23  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1'    1  40  10  10   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A35'     6  33   3   3   'SHUT' 1* 1* .4320 1*  .0 1*  /        /
'P-A35'     6  33   4   4   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1'    1  40  11  11   'SHUT' 1* 1* .4320 1*  .0 1*
'P-A35'     6  33   5   5   'SHUT' 1* 1* .4320 1*  .0 1*  /        /
'P-A35'     6  33   6   6   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1'    1  40  12  12   'SHUT' 1* 1* .4320 1*  .0 1*
'P-A35'     6  33   7   7   'SHUT' 1* 1* .4320 1*  .0 1*  /        /
'P-A35'     6  33   8   8   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A35'     6  33   9   9   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A35'     6  33  10  10   'SHUT' 1* 1* .4320 1*  .0 1*  /        /
'P-A35'     6  33  11  11   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-A35'     6  33  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /        WCONINJE
'Injec'     6  33   3   3   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-A5H' 'WAT' 'SHUT' 'RATE'  0.   1*    1*    1*    1*    /
'Injec'     6  33   4   4   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-A38' 'WAT' 'SHUT' 'RATE'  0.   1*    1*    1*    1*
'Injec'     6  33   5   5   'SHUT' 1* 1* .4320 1*  .0 1*  /        /
'Injec'     6  33   6   6   'SHUT' 1* 1* .4320 1*  .0 1*  /        'Injec' 'WAT' 'SHUT' 'RATE'  0.   1*    1*    1*    1*
'Injec'     6  33   7   7   'SHUT' 1* 1* .4320 1*  .0 1*  /        /
'Injec'     6  33   8   8   'SHUT' 1* 1* .4320 1*  .0 1*  /        'I-NEW1' 'WAT' 'SHUT' 'RATE'  0.   1*    1*    1*    1*    /
'Injec'     6  33   9   9   'SHUT' 1* 1* .4320 1*  .0 1*  /
'Injec'     6  33  10  10   'SHUT' 1* 1* .4320 1*  .0 1*  /        WCONHIST
'Injec'     6  33  11  11   'SHUT' 1* 1* .4320 1*  .0 1*  /        'P-A1H'      'OPEN' 'LRAT'   1965.3       0.0 194668.0 /
'Injec'     6  33  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /        'P-A2AH'     'OPEN' 'LRAT'   1332.2       0.0 131922.5 /
'P-A39A'   19   3  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'P-A17'      'OPEN' 'LRAT'      0.0       0.0      0.0 /
/                                                                 'P-A35'      'OPEN' 'LRAT'      0.0       0.0      0.0 /
'P-A39A'   19   4  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'P-A39A'     'OPEN' 'LRAT'      0.0       0.0      0.0 /
/                                                                 'P-BRH'      'SHUT' 'ORAT'      0.0       0.0      0.0 /
'P-A39A'   19   4  11  11   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       WELTARG
/                                                                 'I-A38'      'WRAT'            0.0 /
'P-A39A'   17   9  10  10   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'I-A5H'      'WRAT'            0.0 /
/                                                                 'Injec'      'WRAT'            0.0 /
'P-A39A'   17  10  10  10   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'I-NEW1'     'WRAT'            0.0 /
/                                                                 /
'P-A39A'   16  10  10  10   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       WEFAC
/                                                                 'P-A1H'     0.283414 /
'P-A39A'   16  11  10  10   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'P-A2AH'    0.254059 /
/                                                                 'P-A17'     0.001001 /
'P-A39A'   16  12  10  10   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'P-A35'     0.001001 /
/                                                                 'P-A39A'    0.001001 /
'P-A39A'   16  13  10  10   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'P-BRH'     0.001001 /
/                                                                 'I-A38'     0.001000 /
'P-A39A'   15  13  10  10   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'I-A5H'     0.001000 /
/                                                                 'Injec'     0.001000 /
'P-A39A'   14  16  11  11   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'I-NEW1'    0.001000 /
/                                                                 /
'P-A39A'   14  17  11  11   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       WELOPEN
/                                                                 'P-A1H'  'OPEN'   /
'P-A39A'   14  18  11  11   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'P-A2AH' 'OPEN'   /
/                                                                 'P-A35'  'SHUT'   /
'P-A39A'   14  15  10  10   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       /
/
'P-A39A'   14  16  10  10   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       --TRACER
/                                                                 --  Yearly report
'P-A39A'   14  17  10  10   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       RPTSCHED
/                                                                 0 0 0 0 0   0 2 2 2 0 22*0 1 /
'I-A5H'     6  15   3   3   'SHUT' 1* 1* .4320 1*  .0 1*  /        --%Report-records: 3   1
'I-A5H'     6  15   4   4   'SHUT' 1* 1* .4320 1*  .0 1*  /        -- Quarterly report
'I-A5H'     6  15   5   5   'SHUT' 1* 1* .4320 1*  .0 1*  /        --RPTSCHED
'I-A5H'     6  15   6   6   'SHUT' 1* 1* .4320 1*  .0 1*  /        --0 0 0 0 0   0 0 2 1 0  /
'I-A5H'     6  15   7   7   'SHUT' 1* 1* .4320 1*  .0 1*  /        --0 0 0 0 0   0 2 0 0 0  /
'I-A5H'     6  15   8   8   'SHUT' 1* 1* .4320 1*  .0 1*  /        --%Report-records: 1   1
'I-A5H'     6  15   9   9   'SHUT' 1* 1* .4320 1*  .0 1*  /        -- Monthly report
'I-A5H'     6  15  10  10   'SHUT' 1* 1* .4320 1*  .0 1*  /        --RPTSCHED
'I-A5H'     6  15  11  11   'SHUT' 1* 1* .4320 1*  .0 1*  /        --0 0 0 0 0   0 0 0 2 0 0 1 /
'I-A5H'     6  15  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /        TUNING
'I-A38'     6   1  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       0.01 20.0  /
/                                                                        /
'I-A38'     6   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'              /
/
'I-A38'     6   3  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       DATES
/                                                                  1 'JAN' 1987    /
'I-A38'     6   4  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       /
/                                                                 RPTSCHED
'I-A38'     6   5  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       32*0  1 13*0   /
/                                                                 WCONHIST
'I-A38'     6   6  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'P-A1H'      'OPEN' 'LRAT'   2182.2       0.0 214817.0 /
/                                                                 'P-A2AH'     'OPEN' 'LRAT'   1444.6       0.0 142244.5 /
'I-A38'     6   7  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       /
/                                                                 WEFAC
'I-A38'     6   8  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       'P-A1H'     0.939355 /
/                                                                 'P-A2AH'    0.927702 /
'I-A38'     6   9  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       /
/
'I-A38'     6  10  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       --  RFT -Date at 29011987 for well I-A5H --
/                                                                 RPTSCHED
'I-A38'     6  11  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       0 0 0 0 0   0 0 0 2 0 0 0 0 0 0 /
/
'I-A38'     6  12  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'
/                                                                 DATES
'I-A38'     6  13  12  12   'SHUT' 1* 1* .4320 1*  .0 1* 'Y'       29 'JAN' 1987    /
/                                                                 /
'I-A38'     5  14   3   4   'SHUT' 1* 1* .4320 1*  .0 1* /         RPTSCHED
'P-BRH'     1   2   6   6   'SHUT' 1* 1* .4320 1*  .0 1* /         32*0  1 13*0    /
'P-BRH'     2   2   6   6  'SHUT' 1* 1* .4320 1*  .0 1* /
'P-BRH'     3   2   6   6   'SHUT' 1* 1* .4320 1*  .0 1* /
'P-BRH'     4   2   8   8  'SHUT' 1* 1* .4320 1*  .0 1* /          DATES
'P-BRH'     5   2  10  10   'SHUT' 1* 1* .4320 1*  .0 1*  /         1 'FEB' 1987    /
'P-BRH'     6   2  11  11   'SHUT' 1* 1* .4320 1*  .0 1*           /
/                                                                 RPTSCHED
'P-BRH'     7   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*           32*0  1 13*0    /
/                                                                 WCONHIST
'P-BRH'     8   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /
'P-BRH'     9   2  12  12   'SHUT' 1* 1* .4320 1*  .0 1*  /
```

```
 'P-A1H'       'OPEN' 'LRAT'    2218.2        0.0  220233.7 /        'I-NEW1'      0.900000 /
 'P-A2AH'      'OPEN' 'LRAT'    1492.1        0.0  148151.5 /        /
/
WEFAC
'P-A1H'       0.987173 /
'P-A2AH'      0.569048 /                                          DATES
/                                                                   1 'JUN' 1987     /
                                                                 /
                                                                 RPTSCHED
                                                                 32*0  1 13*0     /
DATES                                                            WCONHIST
   1 'MAR' 1987     /                                             'P-A1H'       'OPEN' 'LRAT'    3025.9        0.0  300463.9 /
/                                                                 'P-A2AH'      'OPEN' 'LRAT'    1259.7        0.0  125078.0 /
RPTSCHED                                                         /
32*0  1 13*0     /                                               WELTARG
WCONHIST                                                          'I-A5H'       'WRAT'           5017.9 /
 'P-A1H'       'OPEN' 'LRAT'    2382.8        0.0  236515.9 /      'I-NEW1'      'WRAT'           3000 /
 'P-A2AH'      'OPEN' 'LRAT'    1590.8        0.0  157913.1 /     /
/                                                                WEFAC
WEFAC                                                            'P-A1H'       0.883333 /
'P-A1H'       0.919288 /                                         'P-A2AH'      0.823333 /
'P-A2AH'      0.955645 /                                         'I-A5H'       0.876000 /
/                                                                'I-NEW1'      0.876000 /
                                                                 /
-- Yearly report
RPTSCHED                                                         -- Yearly report
0 0 0 0 0    0 2 2 2 0 /                                         RPTSCHED
--%Report-records: 3   1                                         0 0 0 0 0    0 2 2 2 0 /
-- Quarterly report                                              --%Report-records: 3   1
--RPTSCHED                                                       -- Quarterly report
--0 0 0 0 0    0 0 2 1 0 /                                       --RPTSCHED
--0 0 0 0 0    0 2 0 0 0 /                                       --0 0 0 0 0    0 0 2 1 0 /
--%Report-records: 1   1                                        --0 0 0 0 0    0 2 0 0 0 /
-- Monthly report                                               --%Report-records: 1   1
--RPTSCHED                                                       -- Monthly report
--0 0 0 0 0    0 0 0 2 0 0 1 /                                   --RPTSCHED
                                                                 --0 0 0 0 0    0 0 0 2 0 0 1 /

DATES
   1 'APR' 1987     /                                            DATES
/                                                                   1 'JLY' 1987     /
RPTSCHED                                                         /
32*0  1 13*0     /                                               RPTSCHED
COMPDAT                                                          32*0  1 13*0     /
 'I-A5H'       6  15   3   3  'OPEN' 1* 1* .4320 1*  .0 1*   /   WCONHIST
 'I-A5H'       6  15   4   4  'OPEN' 1* 1* .4320 1*  .0 1*   /    'P-A1H'       'OPEN' 'LRAT'    3667.7        0.0  364180.2 /
 'I-A5H'       6  15   5   5  'SHUT' 1* 1* .4320 1*  .0 1*   /    'P-A2AH'      'OPEN' 'LRAT'    1222.4        0.0  121377.3 /
 'I-A5H'       6  15   6   6  'SHUT' 1* 1* .4320 1*  .0 1*   /   /
 'I-A5H'       6  15   7   7  'SHUT' 1* 1* .4320 1*  .0 1*   /   WELTARG
 'I-A5H'       6  15   8   8  'SHUT' 1* 1* .4320 1*  .0 1*   /    'I-A5H'       'WRAT'           5018.9 /
 'I-A5H'       6  15   9   9  'SHUT' 1* 1* .4320 1*  .0 1*   /    'I-NEW1'      'WRAT'           2800 /
 'I-A5H'       6  15  10  10  'SHUT' 1* 1* .4320 1*  .0 1*   /   /
 'I-A5H'       6  15  11  11  'SHUT' 1* 1* .4320 1*  .0 1*   /   WEFAC
 'I-A5H'       6  15  12  12  'SHUT' 1* 1* .4320 1*  .0 1*   /   'P-A1H'       0.949798 /
 'I-NEW1'      1  40   1   1  'OPEN' 1* 1* .4320 1*  .0 1*   /   'P-A2AH'      0.850672 /
 'I-NEW1'      1  40   2   2  'OPEN' 1* 1* .4320 1*  .0 1*   /   'I-A5H'       0.700000 /
 'I-NEW1'      1  40   3   3  'OPEN' 1* 1* .4320 1*  .0 1*   /   'I-NEW1'      0.700000 /
 'I-NEW1'      1  40   4   4  'OPEN' 1* 1* .4320 1*  .0 1*   /   /
 'I-NEW1'      1  40   5   5  'OPEN' 1* 1* .4320 1*  .0 1*   /
 'I-NEW1'      1  40   6   6  'OPEN' 1* 1* .4320 1*  .0 1*   /
 'I-NEW1'      1  40   9   9  'OPEN' 1* 1* .4320 1*  .0 1*   /
 'I-NEW1'      1  40  10  10  'OPEN' 1* 1* .4320 1*  .0 1*
/                                                               DATES
 'I-NEW1'      1  40  11  11  'OPEN' 1* 1* .4320 1*  .0 1*          1 'AUG' 1987     /
/                                                               /
 'I-NEW1'      1  40  12  12  'OPEN' 1* 1* .4320 1*  .0 1*       RPTSCHED
/                                                               32*0  1 13*0     /
/                                                               WCONHIST
WCONINJE                                                         'P-A1H'       'OPEN' 'LRAT'    4048.3        0.0  402004.5 /
'I-A5H' 'WAT' 'OPEN' 'RATE' 0.  1*    1*    1*    1*     /        'P-A2AH'      'OPEN' 'LRAT'    1259.9        0.0  125092.9 /
'I-NEW1' 'WAT' 'OPEN' 'RATE' 0.  1*   1*    1*    1*     /       /
WCONHIST                                                         WELTARG
 'P-A1H'       'OPEN' 'LRAT'    2580.7        0.0  256238.1 /     'I-A5H'       'WRAT'           5127.5 /
 'P-A2AH'      'OPEN' 'LRAT'    1107.1        0.0  109916.8 /     'I-NEW1'      'WRAT'           3100 /
/                                                               /
WELTARG                                                          WEFAC
 'I-A5H'       'WRAT'           3109.9 /                         'P-A1H'       0.968078 /
 'I-NEW1'      'WRAT'           2500 /                           'P-A2AH'      0.954099 /
/                                                               'I-A5H'       0.936000 /
WEFAC                                                            'I-NEW1'      0.936000 /
'P-A1H'       0.950042 /                                         /
'P-A2AH'      0.961792 /
'I-A5H'       0.776000 /
'I-NEW1'      0.776000 /
/                                                               DATES
                                                                   1 'SEP' 1987     /
                                                                /
DATES                                                           RPTSCHED
  15 'APR' 1987     /                                           32*0  1 13*0     /
/                                                               WCONHIST
                                                                 'P-A1H'       'OPEN' 'LRAT'    4107.6        0.0  407908.8 /
WTRACER                                                          'P-A2AH'      'OPEN' 'LRAT'    1250.5        0.0  124156.8 /
'I-A5H' 'IW1' 2673.84  /                                        /
/                                                               WELTARG
                                                                 'I-A5H'       'WRAT'           5203.7 /
DATES                                                            'I-NEW1'      'WRAT'           3100 /
  16 'APR' 1987     /                                           /
/                                                               WEFAC
                                                                'P-A1H'       0.993125 /
WTRACER                                                          'P-A2AH'      0.990625 /
'I-A5H' 'IW1' 0.0  /                                            'I-A5H'       0.889000 /
/                                                               'I-NEW1'      0.889000 /
                                                                 /

                                                                -- Yearly report
DATES                                                           RPTSCHED
   1 'MAY' 1987     /                                           0 0 0 0 0    0 2 2 2 0 /
/                                                               --%Report-records: 3   1
RPTSCHED                                                         -- Quarterly report
32*0  1 13*0     /                                              --RPTSCHED
WCONHIST                                                        --0 0 0 0 0    0 0 2 1 0 /
 'P-A1H'       'OPEN' 'LRAT'    2832.2        0.0  281176.0 /   --0 0 0 0 0    0 2 0 0 0 /
 'P-A2AH'      'OPEN' 'LRAT'    1264.1        0.0  125507.2 /   --%Report-records: 1   1
/                                                               -- Monthly report
WELTARG                                                         --RPTSCHED
 'I-A5H'       'WRAT'           4672.7 /                        --0 0 0 0 0    0 0 0 2 0 0 1 /
 'I-NEW1'      'WRAT'           3500 /
/
WEFAC                                                           DATES
'P-A1H'       0.994288 /                                           1 'OCT' 1987     /
'P-A2AH'      0.973454 /                                        /
'I-A5H'       0.900000 /                                        RPTSCHED
                                                                32*0  1 13*0     /
                                                                WCONHIST
```

```
 'P-A1H'      'OPEN' 'LRAT'     4039.5        0.0  405398.7 /
 'P-A2AH'     'OPEN' 'LRAT'     1242.8        0.0  122323.3 /
/
WELTARG
 'I-A5H'      'WRAT'           5181.9 /
 'I-NEW1'     'WRAT'           3000 /
/
WEFAC
 'P-A1H'      0.988844 /
 'P-A2AH'     0.983199 /
 'I-A5H'      0.805000 /
 'I-NEW1'     0.805000 /
/


DATES
   1 'NOV' 1987     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     4128.8        0.0  413638.7 /
 'P-A2AH'     'OPEN' 'LRAT'     1173.5        0.0  115242.8 /
/
WELTARG
 'I-A5H'      'WRAT'           5114.0 /
 'I-NEW1'     'WRAT'           3000 /
/
WEFAC
 'P-A1H'      0.990694 /
 'P-A2AH'     0.901806 /
 'I-A5H'      0.961000 /
 'I-NEW1'     0.961000 /
/


DATES
   1 'DEC' 1987     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     4202.1        0.0  420849.1 /
 'P-A2AH'     'OPEN' 'LRAT'     1095.0        0.0  107612.8 /
/
WELTARG
 'I-A5H'      'WRAT'           3654.5 /
 'I-NEW1'     'WRAT'           2000 /
/
WEFAC
 'P-A1H'      0.690188 /
 'P-A2AH'     0.020027 /
 'I-A5H'      0.910000 /
 'I-NEW1'     0.910000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0   0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /

---------------------------------------------
--             NEW YEAR 1988           --
---------------------------------------------


DATES
   1 'JAN' 1988     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     4034.4        0.0  404829.4 /
 'P-A2AH'     'OPEN' 'LRAT'     2449.5        0.0  240880.0 /
/
WELTARG
 'I-A5H'      'WRAT'           5196.4 /
 'I-NEW1'     'WRAT'           2000 /
/
WEFAC
 'P-A1H'      0.986694 /
 'P-A2AH'     0.984005 /
 'I-A5H'      0.895000 /
 'I-NEW1'     0.895000 /
/


DATES
   1 'FEB' 1988     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     4061.5        0.0  408382.8 /
 'P-A2AH'     'OPEN' 'LRAT'     2566.0        0.0  254316.4 /
/
WELTARG
 'I-A5H'      'WRAT'           5901.1 /
 'I-NEW1'     'WRAT'           2000 /
/
WEFAC
 'P-A1H'      0.993391 /
 'P-A2AH'     0.991379 /
 'I-A5H'      0.832000 /
 'I-NEW1'     0.832000 /
/


DATES
   1 'MAR' 1988     /
```

```
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     4116.6        0.0  412440.1 /
 'P-A2AH'     'OPEN' 'LRAT'     2390.0        0.0  240678.9 /
/
WELTARG
 'I-A5H'      'WRAT'           5064.7 /
 'I-NEW1'     'WRAT'           3000 /
/
WEFAC
 'P-A1H'      0.995027 /
 'P-A2AH'     0.996640 /
 'I-A5H'      0.941000 /
 'I-NEW1'     0.941000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0   0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
   1 'APR' 1988     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     4196.3        0.0  420468.1 /
 'P-A2AH'     'OPEN' 'LRAT'     2562.8       83.8  258065.1 /
/
WELTARG
 'I-A5H'      'WRAT'           5067.5 /
 'I-NEW1'     'WRAT'           3000 /
/
WEFAC
 'P-A1H'      0.791111 /
 'P-A2AH'     0.941528 /
 'I-A5H'      0.950000 /
 'I-NEW1'     0.950000 /
/


DATES
   1 'MAY' 1988     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     3744.7        0.0  375185.1 /
 'P-A2AH'     'OPEN' 'LRAT'     2465.5      210.7  248286.8 /
/
WELTARG
 'I-A5H'      'WRAT'           5007.5 /
 'I-NEW1'     'WRAT'           3000 /
/
WEFAC
 'P-A1H'      0.578136 /
 'P-A2AH'     0.608468 /
 'I-A5H'      0.708000 /
 'I-NEW1'     0.708000 /
/


DATES
   1 'JUN' 1988     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     2278.1        0.0  228253.9 /
 'P-A2AH'     'OPEN' 'LRAT'        0.0        0.0       0.0 /
/
WELTARG
 'I-A5H'      'WRAT'           4110.9 /
 'I-NEW1'     'WRAT'           2000 /
/
WEFAC
 'P-A1H'      0.910324 /
 'P-A2AH'     0.001001 /
 'I-A5H'      0.680000 /
 'I-NEW1'     0.680000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0   0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
   1 'JLY' 1988     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     3827.1        0.0  383433.7 /
 'P-A2AH'     'OPEN' 'LRAT'     2010.7      283.5  202462.8 /
/
WELTARG
 'I-A5H'      'WRAT'           5338.8 /
 'I-NEW1'     'WRAT'           2000 /
/
```

```
WEFAC
'P-A1H'    0.992742 /
'P-A2AH'   0.847222 /
'I-A5H'    0.918000 /
'I-NEW1'   0.918000 /
/


DATES
  1 'AUG' 1988    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   4317.6      0.0  438470.9 /
 'P-A2AH'     'OPEN' 'LRAT'   2462.9    404.6  256782.3 /
/
WELTARG
 'I-A5H'      'WRAT'          5575.8 /
 'I-NEW1'     'WRAT'          2000 /
/
WEFAC
'P-A1H'    0.970318 /
'P-A2AH'   0.969892 /
'I-A5H'    0.925000 /
'I-NEW1'   0.925000 /
/

-- RFT -Date at 01091988 for well P-A17 --
RPTSCHED
 0 0 0 0 0   0 0 0 2 0 0 0 0 0 /


DATES
  16 'AUG' 1988     /
/

WTRACER
'I-A5H' 'IW2' 660.0 /
/

DATES
  17 'AUG' 1988     /
/
WTRACER
'I-A5H' 'IW2' 0.0 /
/


DATES
  1 'SEP' 1988    /
/
RPTSCHED
32*0  1 13*0    /
COMPDAT
 'P-A17'     11  22   5   5   'OPEN' 1* 1* .4320 1*  .0 1*   /
 'P-A17'     11  22   6   6   'OPEN' 1* 1* .4320 1*  .0 1*   /
 'P-A17'     11  22   9   9   'OPEN' 1* 1* .4320 1*  .0 1*   /
 'P-A17'     11  22  10  10   'OPEN' 1* 1* .4320 1*  .0 1*   /
 'P-A17'     11  23  10  10   'OPEN' 1* 1* .4320 1*  .0 1*   /
 'P-A17'     11  23  11  11   'OPEN' 1* 1* .4320 1*  .0 1*   /
 'P-A17'     11  23  12  12   'OPEN' 1* 1* .4320 1*  .0 1*   /
 'P-A17'     12  23  12  12   'OPEN' 1* 1* .4320 1*  .0 1*   /
/
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   4172.1      0.0  432781.7 /
 'P-A2AH'     'OPEN' 'LRAT'   1796.3    365.9  187573.1 /
 'P-A17'      'OPEN' 'LRAT'   1063.7      0.0  102575.0 /
/
WELTARG
 'I-A5H'      'WRAT'          5771.2 /
 'I-NEW1'     'WRAT'          2000 /
/
WEFAC
'P-A1H'    0.976620 /
'P-A2AH'   0.951620 /
'P-A17'    0.033449 /
'I-A5H'    0.924000 /
'I-NEW1'   0.924000 /
/
WELOPEN
'P-A17'  'OPEN'    /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0  /
--0 0 0 0 0    0 2 0 0 0  /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /

DATES
  1 'OCT' 1988    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   3962.9    605.2  399351.4 /
 'P-A2AH'     'OPEN' 'LRAT'   1612.5    443.2  162235.7 /
 'P-A17'      'OPEN' 'LRAT'    907.9      0.0   88677.5 /
/
WELTARG
 'I-A5H'      'WRAT'          5299.8 /
 'I-NEW1'     'WRAT'          2000 /
/
WEFAC
'P-A1H'    0.976478 /
'P-A2AH'   0.954749 /
'P-A17'    0.857975 /
'I-A5H'    0.944000 /
'I-NEW1'   0.944000 /
/
```

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DATES
  1 'NOV' 1988    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   3843.4   1307.4  385751.5 /
 'P-A2AH'     'OPEN' 'LRAT'   1943.5    858.8  196306.8 /
 'P-A17'      'OPEN' 'LRAT'    829.1      0.0   82913.0 /
/
WELTARG
 'I-A5H'      'WRAT'          5938.3 /
 'I-NEW1'     'WRAT'          2000 /
/
WEFAC
'P-A1H'    0.969444 /
'P-A2AH'   0.928588 /
'P-A17'    0.944444 /
'I-A5H'    0.935000 /
'I-NEW1'   0.935000 /
/


DATES
  1 'DEC' 1988    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   2934.5   1253.0  294342.1 /
 'P-A2AH'     'OPEN' 'LRAT'   1942.5    874.0  196208.1 /
 'P-A17'      'OPEN' 'LRAT'    839.7      0.0   83970.7 /
/
WELTARG
 'I-A5H'      'WRAT'          5869.9 /
 'I-NEW1'     'WRAT'          2000 /
/
WEFAC
'P-A1H'    0.206317 /
'P-A2AH'   0.131496 /
'P-A17'    0.142025 /
'I-A5H'    0.450000 /
'I-NEW1'   0.450000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0  /
--0 0 0 0 0    0 2 0 0 0  /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /

----------------------------------------------
--            NEW YEAR 1989              --
----------------------------------------------


DATES
  1 'JAN' 1989    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   3440.8   1745.8  345101.4 /
 'P-A2AH'     'OPEN' 'LRAT'   1743.8    950.4  176033.4 /
 'P-A17'      'OPEN' 'LRAT'    806.2      0.0   80622.8 /
/
WELTARG
 'I-A5H'      'WRAT'          5167.3 /
 'I-NEW1'     'WRAT'          3000 /
/
WEFAC
'P-A1H'    0.994960 /
'P-A2AH'   0.990703 /
'P-A17'    0.854503 /
'I-A5H'    0.961000 /
'I-NEW1'   0.961000 /
/


DATES
  1 'FEB' 1989    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   2714.8   1997.9  275005.9 /
 'P-A2AH'     'OPEN' 'LRAT'   1872.3   1307.9  190877.7 /
 'P-A17'      'OPEN' 'LRAT'    815.6      0.0   77124.6 /
/
WELTARG
 'I-A5H'      'WRAT'          5210.0 /
 'I-NEW1'     'WRAT'          3000 /
/
WEFAC
'P-A1H'    0.847098 /
'P-A2AH'   0.864955 /
'P-A17'    0.877604 /
'I-A5H'    0.958000 /
'I-NEW1'   0.958000 /
/


DATES
  1 'MAR' 1989    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   2159.3   1996.4  216923.6 /
 'P-A2AH'     'OPEN' 'LRAT'   1606.0   1309.5  162495.2 /
 'P-A17'      'OPEN' 'LRAT'    791.8      0.0   74250.4 /
/
```

```
WELTARG
 'I-A5H'     'WRAT'          5148.6 /
 'I-NEW1'    'WRAT'          3000 /
/
WEFAC
 'P-A1H'      0.995968 /
 'P-A2AH'     0.983647 /
 'P-A17'      0.946685 /
 'I-A5H'      0.968000 /
 'I-NEW1'     0.968000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
   1 'APR' 1989     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    1793.4    1985.1 182306.8 /
 'P-A2AH'     'OPEN' 'LRAT'    1494.0    1370.4 152448.1 /
 'P-A17'      'OPEN' 'LRAT'     801.6       1.3  77483.5 /
/
WELTARG
 'I-A5H'     'WRAT'          5165.4 /
 'I-NEW1'    'WRAT'          3000 /
/
WEFAC
 'P-A1H'      0.949653 /
 'P-A2AH'     0.964699 /
 'P-A17'      0.984722 /
 'I-A5H'      0.960000 /
 'I-NEW1'     0.960000 /
/


DATES
   1 'MAY' 1989     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    1092.6    1162.9 110027.4 /
 'P-A2AH'     'OPEN' 'LRAT'    1054.4    1154.1 106491.9 /
 'P-A17'      'OPEN' 'LRAT'     798.3       5.8  77676.5 /
/
WELTARG
 'I-A5H'     'WRAT'          5358.7 /
 'I-NEW1'    'WRAT'          2000 /
/
WEFAC
 'P-A1H'      0.992384 /
 'P-A2AH'     0.995296 /
 'P-A17'      0.921819 /
 'I-A5H'      0.961000 /
 'I-NEW1'     0.961000 /
/


DATES
   1 'JUN' 1989     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    1220.9    1240.6 122945.9 /
 'P-A2AH'     'OPEN' 'LRAT'    1352.1    1446.0 136555.9 /
 'P-A17'      'OPEN' 'LRAT'     795.7      31.7  77419.1 /
/
WELTARG
 'I-A5H'     'WRAT'          5136.5 /
 'I-NEW1'    'WRAT'          2000 /
/
WEFAC
 'P-A1H'      0.735370 /
 'P-A2AH'     0.772407 /
 'P-A17'      0.776620 /
 'I-A5H'      0.694000 /
 'I-NEW1'     0.694000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
   1 'JLY' 1989     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     945.7     956.2  95231.0 /
 'P-A2AH'     'OPEN' 'LRAT'     903.9    1176.5  91292.3 /
 'P-A17'      'OPEN' 'LRAT'     788.8      38.1  76753.3 /
/
WELTARG
 'I-A5H'     'WRAT'          4078.2 /
 'I-NEW1'    'WRAT'          1600 /
```

```
/
WEFAC
 'P-A1H'      0.896057 /
 'P-A2AH'     0.916331 /
 'P-A17'      0.849350 /
 'I-A5H'      0.940000 /
 'I-NEW1'     0.940000 /
/


DATES
   1 'AUG' 1989     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     906.1     921.9  91248.4 /
 'P-A2AH'     'OPEN' 'LRAT'     814.8    1137.3  82290.3 /
 'P-A17'      'OPEN' 'LRAT'     725.3      35.6  70569.9 /
/
WELTARG
 'I-A5H'     'WRAT'          4014.7 /
 'I-NEW1'    'WRAT'          1000 /
/
WEFAC
 'P-A1H'      0.915771 /
 'P-A2AH'     0.932348 /
 'P-A17'      0.943884 /
 'I-A5H'      0.944000 /
 'I-NEW1'     0.944000 /
/


DATES
   1 'SEP' 1989     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     843.0     843.9  84886.1 /
 'P-A2AH'     'OPEN' 'LRAT'     762.4    1059.7  77005.9 /
 'P-A17'      'OPEN' 'LRAT'     712.5      53.6  69323.5 /
/
WELTARG
 'I-A5H'     'WRAT'          3960.2 /
 'I-NEW1'    'WRAT'          1000 /
/
WEFAC
 'P-A1H'      0.913657 /
 'P-A2AH'     0.955903 /
 'P-A17'      0.952083 /
 'I-A5H'      0.934000 /
 'I-NEW1'     0.934000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
   1 'OCT' 1989     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     825.5     781.4  82525.9 /
 'P-A2AH'     'OPEN' 'LRAT'     870.2    1118.7  87889.5 /
 'P-A17'      'OPEN' 'LRAT'     730.2      97.7  72234.8 /
/
WELTARG
 'I-A5H'     'WRAT'          4488.8 /
 'I-NEW1'    'WRAT'          1000 /
/
WEFAC
 'P-A1H'      0.867496 /
 'P-A2AH'     0.961358 /
 'P-A17'      0.977375 /
 'I-A5H'      0.937000 /
 'I-NEW1'     0.937000 /
/


DATES
   1 'NOV' 1989     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    1082.5    1013.0 107490.3 /
 'P-A2AH'     'OPEN' 'LRAT'    1122.2    1523.6 113342.8 /
 'P-A17'      'OPEN' 'LRAT'     739.9     141.3  73545.1 /
/
WELTARG
 'I-A5H'     'WRAT'          4024.4 /
 'I-NEW1'    'WRAT'          2000 /
/
WEFAC
 'P-A1H'      0.979745 /
 'P-A2AH'     0.992824 /
 'P-A17'      0.989236 /
 'I-A5H'      0.948000 /
 'I-NEW1'     0.948000 /
/


DATES
   1 'DEC' 1989     /
/
RPTSCHED
```

```
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    922.8    896.9   91632.5 /
 'P-A2AH'     'OPEN' 'LRAT'   1175.5   1621.3  118729.3 /
 'P-A17'      'OPEN' 'LRAT'    747.0    149.5   74245.5 /
/
WELTARG
 'I-A5H'      'WRAT'        2425.8 /
 'I-NEW1'     'WRAT'        1000 /
/
WEFAC
 'P-A1H'      0.001560 /
 'P-A2AH'     0.001560 /
 'P-A17'      0.895161 /
 'I-A5H'      0.910000 /
 'I-NEW1'     0.910000 /
/

-- RFT -Date at 01011990 for well I-H2 --
RPTSCHED
 0 0 0 0 0    0 0 0 2 0 0 0 0 0 /
-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0   /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /
-----------------------------------------------------------
-----
-- Joined RPTSCHED - card due to 2  RPTSCHED-cards at the same
date.
-----------------------------------------------------------
-----
RPTSCHED
  0  0  0  0  0    0  2  2  2  0 /

-----------------------------------------------
--             NEW YEAR 1990             --
-----------------------------------------------


DATES
  1 'JAN' 1990    /
/
RPTSCHED
32*0  1 13*0    /
WELSPECS
'I-H2' 'LB-HS'  1   1  1*  'WAT' 1*   'N'   'SHUT' 'YES'
1*  'SEG' /
/
COMPDAT
  'I-H2'      1   1   3   4  'OPEN' 1* 1* .4320 1*  .0 1*  /
/
WCONINJE
'I-H2' 'WAT' 'OPEN' 'RATE'  0.   1*    1*    1*    1*
/
/
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    967.6    685.1   96078.8 /
 'P-A2AH'     'OPEN' 'LRAT'    425.0   1587.1   42930.0 /
 'P-A17'      'OPEN' 'LRAT'    796.2    194.3   79145.5 /
/
WELTARG
 'I-A5H'      'WRAT'        2792.3 /
 'I-H2'       'WRAT'        1000.0 /
 'I-NEW1'     'WRAT'        1000 /
/
WEFAC
 'P-A1H'      0.792787 /
 'P-A2AH'     0.192988 /
 'P-A17'      0.979727 /
 'I-A5H'      0.198000 /
 'I-H2'       1.000000 /
 'I-NEW1'     1.000000 /
/


DATES
  1 'FEB' 1990    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    932.9    823.9   92634.9 /
 'P-A2AH'     'OPEN' 'LRAT'      0.0      0.0       0.0 /
 'P-A17'      'OPEN' 'LRAT'    719.8    182.4   71545.3 /
/
WELTARG
 'I-A5H'      'WRAT'        2365.8 /
 'I-H2'       'WRAT'        1000.0 /
 'I-NEW1'     'WRAT'        1000 /
/
WEFAC
 'P-A1H'      0.967758 /
 'P-A2AH'     0.001001 /
 'P-A17'      0.984623 /
 'I-A5H'      0.524000 /
 'I-H2'       1.000000 /
 'I-NEW1'     1.000000 /
/


DATES
  1 'MAR' 1990    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   1244.5   1173.1  123577.4 /
 'P-A2AH'     'OPEN' 'LRAT'      0.0      0.0       0.0 /
 'P-A17'      'OPEN' 'LRAT'    705.4    185.4   70114.9 /
/
WELTARG
 'I-A5H'      'WRAT'        2601.7 /
```

```
 'I-H2'       'WRAT'        1000.0 /
 'I-NEW1'     'WRAT'        1000 /
/
WEFAC
 'P-A1H'      0.990927 /
 'P-A2AH'     0.001001 /
 'P-A17'      0.968302 /
 'I-A5H'      0.897000 /
 'I-H2'       1.000000 /
 'I-NEW1'     1.000000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0   /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
  1 'APR' 1990    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   1899.7   1958.5  188638.5 /
 'P-A2AH'     'OPEN' 'LRAT'     21.8    451.2    2202.6 /
 'P-A17'      'OPEN' 'LRAT'    712.9    187.5   70863.7 /
/
WELTARG
 'I-A5H'      'WRAT'        4300.7 /
 'I-H2'       'WRAT'        1000.0 /
 'I-NEW1'     'WRAT'        1000 /
/
WEFAC
 'P-A1H'      0.940278 /
 'P-A2AH'     0.010532 /
 'P-A17'      0.992361 /
 'I-A5H'      0.929000 /
 'I-H2'       1.000000 /
 'I-NEW1'     1.000000 /
/


DATES
  1 'MAY' 1990    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   1679.8   2229.5  166434.6 /
 'P-A2AH'     'OPEN' 'LRAT'    396.0   1848.6   39892.6 /
 'P-A17'      'OPEN' 'LRAT'    727.6    197.8   72188.2 /
/
WELTARG
 'I-A5H'      'WRAT'        4581.3 /
 'I-H2'       'WRAT'        1000.0 /
 'I-NEW1'     'WRAT'        1000 /
/
WEFAC
 'P-A1H'      0.793347 /
 'P-A2AH'     0.794467 /
 'P-A17'      0.971326 /
 'I-A5H'      0.949000 /
 'I-H2'       1.000000 /
 'I-NEW1'     1.000000 /
/


DATES
  1 'JUN' 1990    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   1436.6   2050.1  142652.2 /
 'P-A2AH'     'OPEN' 'LRAT'    563.3   1353.7   56889.9 /
 'P-A17'      'OPEN' 'LRAT'    664.1    240.2   66016.6 /
/
WELTARG
 'I-A5H'      'WRAT'        4515.1 /
 'I-H2'       'WRAT'        1000.0 /
 'I-NEW1'     'WRAT'        1000 /
/
WEFAC
 'P-A1H'      0.991435 /
 'P-A2AH'     0.970370 /
 'P-A17'      0.979630 /
 'I-A5H'      0.826000 /
 'I-H2'       1.000000 /
 'I-NEW1'     1.000000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0   /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
  1 'JLY' 1990    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    916.2   1221.8   90981.2 /
```

```
 'P-A2AH'     'OPEN' 'LRAT'    1036.6    2108.9  104699.6 /
 'P-A17'      'OPEN' 'LRAT'     579.9     192.6   57639.0 /
/
WELTARG
 'I-A5H'      'WRAT'          3946.9 /
 'I-H2'       'WRAT'          1000.0 /
 'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A1H'      0.327845 /
'P-A2AH'     0.682012 /
'P-A17'      0.716734 /
'I-A5H'      0.878000 /
'I-H2'       1.000000 /
'I-NEW1'     1.000000 /
/


DATES
   1 'AUG' 1990     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    1005.9    1309.0  102977.8 /
 'P-A2AH'     'OPEN' 'LRAT'    1153.9    2078.7  120051.9 /
 'P-A17'      'OPEN' 'LRAT'     571.4     181.8   58527.6 /
/
WELTARG
 'I-A5H'      'WRAT'          4326.6 /
 'I-H2'       'WRAT'          1000.0 /
 'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A1H'      0.642249 /
'P-A2AH'     0.591398 /
'P-A17'      0.626344 /
'I-A5H'      0.509000 /
'I-H2'       1.000000 /
'I-NEW1'     1.000000 /
/


DATES
   1 'SEP' 1990     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    1386.0    1594.9  140486.0 /
 'P-A2AH'     'OPEN' 'LRAT'    1155.5    2003.0  119375.4 /
 'P-A17'      'OPEN' 'LRAT'     580.9     181.5   58873.7 /
/
WELTARG
 'I-A5H'      'WRAT'          4489.3 /
 'I-H2'       'WRAT'          1000.0 /
 'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A1H'      0.990394 /
'P-A2AH'     0.866667 /
'P-A17'      0.981134 /
'I-A5H'      0.820000 /
'I-H2'       1.000000 /
'I-NEW1'     1.000000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0  /
--%Report-records: 3    1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0  /
--0 0 0 0 0    0 2 0 0 0  /
--%Report-records: 1    1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
   1 'OCT' 1990     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     786.6     929.5   80194.3 /
 'P-A2AH'     'OPEN' 'LRAT'    1211.3    2067.1  125477.8 /
 'P-A17'      'OPEN' 'LRAT'     631.0     162.8   64441.7 /
/
WELTARG
 'I-A5H'      'WRAT'          4968.3 /
 'I-H2'       'WRAT'          1000.0 /
 'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A1H'      0.966622 /
'P-A2AH'     0.952173 /
'P-A17'      0.982191 /
'I-A5H'      0.998000 /
'I-H2'       1.000000 /
'I-NEW1'     1.000000 /
/


DATES
   1 'NOV' 1990     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     799.2     885.1   78428.8 /
 'P-A2AH'     'OPEN' 'LRAT'    1215.9    2189.6  121327.3 /
 'P-A17'      'OPEN' 'LRAT'     624.1     172.3   61327.4 /
/
WELTARG
 'I-A5H'      'WRAT'          5018.3 /
 'I-H2'       'WRAT'          1000.0 /
 'I-NEW1'     'WRAT'          1000 /
```

```
/
WEFAC
'P-A1H'      0.977083 /
'P-A2AH'     0.973727 /
'P-A17'      0.989236 /
'I-A5H'      0.994000 /
'I-H2'       1.000000 /
'I-NEW1'     1.000000 /
/



DATES
   1 'DEC' 1990     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     841.3     938.8   85631.1 /
 'P-A2AH'     'OPEN' 'LRAT'    1091.7    2318.6  112961.0 /
 'P-A17'      'OPEN' 'LRAT'     616.5     235.4   62804.4 /
/
WELTARG
 'I-A5H'      'WRAT'          4130.6 /
 'I-H2'       'WRAT'          1000.0 /
 'I-NEW1'     'WRAT'          2000 /
/
WEFAC
'P-A1H'      0.998096 /
'P-A2AH'     0.976030 /
'P-A17'      0.993056 /
'I-A5H'      0.859000 /
'I-H2'       1.000000 /
'I-NEW1'     1.000000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0  /
--%Report-records: 3    1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0  /
--0 0 0 0 0    0 2 0 0 0  /
--%Report-records: 1    1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /

----------------------------------------------
--            NEW YEAR 1991           --
----------------------------------------------


DATES
   1 'JAN' 1991     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     838.9     942.5   84894.1 /
 'P-A2AH'     'OPEN' 'LRAT'    1044.3    2441.9  107552.9 /
 'P-A17'      'OPEN' 'LRAT'     507.0     220.2   51455.9 /
/
WELTARG
 'I-A5H'      'WRAT'          4482.1 /
 'I-H2'       'WRAT'          1000.0 /
 'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A1H'      0.993952 /
'P-A2AH'     0.990703 /
'P-A17'      1.000000 /
'I-A5H'      0.985000 /
'I-H2'       1.000000 /
'I-NEW1'     1.000000 /
/


DATES
   1 'FEB' 1991     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     886.3    1030.7   89238.1 /
 'P-A2AH'     'OPEN' 'LRAT'     954.5    2460.9   97739.6 /
 'P-A17'      'OPEN' 'LRAT'     512.4     216.9   51643.0 /
/
WELTARG
 'I-A5H'      'WRAT'          4849.6 /
 'I-H2'       'WRAT'          1000.0 /
 'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A1H'      0.993800 /
'P-A2AH'     0.986979 /
'P-A17'      0.967882 /
'I-A5H'      0.978000 /
'I-H2'       1.000000 /
'I-NEW1'     1.000000 /
/


DATES
   1 'MAR' 1991     /
/
RPTSCHED
32*0  1 13*0      /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'     962.7    1169.4   95886.9 /
 'P-A2AH'     'OPEN' 'LRAT'     832.7    2352.7   84473.5 /
 'P-A17'      'OPEN' 'LRAT'     513.1     196.5   51206.7 /
/
WELTARG
 'I-A5H'      'WRAT'          4969.0 /
 'I-H2'       'WRAT'          1000.0 /
 'I-NEW1'     'WRAT'          1000 /
/
WEFAC
```

```
'P-A1H'      0.937164 /                          'I-A5H'      'WRAT'         4753.3 /
'P-A2AH'     0.981071 /                          'I-H2'       'WRAT'         1000.0 /
'P-A17'      0.984095 /                          'I-NEW1'     'WRAT'         1000 /
'I-A5H'      0.934000 /                          /
'I-H2'       1.000000 /                          WEFAC
'I-NEW1'     1.000000 /                          'P-A1H'      0.993728 /
/                                                'P-A2AH'     0.646035 /
-- Yearly report                                 'P-A17'      0.991375 /
RPTSCHED                                         'I-A5H'      0.939000 /
0 0 0 0 0   0 2 2 2 0 /                          'I-H2'       1.000000 /
--%Report-records: 3   1                         'I-NEW1'     1.000000 /
-- Quarterly report                             /
--RPTSCHED
--0 0 0 0 0   0 0 2 1 0 /
--0 0 0 0 0   0 2 0 0 0 /
--%Report-records: 1   1                         DATES
-- Monthly report                                 1 'AUG' 1991     /
--RPTSCHED                                        /
--0 0 0 0 0   0 0 0 2 0 0 1 /                     RPTSCHED
                                                 32*0  1 13*0    /
                                                 WCONHIST
DATES                                            'P-A1H'      'OPEN' 'LRAT'   1354.8   2628.0  134310.6 /
 1 'APR' 1991     /                              'P-A2AH'     'OPEN' 'LRAT'    411.5   2273.3   45106.4 /
/                                                'P-A17'      'OPEN' 'LRAT'    715.8    380.4   71173.5 /
RPTSCHED                                         /
32*0  1 13*0    /                                WELTARG
WCONHIST                                         'I-A5H'      'WRAT'         3305.3 /
'P-A1H'      'OPEN' 'LRAT'   1084.9   1438.5  106388.2 /   'I-H2'       'WRAT'         1000.0 /
'P-A2AH'     'OPEN' 'LRAT'    849.4   2478.0   84711.3 /   'I-NEW1'     'WRAT'         1000 /
'P-A17'      'OPEN' 'LRAT'    511.3    200.5   50168.7 /   /
/                                                WEFAC
WELTARG                                          'P-A1H'      0.556452 /
'I-A5H'      'WRAT'         4020.0 /             'P-A2AH'     0.070116 /
'I-H2'       'WRAT'         1000.0 /             'P-A17'      0.593862 /
'I-NEW1'     'WRAT'         2000 /               'I-A5H'      0.793000 /
/                                                'I-H2'       1.000000 /
WEFAC                                            'I-NEW1'     1.000000 /
'P-A1H'      0.962384 /                          /
'P-A2AH'     0.976157 /
'P-A17'      0.996181 /
'I-A5H'      0.936000 /
'I-H2'       1.000000 /                          DATES
'I-NEW1'     1.000000 /                            1 'SEP' 1991     /
/                                                /
                                                 RPTSCHED
                                                 32*0  1 13*0    /
                                                 WCONHIST
DATES                                            'P-A1H'      'OPEN' 'LRAT'   1311.5   2565.6  129416.2 /
 1 'MAY' 1991     /                              'P-A2AH'     'OPEN' 'LRAT'      0.0      0.0       0.0 /
/                                                'P-A17'      'OPEN' 'LRAT'    567.7    291.5   56046.8 /
RPTSCHED                                         /
32*0  1 13*0    /                                WELTARG
WCONHIST                                         'I-A5H'      'WRAT'         4101.5 /
'P-A1H'      'OPEN' 'LRAT'   1268.2   1737.7  127566.1 /   'I-H2'       'WRAT'         1000.0 /
'P-A2AH'     'OPEN' 'LRAT'    764.6   2399.2   78212.5 /   'I-NEW1'     'WRAT'         1000 /
'P-A17'      'OPEN' 'LRAT'    509.9    238.6   51344.7 /   /
/                                                WEFAC
WELTARG                                          'P-A1H'      1.000000 /
'I-A5H'      'WRAT'         4149.3 /             'P-A2AH'     0.001001 /
'I-H2'       'WRAT'         1000.0 /             'P-A17'      0.993403 /
'I-NEW1'     'WRAT'         2000 /               'I-A5H'      0.968000 /
/                                                'I-H2'       1.000000 /
WEFAC                                            'I-NEW1'     1.000000 /
'P-A1H'      0.968526 /                          /
'P-A2AH'     0.993168 /
'P-A17'      0.926299 /                          -- Yearly report
'I-A5H'      0.959000 /                          RPTSCHED
'I-H2'       1.000000 /                          0 0 0 0 0   0 2 2 2 0 /
'I-NEW1'     1.000000 /                          --%Report-records: 3   1
/                                                -- Quarterly report
                                                 --RPTSCHED
                                                 --0 0 0 0 0   0 0 2 1 0 /
                                                 --0 0 0 0 0   0 2 0 0 0 /
DATES                                            --%Report-records: 1   1
 1 'JUN' 1991     /                              -- Monthly report
/                                                --RPTSCHED
RPTSCHED                                         --0 0 0 0 0   0 0 0 2 0 0 1 /
32*0  1 13*0    /
WCONHIST
'P-A1H'      'OPEN' 'LRAT'   1232.4   1903.7  124037.9 /   DATES
'P-A2AH'     'OPEN' 'LRAT'    636.8   2205.5   65207.2 /    1 'OCT' 1991     /
'P-A17'      'OPEN' 'LRAT'    517.7    208.7   52134.4 /   /
/                                                RPTSCHED
WELTARG                                          32*0  1 13*0    /
'I-A5H'      'WRAT'         4108.6 /             WCONHIST
'I-H2'       'WRAT'         1000.0 /             'P-A1H'      'OPEN' 'LRAT'   1286.9   2482.5  129209.1 /
'I-NEW1'     'WRAT'         2000 /               'P-A2AH'     'OPEN' 'LRAT'      0.0      0.0       0.0 /
/                                                'P-A17'      'OPEN' 'LRAT'    607.8    333.7   61054.7 /
WEFAC                                            /
'P-A1H'      0.993634 /                          WELTARG
'P-A2AH'     0.993519 /                          'I-A5H'      'WRAT'         3691.7 /
'P-A17'      0.993403 /                          'I-H2'       'WRAT'         1000.0 /
'I-A5H'      0.970000 /                          'I-NEW1'     'WRAT'         1000 /
'I-H2'       1.000000 /                          /
'I-NEW1'     1.000000 /                          WEFAC
/                                                'P-A1H'      0.979055 /
                                                 'P-A2AH'     0.001001 /
-- Yearly report                                 'P-A17'      0.992720 /
RPTSCHED                                         'I-A5H'      0.936000 /
0 0 0 0 0   0 2 2 2 0 /                          'I-H2'       1.000000 /
--%Report-records: 3   1                         'I-NEW1'     1.000000 /
-- Quarterly report                             /
--RPTSCHED
--0 0 0 0 0   0 0 2 1 0 /
--0 0 0 0 0   0 2 0 0 0 /
--%Report-records: 1   1                         DATES
-- Monthly report                                 1 'NOV' 1991     /
--RPTSCHED                                        /
--0 0 0 0 0   0 0 0 2 0 0 1 /                     RPTSCHED
                                                 32*0  1 13*0    /
                                                 WCONHIST
DATES                                            'P-A1H'      'OPEN' 'LRAT'   1228.7   2486.5  122366.4 /
 1 'JLY' 1991     /                              'P-A2AH'     'OPEN' 'LRAT'      0.0      0.0       0.0 /
/                                                'P-A17'      'OPEN' 'LRAT'    581.6    324.1   57969.4 /
RPTSCHED                                         /
32*0  1 13*0    /                                WELTARG
WCONHIST                                         'I-A5H'      'WRAT'         3452.7 /
'P-A1H'      'OPEN' 'LRAT'   1220.2   2045.7  125029.0 /   'I-H2'       'WRAT'         1000.0 /
'P-A2AH'     'OPEN' 'LRAT'    427.6   2105.3   44247.1 /   'I-NEW1'     'WRAT'         1000 /
'P-A17'      'OPEN' 'LRAT'    581.6    246.5   59650.4 /   /
/                                                WEFAC
WELTARG                                          'P-A1H'      0.942940 /
                                                 'P-A2AH'     0.001001 /
```

```
 'P-A17'    0.956366 /                              /
 'I-A5H'    0.994000 /                              WELTARG
 'I-H2'     1.000000 /                               'I-A5H'      'WRAT'          3744.3 /
 'I-NEW1'    1.000000 /                              'I-H2'       'WRAT'           200.0 /
/                                                    'I-NEW1'     'WRAT'          1000 /
                                                    /
                                                    WEFAC
                                                     'P-A1H'    0.920475 /
DATES                                                'P-A2AH'    0.347894 /
   1 'DEC' 1991    /                                 'P-A17'    0.939852 /
/                                                    'I-A5H'    0.984000 /
RPTSCHED                                             'I-H2'     1.000000 /
32*0  1 13*0    /                                    'I-NEW1'    1.000000 /
WCONHIST                                            /
 'P-A1H'      'OPEN' 'LRAT'    1323.0   2685.4 132769.5 /
 'P-A2AH'     'OPEN' 'LRAT'       0.0      0.0      0.0 /  -- Yearly report
 'P-A17'      'OPEN' 'LRAT'     634.9    374.4  63845.5 /  RPTSCHED
/                                                    0 0 0 0 0   0 2 2 2 0  /
WELTARG                                             --%Report-records: 3   1
 'I-A5H'      'WRAT'          3838.3 /              -- Quarterly report
 'I-H2'       'WRAT'          1000.0 /              --RPTSCHED
 'I-NEW1'     'WRAT'          1000 /                --0 0 0 0 0   0 0 2 1 0  /
/                                                   --0 0 0 0 0   0 2 0 0 0  /
WEFAC                                               --%Report-records: 1   1
 'P-A1H'    0.876456 /                              -- Monthly report
 'P-A2AH'    0.001001 /                             --RPTSCHED
 'P-A17'    0.969422 /                              --0 0 0 0 0   0 0 0 2 0 0 1 /
 'I-A5H'    0.972000 /
 'I-H2'     1.000000 /
 'I-NEW1'    1.000000 /                             DATES
/                                                      1 'APR' 1992    /
                                                    /
-- RFT -Date at 29121991 for well P-A35 --         RPTSCHED
RPTSCHED                                            32*0  1 13*0    /
  0 0 0 0 0   0 0 0 2 0 0 0 0 0 /                   WCONHIST
                                                     'P-A1H'      'OPEN' 'LRAT'     933.6   2679.4  93457.9 /
                                                     'P-A2AH'     'OPEN' 'LRAT'       0.0    390.3      0.2 /
DATES                                                'P-A17'      'OPEN' 'LRAT'     355.0    236.5  35573.6 /
   29 'DEC' 1991    /                               /
/                                                   WELTARG
RPTSCHED                                             'I-A5H'      'WRAT'          3414.6 /
32*0  1 13*0    /                                    'I-H2'       'WRAT'           200.0 /
-- Yearly report                                     'I-NEW1'     'WRAT'          1000 /
RPTSCHED                                            /
0 0 0 0 0   0 2 2 2 0  /                            WEFAC
--%Report-records: 3   1                             'P-A1H'    0.968056 /
-- Quarterly report                                  'P-A2AH'    0.932292 /
--RPTSCHED                                           'P-A17'    0.993171 /
--0 0 0 0 0   0 0 2 1 0  /                           'I-A5H'    0.979000 /
--0 0 0 0 0   0 2 0 0 0  /                           'I-H2'     1.000000 /
--%Report-records: 1   1                             'I-NEW1'    1.000000 /
-- Monthly report                                   /
--RPTSCHED
--0 0 0 0 0   0 0 0 2 0 0 1 /

-----------------------------------------          DATES
--              NEW YEAR 1992          --              1 'MAY' 1992    /
-----------------------------------------          /
                                                    RPTSCHED
                                                    32*0  1 13*0    /
                                                    WCONHIST
DATES                                                'P-A1H'      'OPEN' 'LRAT'     973.6   3125.3  95663.2 /
   1 'JAN' 1992    /                                 'P-A2AH'     'OPEN' 'LRAT'       0.0    813.2      0.4 /
/                                                    'P-A17'      'OPEN' 'LRAT'     392.9    246.1  38642.5 /
RPTSCHED                                            /
32*0  1 13*0    /                                   WELTARG
WCONHIST                                             'I-A5H'      'WRAT'          6011.3 /
 'P-A1H'      'OPEN' 'LRAT'    1211.6   2786.8 118520.5 /  'I-H2'       'WRAT'           200.0 /
 'P-A2AH'     'OPEN' 'LRAT'       0.0      0.0      0.0 /  'I-NEW1'     'WRAT'          1000 /
 'P-A17'      'OPEN' 'LRAT'     545.9    323.5  53384.9 / /
/                                                   WEFAC
WELTARG                                              'P-A1H'    0.981407 /
 'I-A5H'      'WRAT'          3618.9 /               'P-A2AH'    0.054996 /
 'I-H2'       'WRAT'           200.0 /               'P-A17'    0.968862 /
 'I-NEW1'     'WRAT'          1000 /                 'I-A5H'    0.984000 /
/                                                    'I-H2'     1.000000 /
WEFAC                                                'I-NEW1'    1.000000 /
 'P-A1H'    0.986783 /                              /
 'P-A2AH'    0.001001 /
 'P-A17'    0.975806 /
 'I-A5H'    0.996000 /                              DATES
 'I-H2'     1.000000 /                                 1 'JUN' 1992    /
 'I-NEW1'    1.000000 /                             /
/                                                   RPTSCHED
                                                    32*0  1 13*0    /
                                                    WCONHIST
                                                     'P-A1H'      'OPEN' 'LRAT'     770.7   2656.4  74961.9 /
DATES                                                'P-A2AH'     'OPEN' 'LRAT'       0.0      0.0      0.0 /
   1 'FEB' 1992    /                                 'P-A17'      'OPEN' 'LRAT'     414.9    256.7  40386.2 /
/                                                   /
RPTSCHED                                            WELTARG
32*0  1 13*0    /                                    'I-A5H'      'WRAT'          2645.0 /
WCONHIST                                             'I-H2'       'WRAT'           200.0 /
 'P-A1H'      'OPEN' 'LRAT'    1191.4   2671.3 116965.1 /  'I-NEW1'     'WRAT'          1000 /
 'P-A2AH'     'OPEN' 'LRAT'       0.0      0.0      0.0 / /
 'P-A17'      'OPEN' 'LRAT'     341.0    249.4  33520.2 / WEFAC
/                                                    'P-A1H'    0.660764 /
WELTARG                                              'P-A2AH'    0.001001 /
 'I-A5H'      'WRAT'          3571.5 /               'P-A17'    0.661574 /
 'I-H2'       'WRAT'           200.0 /               'I-A5H'    0.648000 /
 'I-NEW1'     'WRAT'          1000 /                 'I-H2'     1.000000 /
/                                                    'I-NEW1'    1.000000 /
WEFAC                                               /
 'P-A1H'    0.980244 /
 'P-A2AH'    0.001001 /                             -- Yearly report
 'P-A17'    0.986470 /                              RPTSCHED
 'I-A5H'    0.980000 /                              0 0 0 0 0   0 2 2 2 0  /
 'I-H2'     1.000000 /                              --%Report-records: 3   1
 'I-NEW1'    1.000000 /                             -- Quarterly report
/                                                   --RPTSCHED
                                                    --0 0 0 0 0   0 0 2 1 0  /
                                                    --0 0 0 0 0   0 2 0 0 0  /
                                                    --%Report-records: 1   1
DATES                                               -- Monthly report
   1 'MAR' 1992    /                                --RPTSCHED
/                                                   --0 0 0 0 0   0 0 0 2 0 0 1 /
RPTSCHED
32*0  1 13*0    /
WCONHIST                                            DATES
 'P-A1H'      'OPEN' 'LRAT'    1048.5   2846.3 101926.8 /    1 'JLY' 1992    /
 'P-A2AH'     'OPEN' 'LRAT'       0.0    652.1      0.4 / /
 'P-A17'      'OPEN' 'LRAT'     343.0    251.1  33392.6 / RPTSCHED
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```
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    954.5   2948.9  93765.9 /
 'P-A2AH'     'OPEN' 'LRAT'     90.0   2202.2   8617.1 /
 'P-A17'      'OPEN' 'LRAT'    397.6    246.0  38985.6 /
/
WELTARG
 'I-A5H'      'WRAT'           3914.2 /
 'I-H2'       'WRAT'            200.0 /
 'I-NEW1'     'WRAT'           1000 /
/
WEFAC
 'P-A1H'     0.853719 /
 'P-A2AH'    0.114247 /
 'P-A17'     0.888665 /
 'I-A5H'     0.860000 /
 'I-H2'      1.000000 /
 'I-NEW1'    1.000000 /
/


DATES
  1 'AUG' 1992     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    197.7    610.9  19543.9 /
 'P-A2AH'     'OPEN' 'LRAT'     59.4   2523.0   6073.2 /
 'P-A17'      'OPEN' 'LRAT'    414.1    335.1  41531.5 /
/
WELTARG
 'I-A5H'      'WRAT'           3719.7 /
 'I-H2'       'WRAT'            200.0 /
 'I-NEW1'     'WRAT'           1000 /
/
WEFAC
 'P-A1H'     0.011761 /
 'P-A2AH'    0.745184 /
 'P-A17'     0.995632 /
 'I-A5H'     0.987000 /
 'I-H2'      1.000000 /
 'I-NEW1'    1.000000 /
/


DATES
  1 'SEP' 1992     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'      0.0      0.0      0.0 /
 'P-A2AH'     'OPEN' 'LRAT'     58.2   2380.0   5824.5 /
 'P-A17'      'OPEN' 'LRAT'    393.1    323.1  38764.4 /
/
WELTARG
 'I-A5H'      'WRAT'           2888.9 /
 'I-H2'       'WRAT'            200.0 /
 'I-NEW1'     'WRAT'           1000 /
/
WEFAC
 'P-A1H'     0.001001 /
 'P-A2AH'    0.999306 /
 'P-A17'     0.985764 /
 'I-A5H'     0.924000 /
 'I-H2'      1.000000 /
 'I-NEW1'    1.000000 /
/


--  RFT -Date at 15091992 for well I-A38 --
RPTSCHED
  0 0 0 0 0    0 0 0 2 0 0 0 0 0 /


DATES
  15 'SEP' 1992     /
/
RPTSCHED
32*0  1 13*0     /

--  Yearly report
RPTSCHED
 0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
--  Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0  /
--0 0 0 0 0    0 2 0 0 0  /
--%Report-records: 1   1
--  Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
  1 'OCT' 1992     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    879.5   1452.0  87004.3 /
 'P-A2AH'     'OPEN' 'LRAT'    125.5   2273.9  12573.9 /
 'P-A17'      'OPEN' 'LRAT'    358.4    321.1  35332.6 /
/
WELTARG
 'I-A5H'      'WRAT'           3117.6 /
 'I-H2'       'WRAT'            200.0 /
 'I-NEW1'     'WRAT'           2000 /
/
WEFAC
 'P-A1H'     0.525986 /
 'P-A2AH'    0.978271 /
 'P-A17'     1.000000 /
 'I-A5H'     0.659000 /
 'I-H2'      1.000000 /
 'I-NEW1'    1.000000 /
/
```

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DATES
  1 'NOV' 1992     /
/
RPTSCHED
32*0  1 13*0     /
COMPDAT
-- 'I-A38'       6   1  12  12  'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6   2  12  12  'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
-- 'I-A38'       6   3  12  12  'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6   4  12  12  'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6   5  12  12  'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6   6  12  12  'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
-- 'I-A38'       6   7  12  12  'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6   8  12  12  'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
-- 'I-A38'       6   9  12  12  'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
-- 'I-A38'       6  10  12  12  'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
-- 'I-A38'       6  11  12  12  'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6  12  12  12  'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6  13  12  12  'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       5  14   3   4  'SHUT' 1* 1* .4320 1*  .0 1* /
   'I-A38'       5  14   6   8  'OPEN' 1* 1* .4320 1*  .0 1* /

/
WCONINJE
'I-A38' 'WAT' 'OPEN'  'RATE'  0.   1*    1*    1*    1*
/
/
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   1054.2   2402.6 104506.9 /
 'P-A2AH'     'OPEN' 'LRAT'    124.4   2122.4  12613.1 /
 'P-A17'      'OPEN' 'LRAT'    414.1    370.9  41086.1 /
/
WELTARG
 'I-A38'      'WRAT'            932.0 /
 'I-A5H'      'WRAT'           4241.8 /
 'I-H2'       'WRAT'            200.0 /
 'I-NEW1'     'WRAT'           1000 /
/
WEFAC
 'P-A1H'     0.990162 /
 'P-A2AH'    0.281134 /
 'P-A17'     0.997106 /
 'I-A38'     0.458000 /
 'I-A5H'     0.983000 /
 'I-H2'      1.000000 /
 'I-NEW1'    1.000000 /
/


DATES
  1 'DEC' 1992     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'   1013.9   2539.2 100607.0 /
 'P-A2AH'     'OPEN' 'LRAT'      0.0      0.0      0.0 /
 'P-A17'      'OPEN' 'LRAT'    434.8    401.6  43220.2 /
/
WELTARG
 'I-A38'      'WRAT'            662.0 /
 'I-A5H'      'WRAT'           2417.4 /
 'I-H2'       'WRAT'            200.0 /
 'I-NEW1'     'WRAT'           1000 /
/
WEFAC
 'P-A1H'     1.000000 /
 'P-A2AH'    0.001001 /
 'P-A17'     0.983759 /
 'I-A38'     0.994000 /
 'I-A5H'     0.986000 /
 'I-H2'      1.000000 /
 'I-NEW1'    1.000000 /
/
WELOPEN
'P-A2AH' 'SHUT'  /
/

--  Yearly report
RPTSCHED
 0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
--  Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0  /
--0 0 0 0 0    0 2 0 0 0  /
--%Report-records: 1   1
--  Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /

---------------------------------------------
--            NEW YEAR 1993          --
---------------------------------------------


DATES
  1 'JAN' 1993     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'      'OPEN' 'LRAT'    976.0   2779.3  94777.9 /
 'P-A2AH'     'OPEN' 'LRAT'      0.0      0.0      0.0 /
 'P-A17'      'OPEN' 'LRAT'    425.5    400.3  41341.1 /
/
WELTARG
 'I-A38'      'WRAT'            615.4 /
```

```
 'I-A5H'     'WRAT'         3560.9 /
 'I-H2'      'WRAT'          200.0 /
 'I-NEW1'    'WRAT'         2000 /
/
WEFAC
'P-A1H'     0.880264 /
'P-A2AH'    0.001001 /
'P-A17'     0.846550 /
'I-A38'     0.919000 /
'I-A5H'     0.924000 /
'I-H2'      1.000000 /
'I-NEW1'    1.000000 /
/
WELOPEN
'I-H2' 'SHUT'   /
/


DATES
 1 'FEB' 1993    /
/
RPTSCHED
32*0  1 13*0    /
COMPDAT
 'P-A39A'    19   3  12  12 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    19   4  12  12 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    19   4  11  11 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    17   9  10  10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    17  10  10  10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    16  10  10  10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    16  11  10  10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    16  12  10  10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    16  13  10  10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    15  13  10  10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  16  11  11 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  17  11  11 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  18  11  11 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  15  10  10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  16  10  10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  17  10  10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
/
WCONHIST
'P-A1H'     'OPEN' 'LRAT'    874.6    2647.7   83680.2 /
'P-A2AH'    'OPEN' 'LRAT'      0.0       0.0       0.0 /
'P-A17'     'OPEN' 'LRAT'    466.0     423.3   44664.1 /
'P-A39A'    'OPEN' 'LRAT'   1157.0       0.0  104342.2 /
/
WELTARG
'I-A38'     'WRAT'          314.4 /
'I-A5H'     'WRAT'         3731.2 /
'I-H2'      'WRAT'          200.0 /
'I-NEW1'    'WRAT'         2000 /
/
WEFAC
'P-A1H'     0.848834 /
'P-A2AH'    0.001001 /
'P-A17'     0.850198 /
'P-A39A'    0.220982 /
'I-A38'     0.902000 /
'I-A5H'     0.906000 /
'I-H2'      1.000000 /
'I-NEW1'    1.000000 /
/
WELOPEN
'P-A39A' 'OPEN'    /
/


DATES
 1 'MAR' 1993    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
'P-A1H'     'OPEN' 'LRAT'    892.0    3348.5   86567.8 /
'P-A2AH'    'OPEN' 'LRAT'      0.0       0.0       0.0 /
'P-A17'     'OPEN' 'LRAT'    423.0     450.2   41089.3 /
'P-A39A'    'OPEN' 'LRAT'   1469.9       2.7  135025.9 /
/
WELTARG
'I-A38'     'WRAT'          367.8 /
'I-A5H'     'WRAT'         4556.4 /
'I-H2'      'WRAT'          200.0 /
'I-NEW1'    'WRAT'         2000 /
/
WEFAC
'P-A1H'     0.995408 /
'P-A2AH'    0.001001 /
'P-A17'     0.990121 /
'P-A39A'    0.995408 /
'I-A38'     0.962000 /
'I-A5H'     0.959000 /
'I-H2'      1.000000 /
'I-NEW1'    1.000000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
```

```
--  Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /

DATES
 1 'APR' 1993    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
'P-A1H'     'OPEN' 'LRAT'    843.3    3524.7   82803.2 /
'P-A2AH'    'OPEN' 'LRAT'      0.0       0.0       0.0 /
'P-A17'     'OPEN' 'LRAT'    410.5     391.3   40396.9 /
'P-A39A'    'OPEN' 'LRAT'   1475.2       1.4  137255.7 /
/
WELTARG
'I-A38'     'WRAT'          653.7 /
'I-A5H'     'WRAT'         4426.6 /
'I-H2'      'WRAT'          200.0 /
'I-NEW1'    'WRAT'         2000 /
/
WEFAC
'P-A1H'     0.451736 /
'P-A2AH'    0.001001 /
'P-A17'     0.998264 /
'P-A39A'    0.994792 /
'I-A38'     0.919000 /
'I-A5H'     0.195000 /
'I-H2'      1.000000 /
'I-NEW1'    1.000000 /
/


DATES
 1 'MAY' 1993    /
/
RPTSCHED
32*0  1 13*0    /
COMPDAT
-- 'I-A38'       6   1  12  12 'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6   2  12  12 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
-- 'I-A38'       6   3  12  12 'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6   4  12  12 'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6   5  12  12 'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6   6  12  12 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
-- 'I-A38'       6   7  12  12 'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6   8  12  12 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
-- 'I-A38'       6   9  12  12 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
-- 'I-A38'       6  10  12  12 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
-- 'I-A38'       6  11  12  12 'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6  12  12  12 'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       6  13  12  12 'OPEN' 1* 1* .4320 1*  .0 1*
'Y' /
-- 'I-A38'       5  14   3   4 'SHUT' 1* 1* .4320 1*  .0 1* /
 'I-A38'        5  14   6   6 'OPEN' 1* 1* .4320 1*  .0 1* /
 'I-A38'        5  14   8   9 'OPEN' 1* 1* .4320 1*  .0 1* /
/
WCONHIST
'P-A1H'     'OPEN' 'LRAT'    592.3    2359.5   57324.2 /
'P-A2AH'    'OPEN' 'LRAT'      0.0       0.0       0.0 /
'P-A17'     'OPEN' 'LRAT'    413.3     357.7   40062.0 /
'P-A39A'    'OPEN' 'LRAT'   1636.9       0.0  159383.4 /
/
WELTARG
'I-A38'     'WRAT'         5775.0 /
'I-NEW1'    'WRAT'         2000 /
/
WEFAC
'P-A1H'     0.969489 /
'P-A2AH'    0.001001 /
'P-A17'     0.992361 /
'P-A39A'    0.992832 /
'I-A38'     0.955000 /
'I-NEW1'    0.955000 /
/
WELOPEN
'I-A5H' 'STOP'   /
'I-A38' 'OPEN'   /
/


DATES
 1 'JUN' 1993    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
'P-A1H'     'OPEN' 'LRAT'    613.5    3126.2   59652.6 /
'P-A2AH'    'OPEN' 'LRAT'      0.0       0.0       0.0 /
'P-A17'     'OPEN' 'LRAT'    467.7     540.2   45590.9 /
'P-A39A'    'OPEN' 'LRAT'   1544.3       0.0  172134.3 /
/
WELTARG
'I-A38'     'WRAT'         5396.1 /
'I-NEW1'    'WRAT'         3000 /
/
WEFAC
'P-A1H'     0.773125 /
'P-A2AH'    0.001001 /
'P-A17'     0.758542 /
'P-A39A'    0.775579 /
'I-A38'     0.820000 /
'I-NEW1'    0.820000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
```

```
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
 1 'JLY' 1993     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'       'OPEN' 'LRAT'    471.3  3214.4  48250.0 /
 'P-A2AH'      'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A17'       'OPEN' 'LRAT'    460.3   632.5  44189.9 /
 'P-A39A'      'OPEN' 'LRAT'   1646.9     0.0 180911.1 /
/
WELTARG
 'I-A38'    'WRAT'      5137.9 /
 'I-NEW1'   'WRAT'      3000 /
/
WEFAC
'P-A1H'     0.986335 /
'P-A2AH'    0.001001 /
'P-A17'     1.000000 /
'P-A39A'    0.986201 /
'I-A38'     0.981000 /
'I-NEW1'    0.981000 /
/


DATES
 1 'AUG' 1993     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'       'OPEN' 'LRAT'    475.9  3499.0  45747.5 /
 'P-A2AH'      'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A17'       'OPEN' 'LRAT'    452.6   633.9  43567.3 /
 'P-A39A'      'OPEN' 'LRAT'   1667.0     0.0 169624.4 /
/
WELTARG
 'I-A38'    'WRAT'      5444.8 /
 'I-NEW1'   'WRAT'      2000 /
/
WEFAC
'P-A1H'     0.993436 /
'P-A2AH'    0.001001 /
'P-A17'     0.997715 /
'P-A39A'    0.994400 /
'I-A38'     0.995000 /
'I-NEW1'    0.995000 /
/


DATES
 1 'SEP' 1993     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'       'OPEN' 'LRAT'     38.7   789.9   4886.1 /
 'P-A2AH'      'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A17'       'OPEN' 'LRAT'    449.5   652.8  43388.3 /
 'P-A39A'      'OPEN' 'LRAT'   1737.0     2.1 177287.1 /
/
WELTARG
 'I-A38'    'WRAT'      4237.0 /
 'I-NEW1'   'WRAT'      1000 /
/
WEFAC
'P-A1H'     0.939444 /
'P-A2AH'    0.001001 /
'P-A17'     0.997685 /
'P-A39A'    1.000000 /
'I-A38'     1.000000 /
'I-NEW1'    1.000000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
 1 'OCT' 1993     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'       'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A2AH'      'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A17'       'OPEN' 'LRAT'    420.8   674.2  40743.4 /
 'P-A39A'      'OPEN' 'LRAT'   1810.5   114.7 185291.1 /
/
WELTARG
 'I-A38'    'WRAT'      2789.5 /
 'I-NEW1'   'WRAT'      1000 /
/
WEFAC
'P-A1H'     0.001001 /
'P-A2AH'    0.001001 /
'P-A17'     0.986783 /
'P-A39A'    0.990995 /
'I-A38'     0.930000 /
'I-NEW1'    0.930000 /
```

```
/
WELOPEN
'P-A1H' 'SHUT'  /
/

DATES
 1 'NOV' 1993     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'       'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A2AH'      'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A17'       'OPEN' 'LRAT'    405.7   661.2  39167.3 /
 'P-A39A'      'OPEN' 'LRAT'   1280.0   239.1 130682.1 /
/
WELTARG
 'I-A38'    'WRAT'      2358.4 /
 'I-NEW1'   'WRAT'      1000 /
/
WEFAC
'P-A1H'     0.001001 /
'P-A2AH'    0.001001 /
'P-A17'     0.997755 /
'P-A39A'    0.994537 /
'I-A38'     0.977000 /
'I-NEW1'    0.977000 /
/


DATES
 1 'DEC' 1993     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'       'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A2AH'      'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A17'       'OPEN' 'LRAT'    413.2   702.5  39828.3 /
 'P-A39A'      'OPEN' 'LRAT'   1379.3   397.2 140970.8 /
/
WELTARG
 'I-A38'    'WRAT'      2579.2 /
 'I-NEW1'   'WRAT'      1000 /
/
WEFAC
'P-A1H'     0.001001 /
'P-A2AH'    0.001001 /
'P-A17'     0.947760 /
'P-A39A'    0.933020 /
'I-A38'     0.980000 /
'I-NEW1'    0.980000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /

-----------------------------------------------
--             NEW YEAR 1994            --
-----------------------------------------------


DATES
 1 'JAN' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'       'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A2AH'      'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A17'       'OPEN' 'LRAT'    388.0   683.9  38010.1 /
 'P-A39A'      'OPEN' 'LRAT'   1182.1   499.5 122320.7 /
/
WELTARG
 'I-A38'    'WRAT'      2062.6 /
 'I-NEW1'   'WRAT'      1000 /
/
WEFAC
'P-A1H'     0.001001 /
'P-A2AH'    0.001001 /
'P-A17'     0.940166 /
'P-A39A'    0.950022 /
'I-A38'     0.966000 /
'I-NEW1'    0.966000 /
/


DATES
 1 'FEB' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A1H'       'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A2AH'      'OPEN' 'LRAT'      0.0     0.0      0.0 /
 'P-A17'       'OPEN' 'LRAT'    308.9   618.4  30297.5 /
 'P-A39A'      'OPEN' 'LRAT'   1246.8   607.2 129042.4 /
/
WELTARG
 'I-A38'    'WRAT'      2385.8 /
 'I-NEW1'   'WRAT'      1000 /
/
WEFAC
'P-A1H'     0.001001 /
'P-A2AH'    0.001001 /
'P-A17'     0.618304 /
'P-A39A'    0.999082 /
'I-A38'     0.996000 /
```

```
'I-NEW1'    0.996000 /
/


DATES
   1 'MAR' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'      'OPEN' 'LRAT'    307.0    607.5   30499.6 /
 'P-A39A'     'OPEN' 'LRAT'   1262.5    805.0  132737.4 /
/
WELTARG
 'I-A38'      'WRAT'         2131.7 /
'I-NEW1'     'WRAT'         1000 /
/
WEFAC
'P-A17'      0.983893 /
'P-A39A'     0.966263 /
'I-A38'      0.995000 /
'I-NEW1'     0.995000 /
/
-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0   0 0 2 1 0 /
--0 0 0 0 0   0 2 0 0 0 /
--%Report-records: 1   1
--  Monthly report
--RPTSCHED
--0 0 0 0 0   0 0 0 2 0 0 1 /


DATES
   1 'APR' 1994     /
/
RPTSCHED
32*0  1 13*0     /
COMPDAT
  'P-A39A'     19    3  12  12 'SHUT' 1* 1* .4320 1*  .0 1* 'Y'
/
  'P-A39A'     19    4  12  12 'SHUT' 1* 1* .4320 1*  .0 1* 'Y'
/
  'P-A39A'     19    4  11  11 'SHUT' 1* 1* .4320 1*  .0 1* 'Y'
/
/
WCONHIST
 'P-A17'      'OPEN' 'LRAT'    303.2    549.2   29876.9 /
 'P-A39A'     'OPEN' 'LRAT'   1234.9    819.3  128695.1 /
/
WELTARG
 'I-A38'      'WRAT'         2548.8 /
'I-NEW1'     'WRAT'         1000 /
/
WEFAC
'P-A17'      0.994444 /
'P-A39A'     1.000000 /
'I-A38'      0.996000 /
'I-NEW1'     0.996000 /
/
WELOPEN
'P-A39A'  'SHUT'     /
/


DATES
   1 'MAY' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'      'OPEN' 'LRAT'    304.2    583.2   30282.6 /
 'P-A39A'     'OPEN' 'LRAT'   1181.3    662.0  124141.8 /
/
WELTARG
 'I-A38'      'WRAT'         2285.2 /
'I-NEW1'     'WRAT'         1000 /
/
WEFAC
'P-A17'      0.995049 /
'P-A39A'     0.891017 /
'I-A38'      0.894000 /
'I-NEW1'     0.894000 /
/


DATES
   1 'JUN' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'      'OPEN' 'LRAT'    316.8    630.6   32662.7 /
 'P-A39A'     'OPEN' 'LRAT'    992.4     18.3  108147.9 /
/
WELTARG
 'I-A38'      'WRAT'         2288.0 /
'I-NEW1'     'WRAT'         1000 /
/
WEFAC
'P-A17'      0.998148 /
'P-A39A'     0.996991 /
'I-A38'      0.997000 /
'I-NEW1'     0.997000 /
/
-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0   0 0 2 1 0 /
--0 0 0 0 0   0 2 0 0 0 /
--%Report-records: 1   1
```

```
-- Monthly report
--RPTSCHED
--0 0 0 0 0   0 0 0 2 0 0 1 /


DATES
   1 'JLY' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'      'OPEN' 'LRAT'    298.2    625.7   30427.0 /
 'P-A39A'     'OPEN' 'LRAT'    985.0     21.8  106285.8 /
/
WELTARG
 'I-A38'      'WRAT'         1427.5 /
'I-NEW1'     'WRAT'         1000 /
/
WEFAC
'P-A17'      0.988082 /
'P-A39A'     0.988351 /
'I-A38'      0.986000 /
'I-NEW1'     0.986000 /
/
WELOPEN
'I-A5H' 'SHUT'  /
/


DATES
   1 'AUG' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'      'OPEN' 'LRAT'    305.1    563.2   30380.4 /
 'P-A39A'     'OPEN' 'LRAT'    953.0     41.3  100414.7 /
/
WELTARG
 'I-A38'      'WRAT'         1788.3 /
'I-NEW1'     'WRAT'         1000 /
/
WEFAC
'P-A17'      0.490569 /
'P-A39A'     0.501008 /
'I-A38'      0.492000 /
'I-NEW1'     0.492000 /
/


DATES
   1 'SEP' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'      'OPEN' 'LRAT'    298.4    550.7   28610.4 /
 'P-A39A'     'OPEN' 'LRAT'    910.0     40.0   92159.3 /
/
WELTARG
 'I-A38'      'WRAT'         1880.2 /
'I-NEW1'     'WRAT'         1000 /
/
WEFAC
'P-A17'      0.898241 /
'P-A39A'     0.890139 /
'I-A38'      0.958000 /
'I-NEW1'     0.958000 /
/
-- Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0 /
--%Report-records: 3   1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0   0 0 2 1 0 /
--0 0 0 0 0   0 2 0 0 0 /
--%Report-records: 1   1
-- Monthly report
--RPTSCHED
--0 0 0 0 0   0 0 0 2 0 0 1 /


DATES
   1 'OCT' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'      'OPEN' 'LRAT'    279.1    598.6   27441.8 /
 'P-A39A'     'OPEN' 'LRAT'    935.2     57.6   97256.7 /
/
WELTARG
 'I-A38'      'WRAT'         2029.7 /
'I-NEW1'     'WRAT'         1000 /
/
WEFAC
'P-A17'      0.956519 /
'P-A39A'     0.988799 /
'I-A38'      0.868000 /
'I-NEW1'     0.868000 /
/


DATES
   1 'NOV' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'      'OPEN' 'LRAT'    321.8    630.8   32196.4 /
 'P-A39A'     'OPEN' 'LRAT'    924.9     62.6   97799.8 /
/
WELTARG
 'I-A38'      'WRAT'         2026.2 /
'I-NEW1'     'WRAT'         1000 /
/
WEFAC
'P-A17'      0.971505 /
```

```
'P-A39A'    0.878472 /
'I-A38'    0.996000 /
'I-NEW1'    0.996000 /
/


DATES
   1 'DEC' 1994     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'     'OPEN' 'LRAT'    273.3    643.8   27342.3 /
 'P-A39A'    'OPEN' 'LRAT'    910.9    101.8   96344.1 /
/
WELTARG
 'I-A38'     'WRAT'          2018.5 /
'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A17'     0.934117 /
'P-A39A'    0.998096 /
'I-A38'    0.998000 /
'I-NEW1'    0.998000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0     0 2 2 2 0 /
--%Report-records: 3    1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1    1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /

-----------------------------------------------
--             NEW YEAR 1995            --
-----------------------------------------------


DATES
   1 'JAN' 1995     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'     'OPEN' 'LRAT'    242.0    652.1   23915.8 /
 'P-A39A'    'OPEN' 'LRAT'    946.6     65.2   98867.3 /
/
WELTARG
 'I-A38'     'WRAT'          2650.8 /
'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A17'     0.996976 /
'P-A39A'    0.987567 /
'I-A38'    0.994000 /
'I-NEW1'    0.994000 /
/


DATES
   1 'FEB' 1995     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'     'OPEN' 'LRAT'    205.5    610.4   20098.3 /
 'P-A39A'    'OPEN' 'LRAT'    882.8    144.3   91631.4 /
/
WELTARG
 'I-A38'     'WRAT'          3168.0 /
'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A17'     0.906572 /
'P-A39A'    0.978150 /
'I-A38'    0.986000 /
'I-NEW1'    0.986000 /
/


DATES
   1 'MAR' 1995     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'     'OPEN' 'LRAT'    225.4    640.6   21902.5 /
 'P-A39A'    'OPEN' 'LRAT'    857.2    211.2   88082.0 /
/
WELTARG
 'I-A38'     'WRAT'          3081.3 /
'I-NEW1'     'WRAT'          1500 /
/
WEFAC
'P-A17'     0.968728 /
'P-A39A'    0.993638 /
'I-A38'    0.954000 /
'I-NEW1'    0.954000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0     0 2 2 2 0 /
--%Report-records: 3    1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1    1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /
```

```
DATES
   1 'APR' 1995     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'     'OPEN' 'LRAT'    212.0    602.5   21554.5 /
 'P-A39A'    'OPEN' 'LRAT'    769.6    271.0   82739.8 /
/
WELTARG
 'I-A38'     'WRAT'          1905.7 /
'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A17'     0.999144 /
'P-A39A'    0.999398 /
'I-A38'    0.996000 /
'I-NEW1'    0.996000 /
/


DATES
   1 'MAY' 1995     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'     'OPEN' 'LRAT'    202.4    614.1   20154.0 /
 'P-A39A'    'OPEN' 'LRAT'    759.2    313.0   79905.1 /
/
WELTARG
 'I-A38'     'WRAT'          1720.1 /
'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A17'     0.989919 /
'P-A39A'    0.977912 /
'I-A38'    0.977000 /
'I-NEW1'    0.977000 /
/


DATES
   1 'JUN' 1995     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'     'OPEN' 'LRAT'    175.2    585.9   17313.0 /
 'P-A39A'    'OPEN' 'LRAT'    738.3    400.5   77123.2 /
/
WELTARG
 'I-A38'     'WRAT'          1929.3 /
'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A17'     0.997685 /
'P-A39A'    0.998380 /
'I-A38'    0.996000 /
'I-NEW1'    0.996000 /
/

-- Yearly report
RPTSCHED
0 0 0 0 0     0 2 2 2 0 /
--%Report-records: 3    1
-- Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0 /
--0 0 0 0 0    0 2 0 0 0 /
--%Report-records: 1    1
-- Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /

DATES
   1 'JLY' 1995     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'     'OPEN' 'LRAT'    188.7    567.7   18090.3 /
 'P-A39A'    'OPEN' 'LRAT'    640.7    593.0   65134.3 /
/
WELTARG
 'I-A38'     'WRAT'          1607.9 /
'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A17'     0.997424 /
'P-A39A'    0.975694 /
'I-A38'    0.982000 /
'I-NEW1'    0.982000 /
/


DATES
   1 'AUG' 1995     /
/
RPTSCHED
32*0  1 13*0     /
WCONHIST
 'P-A17'     'OPEN' 'LRAT'    198.6    550.5   19555.3 /
 'P-A39A'    'OPEN' 'LRAT'    600.2    588.7   62635.3 /
/
WELTARG
 'I-A38'     'WRAT'          1876.3 /
'I-NEW1'     'WRAT'          1000 /
/
WEFAC
'P-A17'     0.545363 /
'P-A39A'    0.599462 /
'I-A38'    0.620000 /
'I-NEW1'    0.620000 /
/
```

```
DATES                                                    WELTARG
  1 'SEP' 1995    /                                       'I-A38'      'WRAT'          1707.6 /
/                                                         'I-NEW1'     'WRAT'          1000 /
RPTSCHED                                                 /
32*0  1 13*0    /                                        WEFAC
WCONHIST                                                  'P-A17'      0.001001 /
 'P-A17'      'OPEN' 'LRAT'     161.0    513.7  15740.5 /  'P-A35'      0.972110 /
 'P-A39A'     'OPEN' 'LRAT'     493.8    799.8  50920.9 /  'P-A39A'     1.000000 /
/                                                         'I-A38'      0.996000 /
WELTARG                                                   'I-NEW1'     0.996000 /
 'I-A38'      'WRAT'          2026.6 /                    /
 'I-NEW1'     'WRAT'          1000 /
/                                                        -- Yearly report
WEFAC                                                    RPTSCHED
 'P-A17'      0.742824 /                                 0 0 0 0 0    0 2 2 2 0  /
 'P-A39A'     0.981944 /                                 --%Report-records: 3   1
 'I-A38'      0.940000 /                                 -- Quarterly report
 'I-NEW1'     0.940000 /                                 --RPTSCHED
/                                                        --0 0 0 0 0    0 0 2 1 0  /
                                                         --0 0 0 0 0    0 2 0 0 0  /
-- Yearly report                                         --%Report-records: 1   1
RPTSCHED                                                 -- Monthly report
0 0 0 0 0    0 2 2 2 0  /                                --RPTSCHED
--%Report-records: 3   1                                 --0 0 0 0 0    0 0 0 2 0 0 1 /
-- Quarterly report
--RPTSCHED                                               ----------------------------------------------
--0 0 0 0 0    0 0 2 1 0  /                              --           NEW YEAR 1996           --
--0 0 0 0 0    0 2 0 0 0  /                              ----------------------------------------------
--%Report-records: 1   1
-- Monthly report
--RPTSCHED                                               DATES
--0 0 0 0 0    0 0 0 2 0 0 1 /                             1 'JAN' 1996    /
                                                         /
                                                         RPTSCHED
DATES                                                    32*0  1 13*0    /
  1 'OCT' 1995    /                                      WCONHIST
/                                                         'P-A35'      'OPEN' 'LRAT'     544.0    792.9  71663.8 /
RPTSCHED                                                  'P-A39A'     'OPEN' 'LRAT'     561.2   1027.5  60681.1 /
32*0  1 13*0    /                                        /
WCONHIST                                                 WELTARG
 'P-A17'      'OPEN' 'LRAT'     220.2    707.8  21068.2 /  'I-A38'      'WRAT'          2595.7 /
 'P-A39A'     'OPEN' 'LRAT'     464.1    953.9  46926.5 /  'I-NEW1'     'WRAT'          1000 /
/                                                        /
WELTARG                                                  WEFAC
 'I-A38'      'WRAT'          1564.9 /                    'P-A35'      0.988015 /
 'I-NEW1'     'WRAT'          1000 /                      'P-A39A'     0.729996 /
/                                                         'I-A38'      0.966000 /
WEFAC                                                     'I-NEW1'     0.966000 /
 'P-A17'      1.000000 /                                 /
 'P-A39A'     1.000000 /
 'I-A38'      0.993000 /
 'I-NEW1'     0.993000 /
/                                                        DATES
                                                          1 'FEB' 1996    /
BOX                                                      /
  4  6  13  33  6  6  /--P-A35                           RPTSCHED
MULTY                                                    32*0  1 13*0    /
 63*10. /--1500                                          WCONHIST
/                                                         'P-A35'      'OPEN' 'LRAT'     651.0   1016.2  84286.9 /
                                                          'P-A39A'     'OPEN' 'LRAT'     638.3   1146.4  68094.0 /
BOX                                                      /
  4  6  13  33  9  9  /--P-A35                           WELTARG
MULTY                                                     'I-A38'      'WRAT'          2053.5 /
 63*30. /--1500                                           'I-NEW1'     'WRAT'          1600 /
/                                                        /
                                                         WEFAC
                                                          'P-A35'      0.983716 /
DATES                                                     'P-A39A'     0.992433 /
  1 'NOV' 1995    /                                       'I-A38'      0.958000 /
/                                                         'I-NEW1'     0.958000 /
RPTSCHED                                                 /
32*0  1 13*0    /
COMPDAT
  'P-A35'      6   33  8  8  'OPEN' 1* 1* .4320 1*  .0 1*   /
  'P-A35'      6   33  9  9  'OPEN' 1* 1* .4320 1*  .0 1*   /  DATES
  'P-A35'      6   33  10 10 'OPEN' 1* 1* .4320 1*  .0 1*   /    1 'MAR' 1996    /
  'P-A35'      6   33  11 11 'OPEN' 1* 1* .4320 1*  .0 1*   /  /
    'P-A35'    6   33  12 12 'OPEN' 1* 1* .4320 1*  .0 1*      RPTSCHED
/                                                        32*0  1 13*0    /
/                                                        WCONHIST
WCONHIST                                                  'P-A35'      'OPEN' 'LRAT'     365.4    693.3  38273.4 /
 'P-A17'      'OPEN' 'LRAT'     238.8    785.0  23502.6 /  'P-A39A'     'OPEN' 'LRAT'     642.0   1158.1  70954.0 /
 'P-A35'      'OPEN' 'LRAT'     522.3     11.5  52478.0 /  /
 'P-A39A'     'OPEN' 'LRAT'     466.1    974.9  48576.8 /  WELTARG
/                                                         'I-A38'      'WRAT'          2218.7 /
WELTARG                                                   'I-NEW1'     'WRAT'          1600 /
 'I-A38'      'WRAT'          1645.3 /                    /
 'I-NEW1'     'WRAT'          1000 /                      WEFAC
/                                                         'P-A35'      0.966375 /
WEFAC                                                     'P-A39A'     0.874686 /
 'P-A17'      0.635648 /                                  'I-A38'      0.960000 /
 'P-A35'      0.160301 /                                  'I-NEW1'     0.960000 /
 'P-A39A'     0.967361 /                                 /
 'I-A38'      0.994000 /
 'I-NEW1'     0.994000 /                                 -- Yearly report
/                                                        RPTSCHED
WELOPEN                                                  0 0 0 0 0    0 2 2 2 0  /
'P-A35'  'OPEN'   /                                      --%Report-records: 3   1
/                                                        -- Quarterly report
                                                         --RPTSCHED
                                                         --0 0 0 0 0    0 0 2 1 0  /
DATES                                                    --0 0 0 0 0    0 2 0 0 0  /
  25 'NOV' 1995    /                                     --%Report-records: 1   1
/                                                        -- Monthly report
RPTSCHED                                                 --RPTSCHED
32*0  1 13*0    /                                        --0 0 0 0 0    0 0 0 2 0 0 1 /
WELOPEN
'P-A17'  'SHUT'    /
/                                                        DATES
                                                          1 'APR' 1996    /
                                                         /
DATES                                                    RPTSCHED
  1 'DEC' 1995    /                                      32*0  1 13*0    /
/                                                        WCONHIST
RPTSCHED                                                  'P-A35'      'OPEN' 'LRAT'     450.2    908.0  48333.1 /
32*0  1 13*0    /                                         'P-A39A'     'OPEN' 'LRAT'     641.2   1201.0  71991.8 /
WCONHIST                                                 /
 'P-A17'      'OPEN' 'LRAT'       0.0      0.0      0.0 / WELTARG
 'P-A35'      'OPEN' 'LRAT'     918.6    276.3  93471.9 /  'I-A38'      'WRAT'          2193.2 /
 'P-A39A'     'OPEN' 'LRAT'     539.6   1100.7  58106.8 /  'I-NEW1'     'WRAT'          2000 /
/                                                        /
                                                         WEFAC
```

```
'P-A35'     0.981944 /
'P-A39A'     0.991875 /
'I-A38'     0.970000 /
'I-NEW1'    0.970000 /
/


DATES
   1 'MAY' 1996    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A35'     'OPEN' 'LRAT'    432.8    1004.3   48182.9 /
 'P-A39A'    'OPEN' 'LRAT'    620.1    1184.7   65773.7 /
/
WELTARG
 'I-A38'     'WRAT'         3011.7 /
 'I-NEW1'    'WRAT'         1000 /
/
WEFAC
'P-A35'     0.823118 /
'P-A39A'     0.818728 /
'I-A38'     0.823000 /
'I-NEW1'    0.823000 /
/


DATES
   1 'JUN' 1996    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A35'     'OPEN' 'LRAT'    424.6    932.3   46183.7 /
 'P-A39A'    'OPEN' 'LRAT'    627.9    1140.0   67699.2 /
/
WELTARG
 'I-A38'     'WRAT'         3000.3 /
 'I-NEW1'    'WRAT'         1050 /
/
WEFAC
'P-A35'     0.996736 /
'P-A39A'     0.993148 /
'I-A38'     0.993000 /
'I-NEW1'    0.993000 /
/
--  Yearly report
RPTSCHED
0 0 0 0 0    0 2 2 2 0  /
--%Report-records: 3   1
--  Quarterly report
--RPTSCHED
--0 0 0 0 0    0 0 2 1 0  /
--0 0 0 0 0    0 2 0 0 0  /
--%Report-records: 1   1
--  Monthly report
--RPTSCHED
--0 0 0 0 0    0 0 0 2 0 0 1 /


DATES
   1 'JLY' 1996    /
/
RPTSCHED
32*0  1 13*0    /
WCONHIST
 'P-A35'     'OPEN' 'LRAT'    415.1    880.8   43641.1 /
 'P-A39A'    'OPEN' 'LRAT'    629.1    1055.0   67111.8 /
/
WELTARG
 'I-A38'     'WRAT'         2017.3 /
 'I-NEW1'    'WRAT'         1700 /
/
WEFAC
'P-A35'     1.000000 /
'P-A39A'     0.992921 /
'I-A38'     1.000000 /
'I-NEW1'    1.000000 /
/


DATES
   1 'AUG' 1996    /
/
--RPTSCHED
32*0  1 13*0    /

WCONHIST
 'P-A35'     'OPEN' 'LRAT'    431.2    915.1   45791.8 /
 'P-A39A'    'OPEN' 'LRAT'    598.1    1004.3   65454.3 /
/
WELTARG
 'I-A38'     'WRAT'         2089.1 /
 'I-NEW1'    'WRAT'         1900 /
/
WEFAC
'P-A35'     0.998208 /
'P-A39A'     0.997760 /
'I-A38'     0.986000 /
'I-NEW1'    0.986000 /
/


DATES
   28 'AUG' 1996    /
/

WTRACER
'I-A38' 'IW3'  0.169211  /
/

DATES
   29 'AUG' 1996    /
/

WTRACER
'I-A38' 'IW3'  0.0  /
```

```
/

DATES
   1 'SEP' 1996     /
/

RPTSCHED
 32*0  1 13*0    /
WCONHIST
     'P-A35'    'OPEN'    'LRAT'    443.917   942.381
46193.598  4* /
     'P-A39A'    'OPEN'    'LRAT'    609.756  1025.500
65509.648  4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   3046.333   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1400   5* /
/

RPTSCHED
 0 0 0 0 0    0 2 2 2 0  /


-- 3592.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'OCT' 1996/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'    'OPEN'    'LRAT'    186.562   396.048
18862.203  4* /
     'P-A39A'    'OPEN'    'LRAT'    327.411   550.646
34497.746  4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   1454.452   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1000   5* /
/

-- 3623.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'NOV' 1996/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'    'OPEN'    'LRAT'    325.203   693.322
35592.012  4* /
     'P-A39A'    'OPEN'    'LRAT'    535.233   970.162
57532.184  4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   2960.567   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1000   5* /
/

-- 3653.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'DEC' 1996/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'    'OPEN'    'LRAT'    228.735   528.609
29310.660  4* /
     'P-A39A'    'OPEN'    'LRAT'    650.947  1182.236
69231.500  4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   3011.355   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1000   5* /
/

RPTSCHED
 0 0 0 0 0    0 2 2 2 0  /


-- 3684.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'JAN' 1997/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'    'OPEN'    'LRAT'    357.278   779.880
44485.121  4* /
     'P-A39A'    'OPEN'    'LRAT'    827.899  1471.987
87474.891  4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   3079.000   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1000   5* /
/

-- 3715.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'FEB' 1997/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'    'OPEN'    'LRAT'    407.119   925.090
47421.309  4* /
     'P-A39A'    'OPEN'    'LRAT'    814.473  1448.115
81636.930  4* /
/

WCONINJE
```

```
        'I-A38'    'WATER' 1*    'RATE'  3317.643   5* /
        'I-NEW1'   'WATER' 1*    'RATE'  1000   5* /
/

-- 3743.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'MAR' 1997/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'    'OPEN'    'LRAT'   394.423   896.240
45835.039   4* /
     'P-A39A'   'OPEN'    'LRAT'   685.651  1487.802
68334.695   4* /
/

WCONINJE
     'I-A38'    'WATER' 1*    'RATE'  2582.161   5* /
     'I-NEW1'   'WATER' 1*    'RATE'  1000   5* /
/

RPTSCHED
0 0 0 0 0   0 2 2 2 0 /


-- 3774.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'APR' 1997/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'    'OPEN'    'LRAT'   436.714  1063.648
48959.590   4* /
     'P-A39A'   'OPEN'    'LRAT'   620.424  1570.634
67676.297   4* /
/

WCONINJE
     'I-A38'    'WATER' 1*    'RATE'  2506.900   5* /
     'I-NEW1'   'WATER' 1*    'RATE'  1000   5* /
/

-- 3804.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'MAY' 1997/
/

RPTSCHED
32*0  1 13*0    /

--       : P-A39A Perforation RA2 Top: 3886.00 Bot: 3904.00
Diam: 0.18 Skin: 0.00
--       : P-A39A Perforation RA2 Top: 3938.00 Bot: 3944.00
Diam: 0.18 Skin: 0.00
--       : P-A39A Perforation RA2 Top: 3956.00 Bot: 3962.00
Diam: 0.18 Skin: 0.00
--       : P-A39A Perforation RA1 Top: 3204.00 Bot: 3377.00
Diam: 0.18 Skin: 0.00
--       : P-A39A Perforation RA2 Top: 3526.00 Bot: 3766.00
Diam: 0.18 Skin: 0.00
--       : P-A39A Perforation RA2 Top: 3377.00 Bot: 3400.00
Diam: 0.18
-- WARN: Skin defaulted in P-A39A Perforation
--       : P-A39A Connection 14 19 11 Perf. Len  25.38 ( 46.5%)
--       : P-A39A Connection 14 18 11 Perf. Len   8.11 ( 15.1%)
--       : P-A39A Connection 14 18 12 Perf. Len  39.52 ( 73.3%)
--       : P-A39A Connection 15 18 12 Perf. Len  10.55 ( 19.3%)
--       : P-A39A Connection 15 17 12 Perf. Len  31.15 ( 56.2%)
--       : P-A39A Connection 15 17 11 Perf. Len  26.63 ( 48.2%)
--       : P-A39A Connection 15 16 11 Perf. Len  54.66 ( 99.7%)
--       : P-A39A Connection 16 13 10 Perf. Len  54.06 ( 97.3%)
--       : P-A39A Connection 16 12 10 Perf. Len  59.80 (106.8%)
--       : P-A39A Connection 16 11 10 Perf. Len  61.63 (110.1%)
--       : P-A39A Connection 16 10 10 Perf. Len  29.44 ( 52.0%)
--       : P-A39A Connection 17 10 10 Perf. Len  33.01 ( 58.1%)
--       : P-A39A Connection 17  9 10 Perf. Len   2.06 (  3.5%)
-- WARN: P-A39A Connection 17  9 10 SUPPRESSED, perf
percentage too small
--       : P-A39A Connection 17  8  9 Perf. Len   5.02 (  8.9%)
--       : P-A39A Connection 17  7  9 Perf. Len   7.61 ( 13.1%)
--       : P-A39A Connection 18  7  9 Perf. Len  11.36 ( 19.5%)
--       : P-A39A Connection 18  6  9 Perf. Len  21.14 ( 36.8%)
--       : P-A39A Connection 18  6 10 Perf. Len   6.08 ( 10.4%)
--       : P-A39A Connection 18  5 10 Perf. Len  24.35 ( 42.4%)
--       : P-A39A Connection 19  5 10 Perf. Len  30.43 ( 52.6%)
--       : P-A39A Connection 19  3 12 Perf. Len  24.00 ( 41.8%)
WELOPEN
     'P-A39A'   'OPEN'  /
/

COMPDAT
-- WELL          I   J K1 K2      Sat. CF   DIAM KH    SKIN
DIR  Ro
 'P-A39A'    19   3 12 12 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    19   4 12 12 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    19   4 11 11 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    17   9 10 10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    17  10 10 10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    16  10 10 10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    16  11 10 10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    16  12 10 10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    16  13 10 10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    15  13 10 10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  16 11 11 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  17 11 11 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  18 11 11 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  15 10 10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  16 10 10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
 'P-A39A'    14  17 10 10 'OPEN' 1* 1* .4320 1*  .0 1* 'Y'
/
/
-- 'P-A39A'   19   3 12 12 'OPEN' 1* 16 .4320 120.61  2
1* 'Y' /
-- 'P-A39A'   19   4 12 12 'OPEN' 1* 16 .4320 120.61  2
1* 'Y' /
-- 'P-A39A'   19   4 11 11 'OPEN' 1* 16 .4320 120.61  2
1* 'Y' /
-- 'P-A39A'   17   9 10 10 'OPEN' 1* 150 .4320 1087.3  2
1* 'Y' /
-- 'P-A39A'   17  10 10 10 'OPEN' 1* 155 .4320 1087.3  2
1* 'Y' /
-- 'P-A39A'   16  10 10 10 'OPEN' 1* 160 .4320 1087.3  2
1* 'Y' /
-- 'P-A39A'   16  11 10 10 'OPEN' 1* 156 .4320 1087.3  2
1* 'Y' /
-- 'P-A39A'   16  12 10 10 'OPEN' 1* 157 .4320 1098.5  2
1* 'Y' /
-- 'P-A39A'   16  13 10 10 'OPEN' 1* 158 .4320 1098.5  2
1* 'Y' /
-- 'P-A39A'   15  13 10 10 'OPEN' 1* 149 .4320 1119.8  2
1* 'Y' /
-- 'P-A39A'   14  16 11 11 'OPEN' 1* 20 .4320 266.6   2
1* 'Y' /
-- 'P-A39A'   14  17 11 11 'OPEN' 1* 21 .4320 266.6   2
1* 'Y' /
-- 'P-A39A'   14  18 11 11 'OPEN' 1* 25 .4320 232.2   2
1* 'Y' /
-- 'P-A39A'   14  15 10 10 'OPEN' 1* 156 .4320 1117.5  2
1* 'Y' /
-- 'P-A39A'   14  16 10 10 'OPEN' 1* 155 .4320 1054.1  2
1* 'Y' /
-- 'P-A39A'   14  17 10 10 'OPEN' 1* 22 .4320 942.4   2
1* 'Y' /
--/
-- 'P-A39A'   14  19  11  11    'OPEN'  1*       9.756
0.178   729.326  2*       'Y' /    4.878 /
-- 'P-A39A'   14  18  11  11    'OPEN'  1*       5.656
0.178   403.018  2*       'Y' /    4.044 /
-- 'P-A39A'   14  18  12  12    'OPEN'  1*       5.120
0.178   385.477  2*       'Y' /    5.021 /
-- 'P-A39A'   15  18  12  12    'OPEN'  1*       2.034
0.178   147.809  2*       'Y' /    4.366 /
-- 'P-A39A'   15  17  12  12    'OPEN'  1*       7.478
0.178   547.377  2*       'Y' /    4.489 /
-- 'P-A39A'   15  17  11  11    'OPEN'  1*      13.707
0.178  1005.362  2*       'Y' /    4.524 /
-- 'P-A39A'   15  16  11  11    'OPEN'  1*      33.409
0.178  2511.561  2*       'Y' /    4.990 /
-- 'P-A39A'   16  13  10  10    'OPEN'  1*     217.144
0.178 15750.872  2*       'Y' /    4.332 /
-- 'P-A39A'   16  12  10  10    'OPEN'  1*     279.796
0.178 21183.430  2*       'Y' /    5.135 /
-- 'P-A39A'   16  11  10  10    'OPEN'  1*     337.186
0.178 26383.938  2*       'Y' /    5.883 /
-- 'P-A39A'   16  10  10  10    'OPEN'  1*     143.071
0.178 11016.607  2*       'Y' /    5.503 /
-- 'P-A39A'   17  10  10  10    'OPEN'  1*     142.700
0.178 10552.602  2*       'Y' /    4.673 /
-- 'P-A39A'   17   8   9   9    'OPEN'  1*      13.356
0.178  1035.835  2*       'Y' /    5.668 /
-- 'P-A39A'   17   7   9   9    'OPEN'  1*      18.779
0.178  1445.091  2*       'Y' /    5.488 /
-- 'P-A39A'   18   7   9   9    'OPEN'  1*      25.531
0.178  1879.026  2*       'Y' /    4.585 /
-- 'P-A39A'   18   6   9   9    'OPEN'  1*      46.717
0.178  3433.920  2*       'Y' /    4.563 /
-- 'P-A39A'   18   6  10  10    'OPEN'  1*       4.237
0.178   327.007  2*       'Y' /    5.555 /
-- 'P-A39A'   18   5  10  10    'OPEN'  1*       9.804
0.178   712.996  2*       'Y' /    4.377 /
-- 'P-A39A'   19   5  10  10    'OPEN'  1*      26.842
0.178  1829.281  2*       'Y' /    3.425 /
-- 'P-A39A'   19   3  12  12    'OPEN'  1*       3.662
0.179   219.912  2*       'Y' /    2.232 /
--/
--
WCONHIST
     'P-A35'    'OPEN'    'LRAT'   317.147  1150.611
41225.273   4* /
     'P-A39A'   'OPEN'    'LRAT'   557.202  1144.384
60409.375   4* /
/

WCONINJE
     'I-A38'    'WATER' 1*    'RATE'  3067.355   5* /
     'I-NEW1'   'WATER' 1*    'RATE'  1000   5* /
/

-- 3835.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'JUN' 1997/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'    'OPEN'    'LRAT'   540.818  1220.677
64410.789   4* /
     'P-A39A'   'OPEN'    'LRAT'   811.198  1886.005
83920.211   4* /
/

WCONINJE
     'I-A38'    'WATER' 1*    'RATE'  3313.067   5* /
     'I-NEW1'   'WATER' 1*    'RATE'  1000   5* /
/

RPTSCHED
0 0 0 0 0   0 2 2 2 0 /

-- 3865.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'JUL' 1997/
/

RPTSCHED
32*0  1 13*0    /
```

```
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    501.041   1183.326
55043.516   4* /
     'P-A39A'    'OPEN'    'LRAT'    764.478   2006.879
81052.445   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   2856.968   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1000    5* /
/

-- 3896.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'AUG' 1997/
/

RPTSCHED
32*0  1 13*0     /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    426.129   1023.115
45531.453   4* /
     'P-A39A'    'OPEN'    'LRAT'    431.205   1241.695
48058.684   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   2642.903   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1000    5* /
/

-- 3927.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'SEP' 1997/
/

RPTSCHED
32*0  1 13*0     /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    108.292   293.749
10415.656   4* /
     'P-A39A'    'OPEN'    'LRAT'    85.777    239.538
8946.548   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   510.033   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   500   5* /
/

RPTSCHED
0 0 0 0 0   0 2 2 2 0 /


-- 3957.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'OCT' 1997/
/

RPTSCHED
32*0  1 13*0     /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    373.870   1017.927
39706.371   4* /
     'P-A39A'    'OPEN'    'LRAT'    626.960   1733.329
70975.102   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   3898.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1000    5* /
/

-- 3988.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'NOV' 1997/
/

RPTSCHED
32*0  1 13*0     /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    557.655   1471.596
58235.293   4* /
     'P-A39A'    'OPEN'    'LRAT'    777.916   1913.526
87162.328   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   3095.833   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   2200    5* /
/

-- 4018.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'DEC' 1997/
/

RPTSCHED
32*0  1 13*0     /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    543.962   1461.216
55254.020   4* /
     'P-A39A'    'OPEN'    'LRAT'    840.130   2010.083
92936.703   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   3041.710   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   2400    5* /
/

RPTSCHED
0 0 0 0 0   0 2 2 2 0 /


-- 4049.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'JAN' 1998/
/

RPTSCHED
32*0  1 13*0     /
WCONHIST

     'P-A35'     'OPEN'    'LRAT'    546.459   1467.924
55291.703   4* /
     'P-A39A'    'OPEN'    'LRAT'    820.799   1963.831
90269.812   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   3095.677   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1500    5* /
/

-- 4080.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'FEB' 1998/
/

RPTSCHED
32*0  1 13*0     /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    555.790   1492.988
52622.875   4* /
     'P-A39A'    'OPEN'    'LRAT'    779.201   1864.305
80045.609   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   2711.214   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1000    5* /
/

-- 4108.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'MAR' 1998/
/

RPTSCHED
32*0  1 13*0     /


--     : A-5H Plug  Top:  1784.00
-- WARN: A-5H Squeeze interval 1784.000000 1940.862667 Top
changed to 1834.253360
WELOPEN
     'I-A5H'    'SHUT'    0    0    0 /
/

WCONHIST
     'P-A35'     'OPEN'    'LRAT'    515.026   1660.592
52173.711   4* /
     'P-A39A'    'OPEN'    'LRAT'    824.279   1804.534
210337.531   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   4038.258   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1200    5* /
/

RPTSCHED
0 0 0 0 0   0 2 2 2 0 /


-- 4139.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'APR' 1998/
/

RPTSCHED
32*0  1 13*0     /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    254.714   1566.769
34761.633   4* /
     'P-A39A'    'OPEN'    'LRAT'    962.569   2034.136
124635.969   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   3082.167   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1700    5* /
/

-- 4169.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'MAY' 1998/
/

RPTSCHED
32*0  1 13*0     /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    306.961   1034.452
81807.102   4* /
     'P-A39A'    'OPEN'    'LRAT'    693.470   1813.627
77227.766   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   4019.355   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1300    5* /
/

-- 4200.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'JUN' 1998/
/

RPTSCHED
32*0  1 13*0     /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    209.083   704.605
34566.395   4* /
     'P-A39A'    'OPEN'    'LRAT'    182.338   382.702
18238.822   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'   1801.667   5* /
     'I-NEW1'   'WATER'  1*    'RATE'   1000    5* /
/

RPTSCHED
0 0 0 0 0   0 2 2 2 0 /
```

```
-- 4230.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'JUL' 1998/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    361.535   1479.904
49385.105   4* /
     'P-A39A'    'OPEN'    'LRAT'    365.404    784.981
39447.148   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'  2011.968   5* /
     'I-NEW1'   'WATER'  1*    'RATE'  1500   5* /
/

-- 4261.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'AUG' 1998/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    321.969   1446.980
35662.191   4* /
     'P-A39A'    'OPEN'    'LRAT'    443.415    917.368
45694.340   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'  2114.968   5* /
     'I-NEW1'   'WATER'  1*    'RATE'  1000   5* /
/

-- 4292.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'SEP' 1998/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    368.878   1391.243
44068.184   4* /
     'P-A39A'    'OPEN'    'LRAT'    489.643    980.757
54815.633   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'  2014.733   5* /
     'I-NEW1'   'WATER'  1*    'RATE'  1000   5* /
/

RPTSCHED
0 0 0 0 0   0 2 2 2 0 /


-- 4322.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'OCT' 1998/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    284.948    998.601
33621.785   4* /
     'P-A39A'    'OPEN'    'LRAT'    361.741    724.568
39906.410   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'  1985.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'  1000   5* /
/

-- 4353.000000 days from start of simulation ( 1 'DEC' 1986 )
DATES
 1 'NOV' 1998/
/

RPTSCHED
32*0  1 13*0    /
WCONHIST
     'P-A35'     'OPEN'    'LRAT'    190.000      600.000
33000.000   4* /
     'P-A39A'    'OPEN'    'LRAT'      0.000        0.000
0.000   4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'    1985.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'    1000   5* /
/

WELOPEN
 'P-A39A'    'SHUT'  /
/

--------------------------------------------------------
DATES
 1 'DEC' 1998/
/

WCONPROD
     'P-A35'     'OPEN'    'LRAT' 800.0 2* 1800.0 4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'    1885.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'    1000   5* /
/
```

```
DATES
 1 'JAN' 1999/
/

WCONPROD
     'P-A35'     'OPEN'    'LRAT' 800.0 2* 1800.0 4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'    1585.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'    1000   5* /
/

DATES
 1 'MAR' 1999/
/

WCONPROD
     'P-A35'     'OPEN'    'LRAT' 800.0 2* 1800.0 4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'    1085.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'    1000   5* /
/

DATES
 1 'MAY' 1999/
/

WCONPROD
     'P-A35'     'OPEN'    'LRAT' 800.0 2* 1800.0 4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'    1085.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'    900   5* /
/

DATES
 1 'JUL' 1999/
/

WCONPROD
     'P-A35'     'OPEN'    'LRAT' 800.0 2* 1800.0 4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'    1000.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'    900   5* /
/

DATES
 1 'SEP' 1999/
/

WCONPROD
     'P-A35'     'OPEN'    'LRAT' 800.0 2* 1800.0 4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'    1000.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'    800   5* /
/

DATES
 1 'NOV' 1999/
/

WCONPROD
     'P-A35'     'OPEN'    'LRAT' 800.0 2* 1800.0 4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'    1000.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'    700   5* /
/

DATES
 1 'JAN' 2000/
/

WCONPROD
     'P-A35'     'OPEN'    'LRAT' 800.0 2* 1800.0 4* /
/

WCONINJE
     'I-A38'    'WATER'  1*    'RATE'    1000.645   5* /
     'I-NEW1'   'WATER'  1*    'RATE'    600   5* /
/

DATES
 1 'MAR' 2000/
/

WCONPROD
     'P-A35'     'OPEN'    'LRAT' 800.0 2* 1800.0 4* /
/
```

```
WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      1000.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      500    5* /
/


DATES
 1 'MAY' 2000/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      1000.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      500    5* /
/


DATES
 1 'JUL' 2000/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      1000.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      450    5* /
/


DATES
 1 'SEP' 2000/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      1000.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'NOV' 2000/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      1000.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'JAN' 2001/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      1000.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'MAR' 2001/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      900.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'MAY' 2001/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      900.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/
```

```
DATES
 1 'JUL' 2001/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /
/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      900.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'SEP' 2001/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      900.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'NOV' 2001/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      800.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'JAN' 2002/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      800.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'MAR' 2002/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      800.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'MAY' 2002/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      800.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'JUL' 2002/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER'  1*     'RATE'      700.645   5* /
     'I-NEW1'   'WATER'  1*     'RATE'      400    5* /
/


DATES
 1 'SEP' 2002/
/

WCONPROD
     'P-A35'      'OPEN'     'LRAT' 800.0 2* 1800.0 4* /

/
```

```
       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      700.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'NOV' 2002/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      700.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'JAN' 2003/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      600.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'MAR' 2003/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      600.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'MAY' 2003/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      600.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'JUL' 2003/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      600.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'SEP' 2003/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      500.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'NOV' 2003/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      500.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
```

```
        1 'JAN' 2004/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      500.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'MAR' 2004/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      400.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'MAY' 2004/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      400.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'JUL' 2004/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      400.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      400   5* /
       /

       DATES
        1 'SEP' 2004/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      400.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      300   5* /
       /

       DATES
        1 'NOV' 2004/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      400.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      300   5* /
       /

       DATES
        1 'JAN' 2005/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /

       WCONINJE
           'I-A38'   'WATER'  1*      'RATE'      400.645   5* /
           'I-NEW1'  'WATER'  1*      'RATE'      300   5* /
       /

       DATES
        1 'MAR' 2005/
       /

       WCONPROD
           'P-A35'      'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

       /
```

```
WCONINJE
     'I-A38'    'WATER' 1*    'RATE'      300.645  5* /
     'I-NEW1'   'WATER' 1*    'RATE'      300   5* /
/


DATES
 1 'MAY' 2005/
/

WCONPROD
     'P-A35'    'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER' 1*    'RATE'      300.645  5* /
     'I-NEW1'   'WATER' 1*    'RATE'      300   5* /
/


DATES
 1 'JUL' 2005/
/

WCONPROD
     'P-A35'    'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER' 1*    'RATE'      300.645  5* /
     'I-NEW1'   'WATER' 1*    'RATE'      300   5* /
/


DATES
 1 'SEP' 2005/
/

WCONPROD
     'P-A35'    'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER' 1*    'RATE'      300.645  5* /
     'I-NEW1'   'WATER' 1*    'RATE'      300   5* /
/


DATES
```

```
 1 'NOV' 2005/
/

WCONPROD
     'P-A35'    'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER' 1*    'RATE'      300.645  5* /
     'I-NEW1'   'WATER' 1*    'RATE'      300   5* /
/


DATES
 1 'JAN' 2006/
/

WCONPROD
     'P-A35'    'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER' 1*    'RATE'      300.645  5* /
     'I-NEW1'   'WATER' 1*    'RATE'      300   5* /
/


DATES
 1 'MAR' 2006/
/

WCONPROD
     'P-A35'    'OPEN'    'LRAT' 800.0 2* 1800.0 4* /

/


WCONINJE
     'I-A38'    'WATER' 1*    'RATE'      300.645  5* /
     'I-NEW1'   'WATER' 1*    'RATE'      200   5* /
/


DATES
 1 'MAY' 2006/
/


--STOP

END
```