*MINISTRY OF EDUCATION OF THE AZERBAIJAN REPUBLIC*

KHAZAR UNIVERSITY

GRADUATE SCHOOL OF SCIENCE, ART, AND TECHNOLOGY

Petroleum and Gas Engineering

MASTER THESIS

Title:

# Injection Evaluation and increase of water flooding efficiency in shallow water Gunashli field.

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# ABSTRACT

Azerbaijan has played a significant role in today's oil and gas history with Baku being one of the birthplaces of the oil and gas industry. The Gunashli field also constitutes an important role in the oil industry of the country, and it is located 120km east of Baku made up of 2 parts, namely the deep water Gunashli (DWG) which is the deep-water section and part of the Azeri-Chirag-Gunashli oilfields, and the western part called shallow water Gunashli (SWG). The shallow water Gunashli is one of the richest fields and is operated by SOCAR with over 170 million tons of oil and gas extracted for over 35 years now.

Water injection is an essential part of the development of oil and gas fields.

The purpose of the work – The main aim is to enhance and improve the shallow water Gunashli (SWG) fields by waterflooding mainly through injection.

For the preparation of this thesis, I based my data and research on the current state of development on the IX, X horizons and FLD where injection is planned for the Gunashli field, the mining indicators of the injection process applied during the development period, the operating facilities processed by the injection process the current conditions and the technical condition of injection wells were investigated. The efficiency of injection and gas injection processes in the shallow Gunashli field was analyzed using a hydrodynamic model.

The selection of the optimal option for restoration of the injection system on the IX, X horizons and FLD, where injection is planned, was considered. Thus, the number of locations of new injection wells and the volume of water to be pumped have been determined and the efficiency of the injection method has been evaluated. It was recommended to maintain 7 wells in the working injection fund of the Gunashli field and transfer 11 wells in the operating fund to the injection fund. Thus, as a result of the application of the injection method, 250.97 thousand tons of additional oil is expected to be extracted according to the operational pumping fund, and 1019.85 thousand tons according to the intended pumping fund. The effectiveness of the injection method is economically justified. That is, the price of 1 t of oil: 289.32 man/t (project 118887.7 thousand manats if the price is the decision of the Price Council of SOCAR; If it is 337.0 manat/t (formation of the revenue part of the budget of the Republic) 158628.4 thousand manat, 1 barrel=$60; If it is 635 manat/t (the world price of oil), it is expected to be 407008.2 thousand manat.

KEY WORDS: Azeri-Chirag-Gunashli (ACG), State Oil Company of Azerbaijan Republic (SOCAR), deposit, geology, reservoir pressure, oil yield coefficient.

#### Xülasə

Bakının neft və qaz sənayesinin doğulduğu yerlərdən biri olması ilə Azərbaycan bugünkü neft və qaz tarixində mühüm rol oynamışdır. “Günəşli” yatağı da ölkənin neft sənayesində mühüm rol oynayır və o, Bakıdan 120 km şərqdə yerləşir və 2 hissədən, yəni dərinsulu Günəşli (DSG) və Azəri yatağının bir hissəsidir. - Çıraq-Günəşli neft mədənləri, qərb hissəsi isə dayazsulu Günəşli (SGG) adlanır. Dayazsulu Günəşli ən zəngin yataqlardan biridir və artıq 35 ildən çoxdur ki, hasil edilən 170 milyon tondan çox neft və qazla SOCAR tərəfindən istismar edilir.
Suyun vurulması neft və qaz yataqlarının işlənməsinin vacib hissəsidir.
İşin məqsədi – Əsas məqsəd dayazsulu Günəşli (SG) yataqlarının əsasən suvarma yolu ilə su basması yolu ilə yaxşılaşdırılması və yaxşılaşdırılmasıdır.
Bu dissertasiyanın hazırlanması üçün mən “Günəşli” yatağının suvarılması nəzərdə tutulan IX, X horizontları və FLD üzrə hazırkı işlənmə vəziyyəti, işlənmə dövründə tətbiq edilən suvarma prosesinin mədən göstəriciləri, irriqasiya prosesinin mədən göstəriciləri, s. suvarma prosesi ilə emal edilən istismar obyektləri, mövcud şərait və suvarma quyularının texniki vəziyyəti araşdırılmışdır. Dayazsulu “Günəşli” yatağında suvarma və qazın vurulması proseslərinin səmərəliliyi hidrodinamik model vasitəsilə təhlil edilmişdir.
Suvarma nəzərdə tutulan IX, X horizontlar və FLD üzrə suvarma sisteminin bərpası üçün optimal variantın seçilməsi nəzərdən keçirilmişdir. Belə ki, yeni suvarma quyularının yerlərinin sayı və vurulacaq suyun həcmi müəyyən edilmiş və vurulma üsulunun səmərəliliyi qiymətləndirilir. “Günəşli” yatağının işlək suvarma fondunda 7 quyunun saxlanılması, istismar fondunda olan 11 quyunun isə suvarma fonduna verilməsi tövsiyə olunub. Belə ki, vurulma metodunun tətbiqi nəticəsində istismar nasosları fondu üzrə 250,97 min ton, nəzərdə tutulan nasos fondu üzrə isə 1019,85 min ton əlavə neft hasil ediləcəyi gözlənilir. Enjeksiyon metodunun effektivliyi iqtisadi cəhətdən əsaslandırılır. Yəni 1 ton neftin qiyməti: 289,32 manat/t (layihə 118887,7 min manat, qiymət ARDNŞ-nin Qiymət Şurasının qərarı olduqda; 337,0 manat/t olduqda (büdcənin gəlir hissəsinin formalaşması) Respublika) 158628,4 min manat, 1 barel=60 dollar;635 manat/t (neftin dünya qiyməti) olduğu halda 407008,2 min manat olacağı gözlənilir.

AÇAR SÖZLƏR: Azəri-Çıraq-Günəşli (AÇG), Azərbaycan Respublikası Dövlət Neft Şirkəti (ARDNŞ), yataq, geologiya, lay təzyiqi, neftvermə əmsalı.

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## 1. Introduction

The Gunashli oil and gas field is located in the Azerbaijani sector of the Caspian Sea, in the central part of the Absheron-Balkhanyan oil and gas zone, 12 km southeast of the famous Neft Dashlari field. The rise of Gunashli was discovered as a result of seismic exploration works conducted in 1958-1963. Since 1974, seismic-exploration works have been carried out in the Azerbaijan and Turkmenistan sectors of the Caspian Sea by applying GNDM. Seismic exploration works with the National Mining and Geotechnical Service were carried out by covering the Gunashli area several times, and as a result, this rise was prepared for deep excavation works. As a result of the exploratory drilling, the oil and gas content of the horizons and formations of the lower and upper departments of the MQ was discovered.

Deep exploration drilling in the deposit was started in 1977 with the drilling of well No. 1 in the NE periclinal part of the structure. The deposit was discovered in 1979 in connection with exploration well No. 4; 230 t/day of oil fountain was obtained from the well in the interval of 3455-3423 m of the X horizon of the BLD during the test works. Then, in November 1980, 320 t/day of oil was obtained as a result of the testing of the exploratory well No. 6 from FLD.

The large amount of residual oil reserves in the field requires the drilling of new wells in areas with large residual reserves and the improvement of the injection process in order to maintain and increase production.

In the first years of the development of the oil industry (up to the 1940s), the fields were exploited in the depletion mode, which ensured that the oil yield was up to 40% even in the best case. Starting from the end of the 40s, water injection techniques were applied in the fields. Up to 80% of the oil produced in modern times is extracted from fields where injection is applied.

Currently, there are three types of water injection techniques (behind the contour, along the contour, inside the contour) and their various modifications are used. Water flooding, being a highly effective method of impacting the formations, keeps the formation pressure stable, increases the rate of development, which ultimately creates conditions for increasing the oil production coefficient. On the other hand, water injection helps to reduce the working time.

Therefore, it is very important to evaluate the effectiveness of the applied water injection process in order to ensure the efficient working of the deposits in the future.

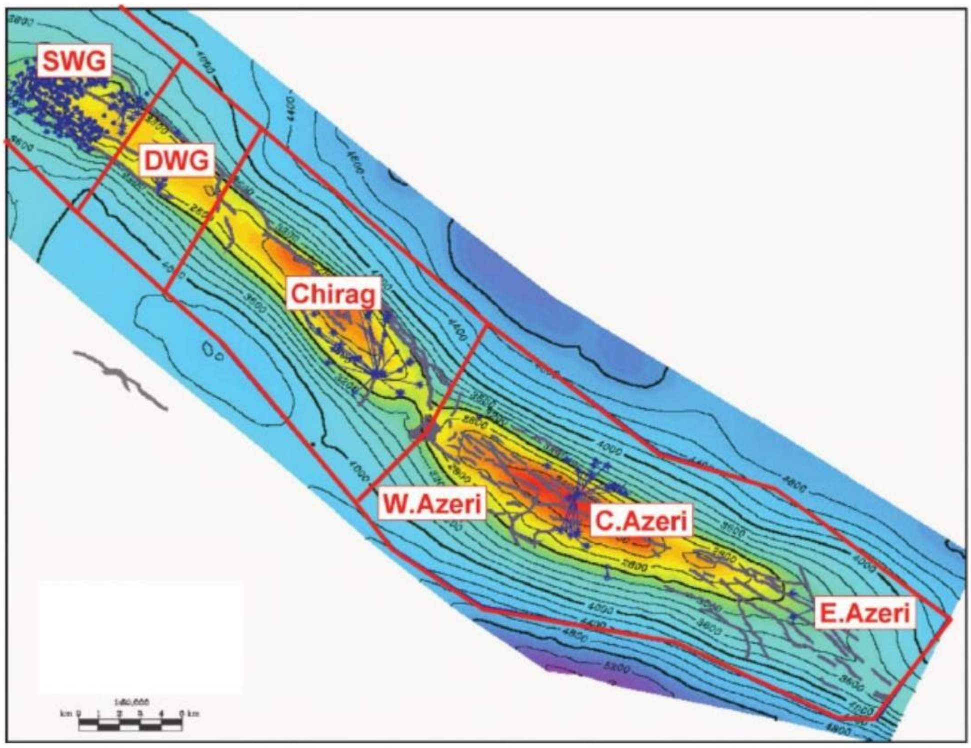



Figure 1 Structural map of Shallow water Gunashli field location (Stephane Lanchec, 2005)

Possible solutions for this problem

Recently, there has been a numerous number of suggestions regarding reservoir performance for waterflooding and water injection with a considerable number of injection projects which have provided the basis for evaluation of the benefits of these forementioned projects.

With this knowledge, I can conclusively say that the optimization of waterflooding performance plays a vital role in reservoir management.

Matter of the thesis

The dissertation will consist of 4 parts:

1. Reservoir characteristics and development problems in Gunashli field.
   1.1 General information about water injection.
   1.2 Water injection in Gunashli field
2. Appraisal and evaluation of water injection.
   2.1 Appraisal and evaluation of water injection in FLD Zone.
   2.2 Appraisal and evaluation of water injection in Balaxany X Zone.
   2.3 Appraisal and evaluation of water injection in Balaxany XI Zone.
   2.4 Appraisal and evaluation of water injection for Gunashli field (total).
3. Increase of efficiency of. Water flooding in Gunashli field.

Development problems in Gunashli field

1. Time to start injection. It is known from the world oil extraction experience that it is appropriate to start the injection process after some time after starting the development of fields - when a small amount of degassing occurs in the formation, when the formation pressure is 10-20% lower than the gas dissolution pressure in oil.
2. Location system of wells. It is known that the efficient development of oil and gas fields depends on the density of the well network and the placement system. This dependence is more pronounced when the development process is carried out by injection.
3. Injection rate. The volume of water injected into the fields in the process of injection should be 10-20% more than the volume of the total fluid produced from the field (oil and water) in formation conditions.
4. Stopping the injection process. When the percentage of water in the fluid produced from working wells located around the contour of the field reaches a very high level (80-90% and more) in the process of injection of the contour or the contour, the striking wells should be gradually maintained.
5. Prediction of the effectiveness of the injection process. The effectiveness of the injection process should be predicted, as well as all geological-technical measures applied in the development of deposits.

# 2. Literature Review

## 2.1 Reservoir characteristics and development problems in Gunashli field

### 2.1.1 The History of Shallow water Gunashli

Oil was first discovered in the Shallow water Gunashli field in the years 1958 -1963 after a number of seismic explorations had been conducted and in the early 1974 seismic explorations were conducted by covering Gunashli field several times in both Azerbaijan and Turkmenistan sections of the Caspian Sea.

The first well was drilled in 1977 with the main aim of understanding the geologic structure of the field, lithofacies. Of productive zones and oil-gas saturation.

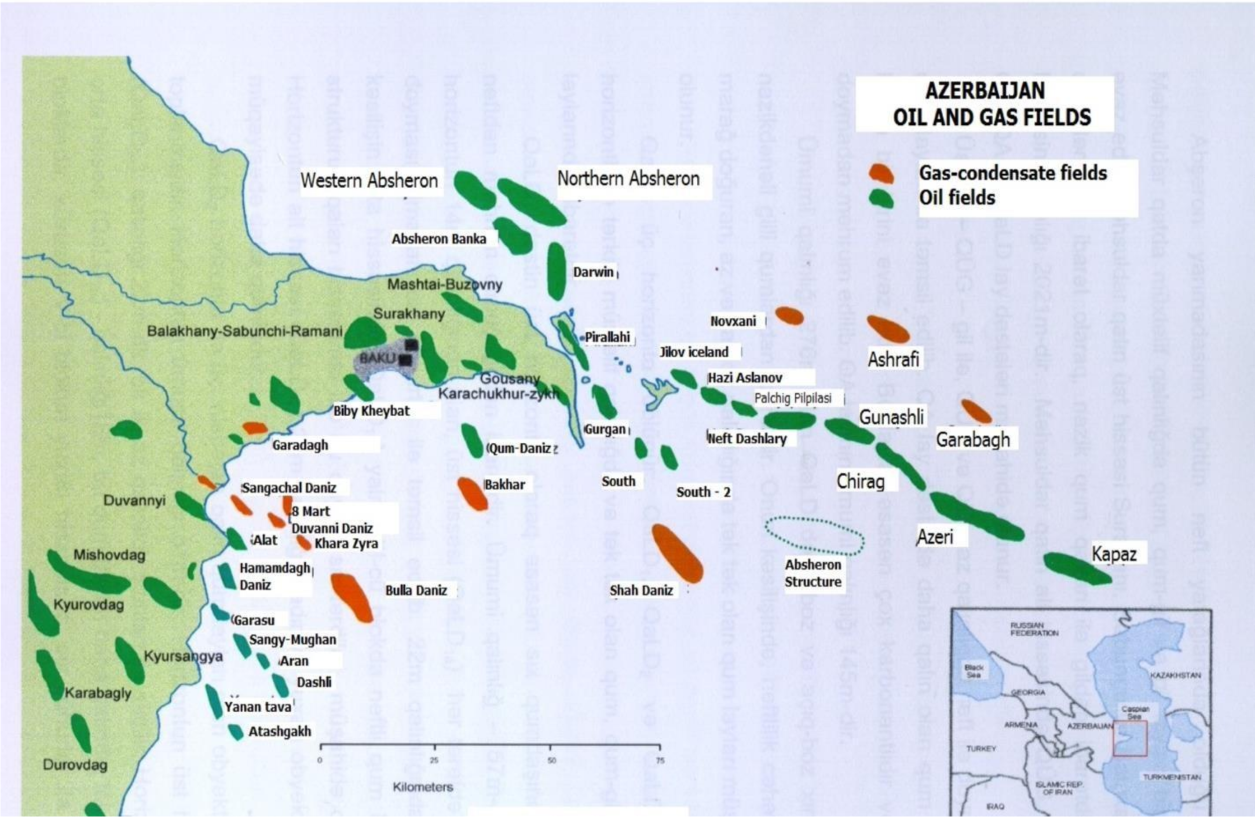



Figure 1.1 Location of oil and gas fields of Azerbaijan

Discovery of Gunashli field relates to production of number 4 exploration well in 1979. During tests of 3455-3423m interval in X-horizon of Balaxani layer well flowed naturally with 230 tons per day rate. Later well number 6 gave natural flow of 320 tons per day during tests of SWG in 1980 November. Gunashli field locates in Caspian Sea, 12 km southeast from well-known Oil Rocks, sea depth changes between 84-300 m in the area of the field (Figure1.1). Oil-gas saturation in upper and lower zones of production zones was discovered during exploration work. The calculation of the oil, gas, gas condensate was carried out in the laboratory of the "Oil Gas Scientific Research Project" Institute department "Estimation of oil and gas reserves". Oil, gas and condensate reserves was calculated during operating period in 1985, 1998, 2005 and 2011.

### 2.1.2 Stratigraphy

The bearing zones of the SWG field have been attached to the productive zones by means of sediments. The Cross-section consist of a layer of about 4300m thick and the layer dates to the Miocene period (Lindas,2006).

The SWG consist of about 18 oil and gas bearing horizons and layers. The difference in thickness between these layers is 2800 -3000m.

The productive zones of the field have been investigated with the exploration wells.

The SWG layers and horizons will be explained in detail below.

Kalin Suite (KaS) is made up of clay and sand layers. It is divided into 3 parts: KaS -1, KaS -2 and KaS -3. From the cross section the percentage of sand increases from. Top to bottom.

The wells show that sand layer is located in the cross section and this sand layer has a height of about 120m. Apparent Resistivity (AR) raises up 20 ohmmeters. This shows that the horizon contains low-density hydrocarbons.

Clays are the main constituent of KaS -1and KaS -1 productivity is lower than that of KaS -2 and KaS -3.

The most productive horizon of the SWG is the pereriva suite (PS) and it is made up of coarse and medium grained sand sediments with thinly layered clays. The PS has a thickness of about 110. - 150m (approximately 361 - 492ft) with a depth of about 2700 – 3550m.

The Balakhani productive series (BPS) is made principally of clay rocks and sand. The cross section of BPS, V, VI, VII, VIII, IX and X horizons separate with the clay's layers. The X horizon has proven to be the most productive of them all. It has a thickness of about 60 -80m and a depth of about 2000 -3050m. The thickness of the IX horizon is about 100 – 130m while the other horizons VIII, VII, VI and V have different variations of thickness ranging from 70 – 140m.

Other productive horizons of the SWG field include the Absheron layer which has a thickness of about 250 -320m and made up of mainly dark gray clays with sands.

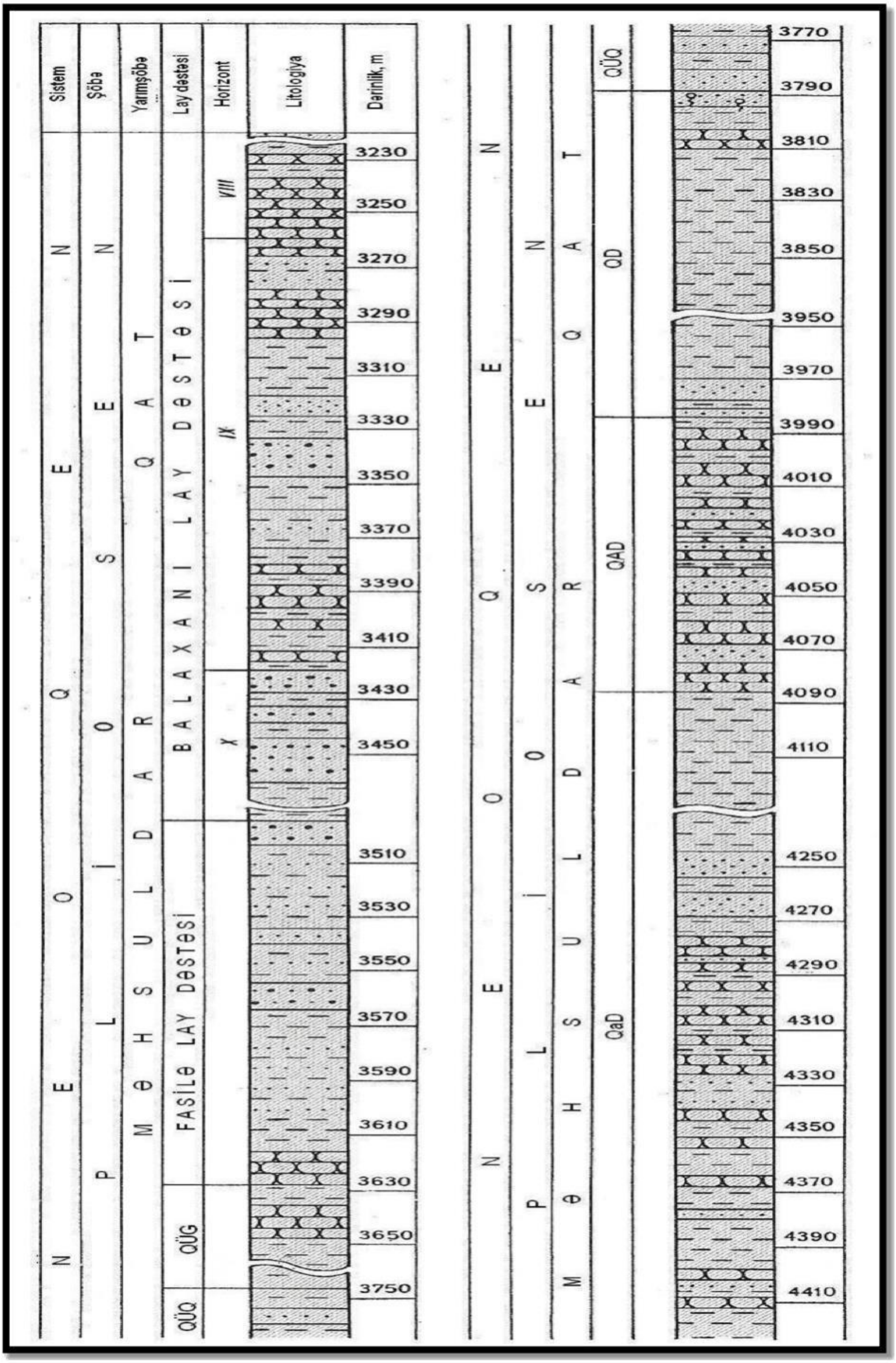



Figure 1.2 Stratigraphic Cross-Section of Gunashli field

### 2.1.3 Lithology

The SWG. Field horizons of VII, VIII, IX, X and FLD were studied with data well test results brought out.

| Horizons | Average Thickness, m | Effective Thickness, m |
|---|---|---|
| VII | 104 | 27 |
| VIII | 106 | 22 |
| IX | 114 | 17 |
| X | 86 | 32 |
| FLD | 129 | 73 |

Table 1.1 Average and effective thickness of horizons

The results of the properties of these zones aided in the calculation of oil and gas reserves. Laboratory analysis of rock samples helps us in determining the reservoir properties as well as geophysical research data of wells. (Linda, S 2006).

## 2.2 General Information about water Injection

There are several methods by which we can recover oil. These methods range from recovery due to reservoir energy (that is the oil flows from the well hole without assistance) to enhanced recovery methods in which considerable energy must be added to the reservoir to produce heavy oil. However, the effect of the methods on the properties of the heavy oil and on the reservoir must be considered before application (Selby et al., 1989).

A large amount of oil is left behind after primary production due to a fall in reservoir pressure up to a point where it cannot force the oil to the surface. In heavy oil reservoirs, about 90% or more of the original oil in place (OOIP) is left in the reservoir after primary production (Curtis et al.,2002). Secondary oil recovery uses various ways to aid in recovering oil and they do so by increasing the reservoir pressure by water injection (waterflooding).

### 2.2.1 Waterflooding

Waterflooding is one of the major oil recovery techniques whereby the energy required to move the oil from the reservoir rock into a producing well is supplied from the surface by means of water injection and induced pressure from the presence of additional water (James G. Speight, 2013). Water injection is used to prevent low pressure in the reservoir and the water replaces the oil which

has been taken, thereby maintaining the production rate and pressure over a long period of time.
Generally, waterflooding is done by pumping water into a series of injection wells and hydrocarbons production through the production wells (Vladimir, Ahmad, Eldar, 2019).
The main aims of waterflooding is basically to maintain reservoir pressure, remove the remaining water after separation from hydrocarbons and finally to create a scheme where there’s going to be a separation of hydrocarbons from injection wells into production wells (Kumar, 2006).
Waterflooding has been successful for a number of reasons, namely,
The availability of water
Cheap cost compared to other injection fluids.
It is very easy to inject water int a formation.
The high efficiency with which water displaces oil.
Water injection is carried out by a number of waterflooding schemes which include, areal (pattern flooding), Contouring (peripheral flooding) and peripheral flooding (crested flooding). (Vladimir, Ahmad, Eldar, 2019).

### 2.2.2 Pattern Flooding

The pattern waterflood maybe divided into 2 namely, Irregular and Regular patterns. It has been recorded that a lot of fields use irregular patterns because it is very difficult to evaluate the recovery efficiency and monitor an irregular pattern (Fuad Islamov, 2019).
Regular repeating patterns are used unless it is a relatively small reservoir.
The repeatable flood patterns may be classified into line drive, 4-spot, 5-spot, 7-spot and 9 -spot patterns.

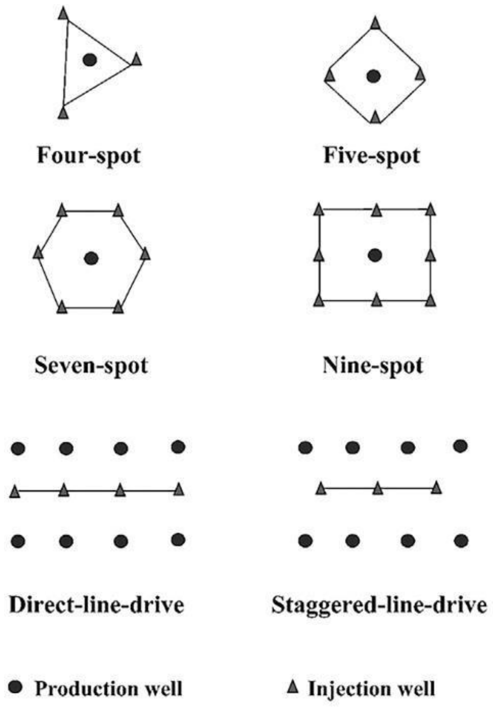



Figure 1.3 Some Schemes for Pattern Waterflooding
Source: (Vladimir, Ahmad, Eldar, 2019).

### 2.2.3 Contour Flooding

In contour flooding, the injection wells are located along the perimeter of the reservoir (Vladimir, Ahmad, Eldar, 2019).

In Fig A, it can be clearly seen that the injection wells are in such a way that the water enters displacing the oils into the production wells in the upper part of the reservoir.

In Fig B, the injection wells have been placed beneath the water – oil contact to take advantage of gravity.

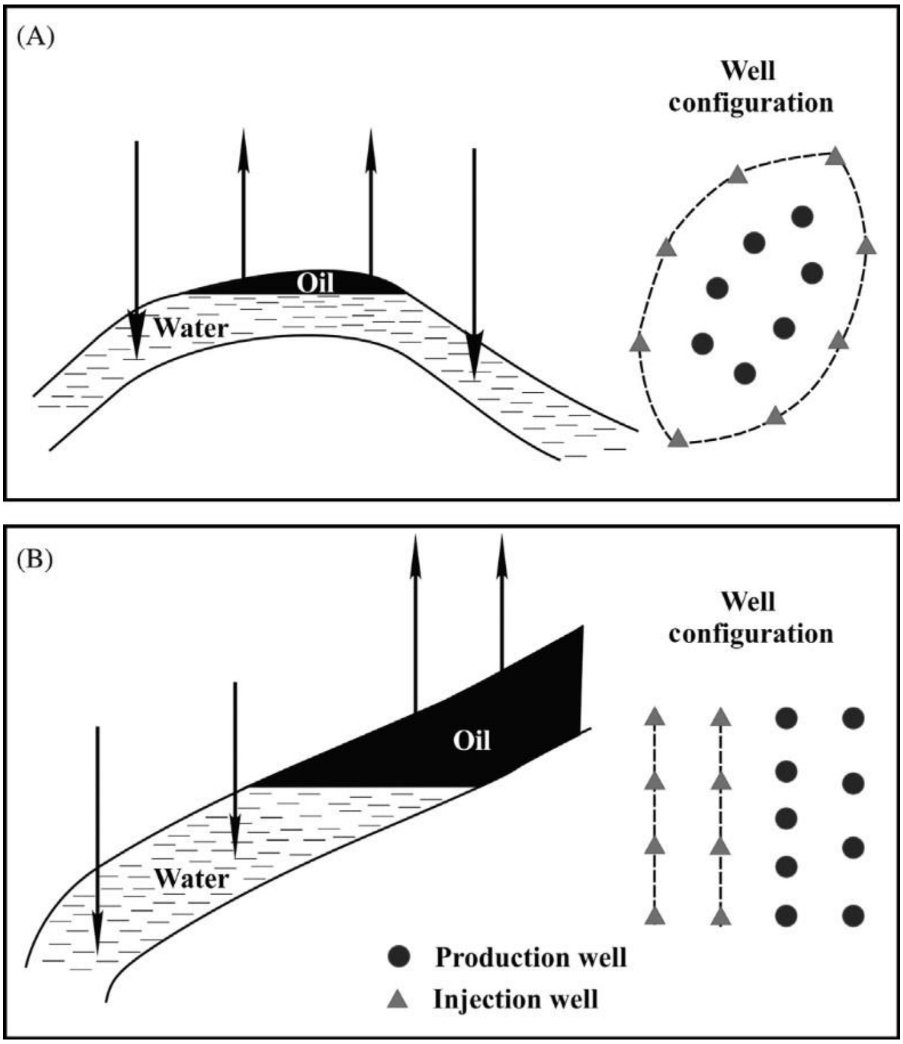



Figure 2A and 2B Contour Flooding Injection well arrangement

Factors influencing Waterflood Recovery.

There are basically 4 factors that influence oil recovery.

1.) Oil in place at the beginning of the waterflood: -

This is basically because of pore volume and oil saturation. The pore volume is dependent on permeability and porosity (James. T. Smith, Williams Cobb, 1997).

2.) Areal Sweep Efficiency: -

It refers to the horizontal area that will contact water and it relies on properties of oil and water.

3.) Vertical Sweep Efficiency: -

It refers to the cross-sectional area that can be invaded by water. It depends solely on the vertical plane existing in the reservoir.

4.) Displacement Sweep Efficiency: -

It represents the fraction of oil which water will displace.

# 3. Field. Overview

## 3.1 Appraisal and Evaluation of water injection in Gunashli field.

### 3.1.1 The Distribution of primary and residual oil reserves by blocks and horizons

The Gunashli field has been under development for 33 years. As a result of exploratory drilling carried out in the field since 1979, oil and gas condensate layers were found in the following horizons and layers in the cutting of MQ sediments: IV, V, VI, QalD-3 – gas condensate; VII, VIII, IX, X, FLD, KÜG - oil; QUQ, QA – gas condensate with oil rim.

The oil and gas condensate layers of the indicated horizons and formations are contoured on the blocks of the field and are currently under industrial development. The first balance reserves of the FLD, X and partially IX horizons make up 91.8% of the total reserves of the field (93.5% extractable). As of 01.01.2013, 140,376 thousand tons of oil were produced from the 3 horizons, which is 95.5% of the recoverable oil reserves of the field. As it can be seen, as of 01.01.2013, the extractable residual oil reserve on FLD, X and IX horizons is 72.7% (46888 thousand t) of the total reserve on the field. 96% or 45,032 thousand t of the remaining extractable oil reserves (46,888,000 tons) on the IX block.

Thus, the extractable residual oil reserves of the Gunashli field IX, X and FLD are located mainly in the IX and partially X blocks of the structure (Table 1.2). Therefore, the injection evaluation on the field should be under special control. Considering this, residual recoverable oil reserves are given in IX and X blocks on IX, X horizons and FLD (Table 1.3). As can be seen from the table, the residual recoverable oil reserve in block IX of the Gunashli field is 13,851-thousand-ton horizons IX, X and FLD; This figure is 5581 thousand t in block X, 19432 thousand t in blocks IX and X (balance reserve 64759 thousand t). In blocks IX and X, the main volume of recoverable oil reserves on IX, X horizons and FLD falls on FLD (58%). In the process of selecting and placing injection wells during the implementation of the injection evaluation on the Gunashli field, special attention should be paid to blocks IX and X.

| Horizon | Primary reserves of oil, thousand tons | | Total production as of 01.01.2013, thousand tons | Residual oil reserves i, thousand t | |
|---|---|---|---|---|---|
| | balance | removable | | balance | removable |
| IX | 9368 | 3841 | 0 | 9368 | 3841 |
| X | 26936 | 14249 | 9923 | 17023 | 4326 |
| FLD | 67781 | 40668 | 29403 | 38378 | 11265 |
| IX+X+FLD | 104085 | 58758 | 39326 | 64769 | 19432 |

Table 1.2 Distribution of Oil reserves on IX and X horizons

| Block | Horizon | Primary reserves of oil, thousand tons | | 01.01.2013 total production to date, thousand tons | Residual oil reserves i, thousand t | |
|---|---|---|---|---|---|---|
| | | balance | removable | | balance | removable |
| IX | IX | 6486 | 2659 | 0 | 6486 | 2659 |
| | X | 19842 | 10496 | 7323 | 12519 | 3173 |
| | FLD | 48249 | 28949 | 20930 | 27319 | 8019 |
| Total for Block IX: | | 74577 | 42104 | 28253 | 46324 | 13851 |
| X | IX | 2882 | 1182 | 0 | 2882 | 1182 |
| | X | 7094 | 3753 | 2600 | 4494 | 1153 |
| | FLD | 19532 | 11719 | 8473 | 11059 | 3246 |
| Total for X block: | | 29508 | 16654 | 11073 | 18435 | 5581 |
| Total: | | 104085 | 58758 | 39326 | 64759 | 19432 |

Table 1.3 Performance indicators for horizons X, IX, FLD

on the IX, X horizons and FLD in the Gunashli field was considered in blocks IX and X (see Table 1.3). As it can be seen, the first recoverable oil reserves in the indicated blocks are 58758 thousand t on all 3 horizons. As of 01.01.2013, considering that the oil reserves are 39326 thousand tons, the remaining extractable reserve will be 19432 thousand tons.

The application of water flooding in the proposed variant will allow to extract the specified residual recoverable oil reserves.

### 3.1.2 The application of the Injection technique on the Gunashli field

As a result of the analysis carried out on the Gunashli field, it was found that the application of water flooding intended to produce residual extractable oil can give more effective results on the IX, X horizons and FLD in the IX and X blocks. Taking this into account, the remaining recoverable oil reserves were calculated for the objects indicated in blocks IX and X of the field as of 01.01.2013 (see Tables 1.2 and 1.3).

It should be noted that water injection in the Gunashli field is mainly planned for the IX, X horizons and FLD in the IX and X blocks. The first recoverable oil reserves on the indicated horizons were 50758 thousand t, and vary in the range of 1182-28249 thousand t.

As of 01.01.2013, if it is considered that the amount of oil produced in the specified block (IX, X blocks) and horizons (IX, X and FLD) is 39326 thousand t, then the remaining recoverable oil reserve will be 19432 thousand t. Thus, the following factors should be considered to have the expected effect of water flooding to improve the efficiency and further development process of the Oil Stones and Gunashli fields:

- Treatment of the sea (or formation) water to be pumped as much as possible.
- Accurate determination of the volume of produced oil, gas, and water in reservoir conditions.
- The most important thing is to estimate the volume of water that can enter the contour of the water to be pumped parallel to the oil layer.

As is known, the Gunashli field was exploited in the mode of reservoir energy depletion until 1986. On 04.04.1986, through well No. 1 located in the south-west wing of the field, with the daily injections volume 259 $m^3$to the X horizon water has started to be pumped. As of 01.04.2013, 26 water wells were drilled in the field to keep the formation pressure stable and increase the development rate. 25 of these wells were given to the injection fund, and 1 well (No. 284) was canceled during drilling. 19 of these wells were drilled to FLD (18 wells were given to the injection fund, while well No. 284 was canceled due to technical reasons during drilling), and 7 were drilled to the X horizon. Due to certain geological and technical reasons, the wells drilled in the X horizon were cancelled. Of the wells drilled in FLD, 2 wells were canceled, 7 wells were given to the operational fund, 3 wells were in the inactive fund, 1 well (No. 65) was in the fund pending cancellation, 4 wells were in the operation, and 1 well was active (Table 1.4). 60 wells/facilities participated in the water flooding process (Table 1.5). The results obtained without injection the horizons by zone are given (Table 1.6).

Injecting water into the IX horizon started in 2009. To inject water into this horizon, wells returned from lower objects are used as injection wells. Currently, water is pumped into the IX horizon through 7 wells per day. 2888 $m^3$Wellhead pressure is 19.0 MPa.

As shown above, the second oil-bearing object of the field is the X horizon of the Balakhani formation. The horizon was intensively developed, the maximum production rate was 5.7%. The method of artificial influence on the horizon was started in 1986, the method of contour arch and contour injection was applied; 23 wells participated in injection, currently 2904 $m^3$water is pumped through 5 wells per day. Wellhead pressure is 19.0 MPa. The water injection process was carried out mainly in the north-west periclinal and south-west wing of the field.

| No | Well no | Horizon | Date of commissioning | Stop date | Injected water | | | Note |
|---|---|---|---|---|---|---|---|---|
| | | | | | monthly, $m^3$ | Yearly, thousand $m^3$ | From the beginning of the impact, thousand $m^3$ | |
| 1 | 1 | X | 04.04.1986 | 11.05.1986 | | | 3.5 | Repaying |
| | | FLD | 08.08.1986 | 14.03.1987 | | | 177.8 | Canceled |
| 2 | 51 | X | 18.04.1989 | 04.06.1994 | | | 482.6 | Canceled |
| 3 | 53 | X | 30.11.1988 | 04.06.1994 | | | 392.1 | Canceled |
| 4 | 64 | X | 26.12.1988 | 08.03.1992 | | | 212.3 | Canceled |
| 5 | 65 | FLD | 25.07.1988 | 12.08.1990 | | | 380.4 | Repaying |
| | | X | 24.04.1998 | 29.06.2004 | | | 293.4 | Cancellation pending |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | 139 | FLD | 28.02.1987 | 19.04.1991 | | | 500.3 | Repaying |
| | | X | 10.03.1994 | 24.05.2001 | | | 323.5 | Transferred to the operating fund |
| 7 | 55 | X | 12.10.1988 | 03.12.2003 | | | 1047.5 | Canceled. |
| 8 | 82 | X | 18.02.1991 | 09.06.1995 | | | 518.8 | Canceled. |
| 9 | 150 | X | 22.03.1988 | 09.10.1991 | | | 311.3 | Canceled. |
| 10 | 158 | FLD | 30.01.1987 | 01.02.1987 | | | 0.4 | Repaying |
| | | X | 21.04.1993 | 20.06.1997 | | | 433.8 | Transferred to the operating fund |
| 11 | 201 | FLD | 31.08.1989 | 02.10.1991 | | | 21.6 | Repaying |
| | | X | 23.09.1998 | 01.09.2008 | | | 511.3 | Transferred to the operating fund |
| 12 | 206 | FLD | 02.01.1990 | 26.12.1993 | | | 289.5 | Repaying |
| | | X | 20.01.1999 | 10.09.2007 | | | 454.2 | Does not accept |
| 13 | 214 | FLD | 30.04.1989 | 31.01.1993 | | | 300.6 | Repaying |
| | | X | 09.01.1995 | 13.10.1995 | | | 57.3 | Repaying |
| | | IX | 28.04.2010 | it works | 6, 9 | 20.1 | 236.5 | it works |
| 14 | 127 | FLD | 14.10.1986 | 13.08.2000 | | | 1087.7 | Repaying |
| | | IX | 23.04.2010 | it works | 6, 9 | 20.1 | 288.5 | it works |
| 15 | 128 | FLD | 27.09.1986 | 31.03.2001 | | | 987.8 | Repaying |
| | | IX | 04.11.2009 | it works | 7.2 | 20.9 | 354.2 | it works |
| 16 | 129 | FLD | 28.01.1988 | 30.10.1996 | | | 485.7 | Canceled. |
| 17 | 66 | FLD | 30.09.1989 | 07.01.1996 | | | 2,3 | Transferred to the operating fund |
| 18 | 67 | FLD | 31.08.1991 | 08.02.1992 | | | 22.4 | Transferred to the operating fund |
| 19 | 140 | FLD | 21.01.1988 | 16.05.1997 | | | 659.8 | Transferred to the operating fund |
| 20 | 215 | FLD | 30.11.1989 | 01.12.1989 | | | 0.1 | No water line |
| 21 | 227 | FLD | 30.06.1988 | 23.04.1993 | | | 91.0 | Repaying |
| | | X | 04.02.2012 | it works | 8, 4 | 24.3 | 104.4 | it works |
| 22 | 270 | FLD | 29.04.1989 | 23.04.1993 | | | 84.4 | Canceled |
| 23 | 159 | FLD | 24.10.1987 | it works | 8, 6 | 24.9 | 2803.2 | it works |
| 24 | 62 | FLD | 28.02.1990 | 31.01.1999 | | | 404.2 | Transferred to the operating fund |
| 25 | 63 | FLD | 25.03.1991 | - | | | 1761.2 | GAITS is waiting |
| 26 | 284 | Canceled during drilling | | | | | | |

Table 1.4 Information about injection wells

| Ordinal numeral | Horizon | Date of commencement of operation | Start date of injection | well, / facility | Injection | | | Yield from injection, thousand t | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | average daily, $m^3$ | $^3$ during the first quarter | from the beginning of development, thousand $m^3$ | During the first quarter | from the beginning of development |
| 1 | IX | 1992 | 04.11.2009 | 8 | 2884.9 | 259.9 | 2648.9 | 7.6 | 57.5 |
| 2 | X | 1979 | 04.04.1986 | 23 | 2901.2 | 261.1 | 13274.7 | 10.6 | 1971,4 |
| 3 | FLD | 1980 | 08.08.1986 | 29 | 1879.9 | 169.3 | 18829.4 | 2.5 | 5190.8 |
| Total: | | | | 60 | 7666.0 | 690.3 | 34753 .0 | 20.7 | 7219.7 |

Table1.5 Information about injection wells (wells/facilities) involved in the exploitation of horizons.

| Bed | Tectonic field | Horizon | Effective date | Injection well fund, no.: common | Injection well fund, no.: working | Affected wells no. | Injection pressure, atm | Current reservoir pressure, MPa | The volume of water injected: g hole , m 3 / g | The volume of water injected: monthly, m in m 3 | The volume of water injected: quarterly, m in m 3 | The volume of water injected: since the beginning of the year, thousand m 3 | The volume of water injected: from the beginning of the impact, thousand m 3 | Fluid volume produced from the impact area: daily: oil t/g | daily: water, m 3 /g | monthly: oil, thousand tons | monthly: water, min m 3 | quarterly: oil, thousand tons | quarterly: water, thousand m 3 | since the beginning of the year: oil, thousand tons | since the beginning of the year: water, thousand m 3 | from the beginning of development: oil, thousand tons | from the beginning of development: water, thousand m 3 | Injection coefficient: current | Injection coefficient: from the beginning of the process | Oil growth: monthly, thousand t | Oil growth: quarterly, thousand t | Oil growth: from the beginning of the year, thousand t | Oil growth: from the beginning of the impact, thousand t |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| Sunny | 1 | IX | 07.10.2013 | 2 | 2 | 5 | 190 | | 1459 | 45, 2 | 134, 0 | 528, 1 | 797, 7 | 93 | 24 | 2, 9 | 0, 8 | 6, 7 | 1, 7 | 27, 8 | 5, 5 | 59, 8 | 10, 5 | 7, 40 | 0, 91 | 1, 0 | 2, 4 | 9 | 18, 3 |
| | | X | 01.04.1986 | 4 | 3 | 5 | 190 | 13, 7 | 1573 | 48, 6 | 144, 0 | 551, 0 | 2845, 4 | 70 | 9 | 2, 2 | 0, 3 | 14, 1 | 1, 0 | 70, 3 | 6, 2 | 1897, 4 | 140, 9 | 8, 00 | 1, 88 | 0, 7 | 4, 9 | 22, 7 | 938, 0 |
| | | FLD | 01.08.1986 | 2 | - | - | 190 | 20, 6 | - | - | - | - | 3383, 7 | - | - | - | - | 3, 5 | 4.4 | 20, 8 | 22, 4 | 7453, 4 | 198, 5 | - | 0, 61 | - | 1, 2 | 6, 7 | 2348, 7 |
| | 2 | FLD | | | | | | | | | | | 1435, 9 | | | | | | | | | | | | | | | | |
| | 3 | IX | 11.09.2013 | 6 | 5 | 11 | 190 | | 1428 | 44, 1 | 130, 9 | 516, 4 | 1591, 3 | 143 | 68 | 4, 4 | 2, 1 | 8, 8 | 5, 0 | 49, 5 | 16, 9 | 108, 5 | 55, 5 | 3, 20 | 0, 43 | 1, 6 | 3, 1 | 15, 9 | 31, 6 |
| | | X | 01.04.1986 | 3 | 2 | 7 | 190 | 17, 5 | 1329 | 41, 1 | 122, 0 | 485, 0 | 10168, 3 | 321 | 78 | 10, 0 | 2, 4 | 19, 3 | 4, 1 | 39, 5 | 8, 1 | 3787, 8 | 352, 4 | 2, 50 | 0, 58 | 3, 5 | 6, 7 | 13, 1 | 1022, 8 |
| | | FLD | 01.08.1986 | 5 | 3 | 3 | 190 | 22, 5 | 1878 | 58, 2 | 173, 1 | 689, 5 | 13840, 6 | 76 | 85 | 2, 4 | 2, 6 | 4, 9 | 5, 8 | 29, 4 | 35, 4 | 7765, 8 | 850, 2 | 2, 90 | 0, 39 | 0, 8 | 1, 7 | 9, 4 | 2839, 6 |
| On the bed | | | | 22 | 15 | 31 | | | 7667 | 237, 4 | 704, 0 | 2770 | 34062, 8 | 703 | 264 | 21, 9 | 8, 2 | 57, 3 | 22, 0 | 237, 3 | 94, 5 | 21072, 7 | 1608.0 | 0, 52 | 0, 20 | 7, 6 | 20, 0 | 76, 8 | 7199, 0 |

Table 1.6 Injection horizons by zones and the results obtained (as of 01.01.2013)

As a result, the main area of the bed in the south-western wing is flooded. As a result of the intensive development and the unsatisfactory condition of the artificial impact method, the initial formation pressure of the field has decreased from 32.0 MPa to approximately 9.0-15.0 MPa, which has a negative effect on the final oil yield of the field. That is why the current gas factor of the wells is 4-6 times higher than its initial value. This essentially indicates that the horizon in the central area is operating in a purely dissolved gas regime.

Processing of FLD is carried out with effect from 08.08.1986. The injection process was started from the north-west periclinal and south-west wing of the field, according to the excavation of the field. During the past period, 29 wells participated in injection in this horizon, of which 5 were in the north and 24 were in the south-west area. Currently, 3 wells are operating in this horizon, and they are in the southern part of the field. The remaining wells do not work for various reasons (lack of discharge line, loss of receiving capacity, being in an emergency state, etc.). Currently, the volume of water pumped daily by these 3 wells is 1879 $m^3$.

Wellhead pressure is 19.0 MPa. As a result of intensive exploitation of the FLD horizon and unsatisfactory implementation of artificial impact methods, the efficiency of the wells decreased significantly, the initial reservoir pressure decreased from 34.0 MPa to 12.0-28.5 MP.

### 3.1.3 Current Status of its facilities

As of 01.04.2013, there were 20 injection wells, of which 15 are operational and 6 are inactive. 1 well is awaiting cancellation (Table 1.7).

The current conditions of injection wells in the field were analyzed, the results of the analysis below given. Unsystematic placement of injection wells in the field and delay of the process caused the movement of the oil-water contour in different forms, and as a result, the effect was relatively small.

3 objects are operated by the process of injection in the field: FLD, X and IX horizons.

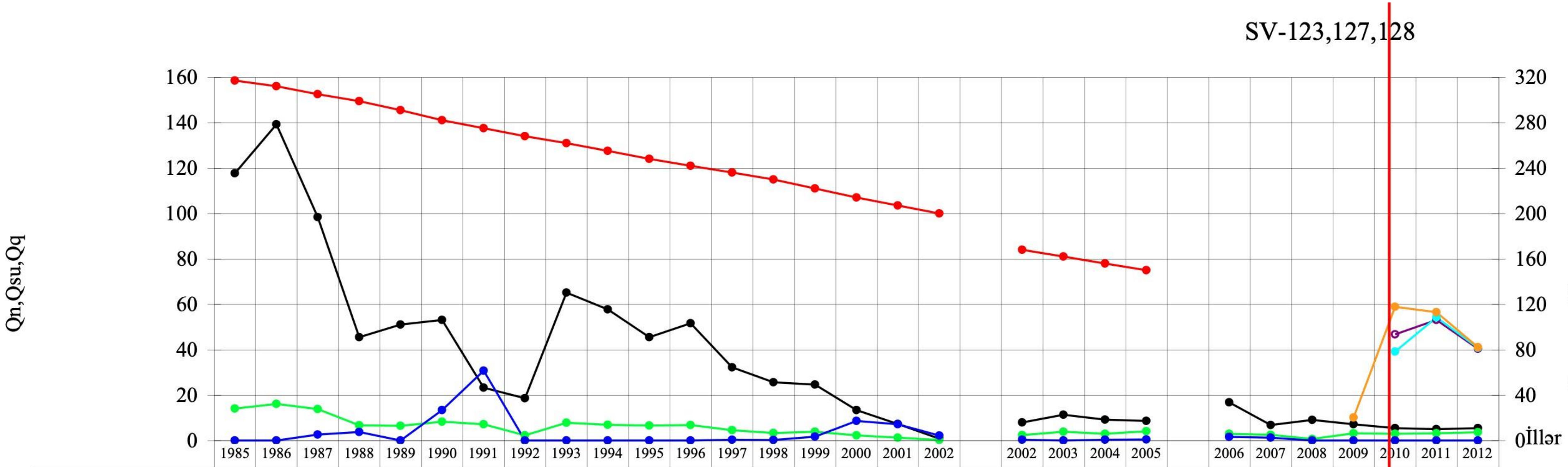
The FLD and X horizon injection system does not have an effect; on the one hand, this is due to the small volume of injected water, and on the other hand, there are no production wells in the area of influence of the currently operating pressure wells.

At present, water is pumped into the IX horizon by means of 7 injection wells. 5 of the wells are in the south of the field, and 2 are in the north located in the wing. Since the beginning of development (as of 01.04.2013), 2648.9 thousand $m^3$ of water has been pumped into this horizon. The volume of injected water in the first quarter of 2013 was 259.9 thousand $m^3$. From the beginning of the impact on the yield from injection on the IX horizon, it was 57.5 thousand t, and 7.6 thousand t per quarter. The dilution factor is 0.317 from the beginning of the impact, 2.820 quarterly. The injection process was mainly carried out in the southern area, the amount of water injected into this area (1719.9 thousand $m^3$) is 4.9% of the total injected water (34753.0 thousand m3).

Development dynamics of injection wells Nos. 123, 127 and 128 and affected wells Nos. 120, 125, 255 and 290 located in the XV-tectonic block of the southern wing are given (Figures 3.1 - 3.4). As can be seen from the dynamics, despite the fact that they are operated from the same peaks, the water pumped through wells No. 123, 127, 128 does not have an effect on operational wells No. 120, 126 and 290.

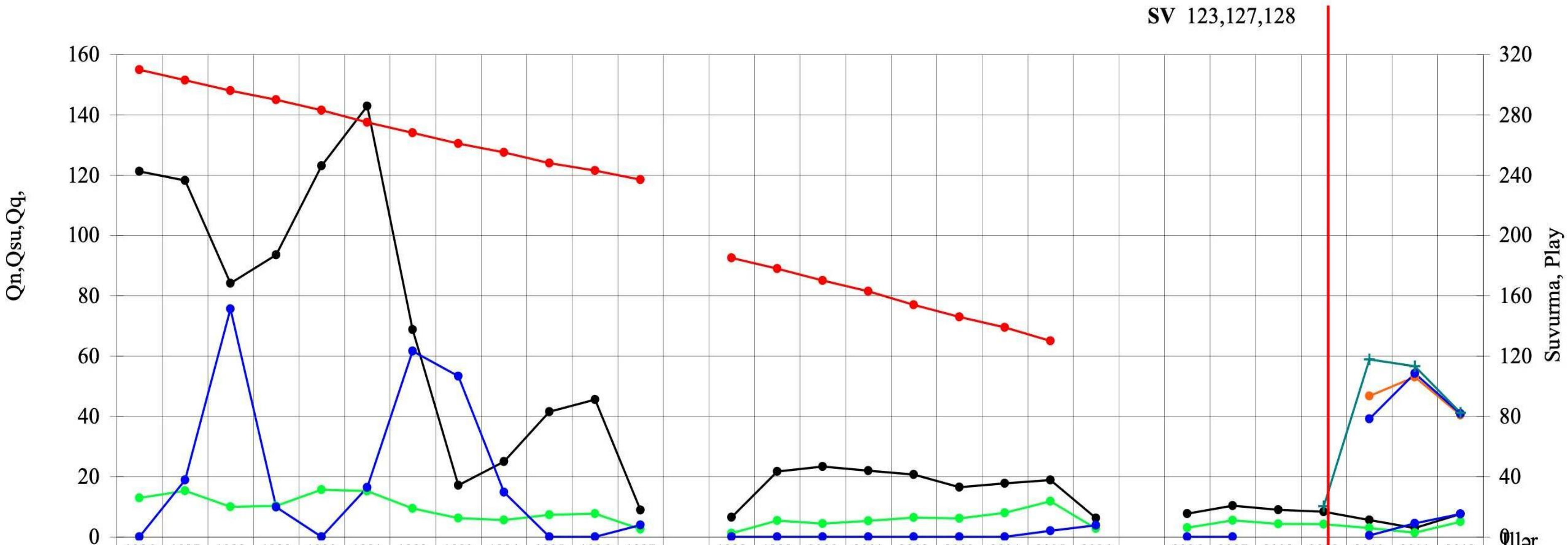
| Ordinal numeral | Well No | Zones | Horizon | Date of commissioning | Daily intake, $m^3$ /g | Pumped water, thousand $m^3$ | | | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | monthly | quarterly | t from the beginning of the century | |
| 1 | 227 | North | X | 04.02.2012 | 27 0 | 8, 4 | 24.3 | 104.4 | it works |
| 2 | 86 | | X | 15.10.2008 | 689 | 21.3 | 61.9 | 800.3 | it works |
| 3 | 87 | | X | 02.10.2007 | 614 | 19.0 | 55.3 | 842.6 | it works |
| 4 | 278 | | IX | 0 9.10.2011 | 87 0 | 26.9 | 78.2 | 461.2 | it works |
| 5 | 280 | | IX | 30.07.2010 | 5 92 | 18, 3 | 53 | 467.8 | it works |
| 6 | 417 | South | FLD | 13.08.2010 | 80 2 | 24.9 | 72.2 | 757 | it works |
| 7 | 122 | | FLD | 10.09.2007 | 801 | 24, 8 | 72.2 | 1 1681.1 | it works |
| 8 | 159 | | FLD | 24.10.1987 | 276 | 8.6 | 24.9 | 2803.2 | it works |
| 9 | 124 | | X | 27.07.2011 | 90 6 | 28.1 | 81.6 | 531.4 | it works |
| 10 | 258 | | X | 28.10.1999 | 42 5 | 13, 1 | 38 | 2738.9 | it works |
| 11 | 157 | | IX | 28.04.2010 | 52 7 | 16.3 | 47.4 | 540.2 | it works |
| 12 | 123 | | IX | 03/04/2010 | 22 2 | 6.9 | 20.1 | 300.5 | it works |
| 13 | 214 | | IX | 28.04.2010 | 22 5 | 6, 9 | 20.1 | 236.5 | it works |
| 14 | 128 | | IX | 04.11.2009 | 23 1 | 7, 2 | 20.9 | 354.2 | it works |
| 15 | 127 | | IX | 23.04.2010 | 221 | 6.9 | 20.1 | 288.5 | it works |

Table 1.7 Information about working injection wells



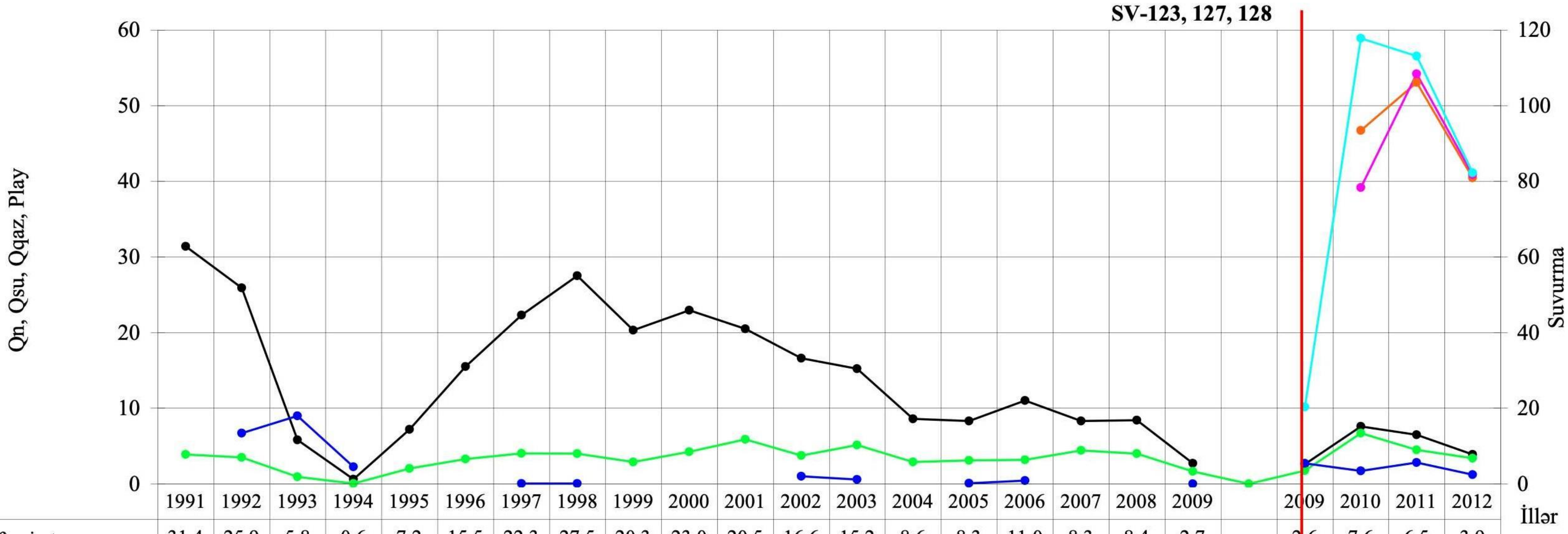

| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qn, min t | 117,7 | 139,2 | 98,4 | 45,5 | 51,1 | 53,1 | 23,3 | 18,6 | 65,1 | 57,8 | 45,5 | 51,6 | 32,2 | 25,6 | 24,6 | 13,4 | 7,3 | 0,8 | 8 | 11,3 | 9,2 | 8,6 | 16,8 | 6,8 | 9,1 | 7,1 | 5,4 | 5 | 5,4 |
| Qqaz, mln. m3 | 14,1 | 16,1 | 13,9 | 6,7 | 6,5 | 8,3 | 7,2 | 2,3 | 7,8 | 6,9 | 6,6 | 6,8 | 4,5 | 3,3 | 3,9 | 2,3 | 1,3 | 0,2 | 2,4 | 3,9 | 3 | 4,1 | 2,9 | 2,5 | 0,7 | 3,2 | 2,9 | 3,2 | 3,6 |
| Su, min t | 0 | 0 | 2,6 | 3,8 | 0 | 13,4 | 30,8 | 0 | 0 | 0 | 0 | 0 | 0,3 | 0,2 | 1,7 | 8,6 | 7,2 | 2,1 | 0,3 | 0 | 0,3 | 0,4 | 1,6 | 1,3 | 0 | 0 | 0,04 | 0 | 0 |
| Play,atm | 317 | 312 | 305 | 299 | 291 | 282 | 275 | 268 | 262 | 255 | 248 | 242 | 236 | 230 | 222 | 214 | 207 | 200 | 168 | 162 | 156 | 150 | | | | | | | |
| 123-suvurma,min m3 | | | | | | | | | | | | | | | | | | | | | | | | | | | 93,4 | 106,1 | 80,9 |
| 127-suvurma,min m3 | | | | | | | | | | | | | | | | | | | | | | | | | | | 78,3 | 108,4 | 81,7 |
| 128-suvurma,min m3 | | | | | | | | | | | | | | | | | | | | | | | | | | 20,3 | 117,8 | 113,1 | 82,2 |

Figure 3.1 Development dynamics of well No 120



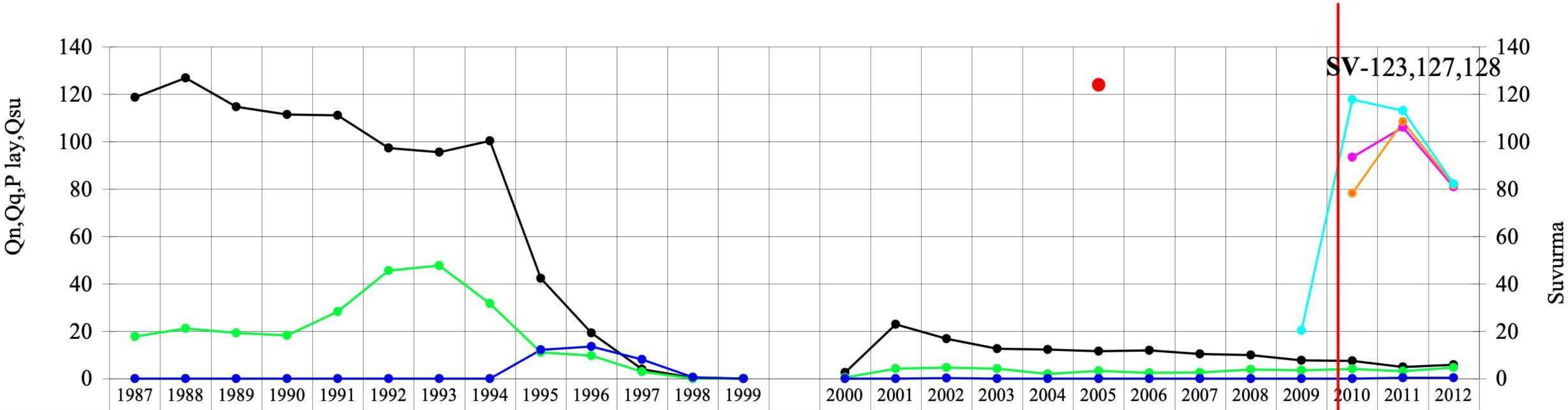

| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qn, mln t | 121,2 | 118,2 | 84,1 | 93,5 | 123,1 | 142,9 | 68,8 | 17,1 | 25 | 41,5 | 45,5 | 8,9 | 6,5 | 21,7 | 23,3 | 21,9 | 20,7 | 16,5 | 17,7 | 18,8 | 6,2 | 7,7 | 10,3 | 9 | 8,3 | 5,6 | 2,9 | 7,6 |
| Qqaz,mln m3 | 12,9 | 15,3 | 10 | 10,2 | 15,6 | 15,2 | 9,4 | 6,2 | 5,6 | 7,3 | 7,7 | 2,6 | 1,2 | 5,4 | 4,4 | 5,3 | 6,4 | 6,1 | 8 | 11,8 | 2,7 | 3 | 5,5 | 4,3 | 4,2 | 2,9 | 1,4 | 5 |
| Su,mln t | 0 | 18,8 | 75,6 | 9,9 | 0 | 16,4 | 61,6 | 53,3 | 14,8 | 0 | 0 | 3,9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3,8 | 0 | 0 | | | 0,5 | 4,5 | 7,6 |
| Play,atm | 310 | 303 | 296 | 290 | 283 | 275 | 268 | 261 | 255 | 248 | 243 | 237 | 185 | 178 | 170 | 163 | 154 | 146 | 139 | 130 | | | | | | | | |
| 123-suvurma,mln m3 | | | | | | | | | | | | | | | | | | | | | | | | | | 93,4 | 106,1 | 80,9 |
| 127-suvurma,mln m3 | | | | | | | | | | | | | | | | | | | | | | | | | | 78,3 | 108,4 | 81,7 |
| 128-suvurma,mln m3 | | | | | | | | | | | | | | | | | | | | | | | | | 20,3 | 117,8 | 113,1 | 82,2 |

Figure 3.2. Development dynamics of well No 125




| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neft,min t | 31,4 | 25,9 | 5,8 | 0,6 | 7,2 | 15,5 | 22,3 | 27,5 | 20,3 | 23,0 | 20,5 | 16,6 | 15,2 | 8,6 | 8,3 | 11,0 | 8,3 | 8,4 | 2,7 | | 2,6 | 7,6 | 6,5 | 3,9 |
| Qaz,mln. m3 | 3,9 | 3,5 | 0,9 | 0,0 | 2,0 | 3,3 | 4,0 | 4,0 | 2,9 | 4,2 | 5,9 | 3,7 | 5,1 | 2,9 | 3,1 | 3,2 | 4,4 | 4,0 | 1,6 | 0,0 | 1,7 | 6,7 | 4,5 | 3,4 |
| Su,min t | | 6,7 | 9,0 | 2,2 | | | 0,0 | 0,0 | | | | 1,0 | 0,6 | | 0,1 | 0,4 | | | 0,0 | | 2,7 | 1,7 | 2,8 | 1,2 |
| Play,atm | | | | | | | | | | | | | | | | | | | | | | | | |
| 123-suvurma,min m3 | | | | | | | | | | | | | | | | | | | | | | 93,4 | 106,1 | 80,9 |
| 127-suvurma,min m3 | | | | | | | | | | | | | | | | | | | | | | 78,3 | 108,4 | 81,7 |
| 128-suvurma,min m3 | | | | | | | | | | | | | | | | | | | | | 20,3 | 117,8 | 113,1 | 82,2 |

Figure 3.3. Development dynamics of well No 255




| İllər | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qn, min t | 118,7 | 126,9 | 114,8 | 111,5 | 111,1 | 97,3 | 95,5 | 100,4 | 42,3 | 19,3 | 4,0 | 0,4 | 0,0 | 2,6 | 23,0 | 16,9 | 12,6 | 12,3 | 11,6 | 12,0 | 10,4 | 10,0 | 7,8 | 7,5 | 4,9 | 5,8 |
| Qqaz,mln m3 | 17,8 | 21,2 | 19,3 | 18,2 | 28,3 | 45,6 | 47,7 | 31,7 | 11,1 | 9,7 | 3,0 | 0,1 | 0,0 | 0,4 | 4,2 | 4,7 | 4,2 | 2,0 | 3,2 | 2,5 | 2,6 | 3,9 | 3,5 | 4,1 | 3,1 | 4,7 |
| Play,atm | | | | | | | | | | | | | | | | | | | 124 | | | | | | | |
| Su,min t | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12,16 | 13,58 | 8,036 | 0,575 | 0 | 0 | 0 | 0,255 | 0 | 0 | 0,052 | 0 | 0 | 0,035 | 0,028 | 0 | 0,3 | 0,4 |
| 123-suvurma,min m3 | | | | | | | | | | | | | | | | | | | | | | | | 93,4 | 106,1 | 80,9 |
| 127-suvurma,min m3 | | | | | | | | | | | | | | | | | | | | | | | | 78,3 | 108,4 | 81,7 |
| 128-suvurma,min m3 | | | | | | | | | | | | | | | | | | | | | | | 20,3 | 117,8 | 113,1 | 82,2 |

Figure 3.4. Development dynamics of well No 290

This effect of producing affected the wells (the amplitude of the fracture is more than 100-m). Perhaps, unlike the northern zone, this effect is not noticeable due to the fact that the formation water flow is strong in the southern zone of the field, and the volume of injected water is small.

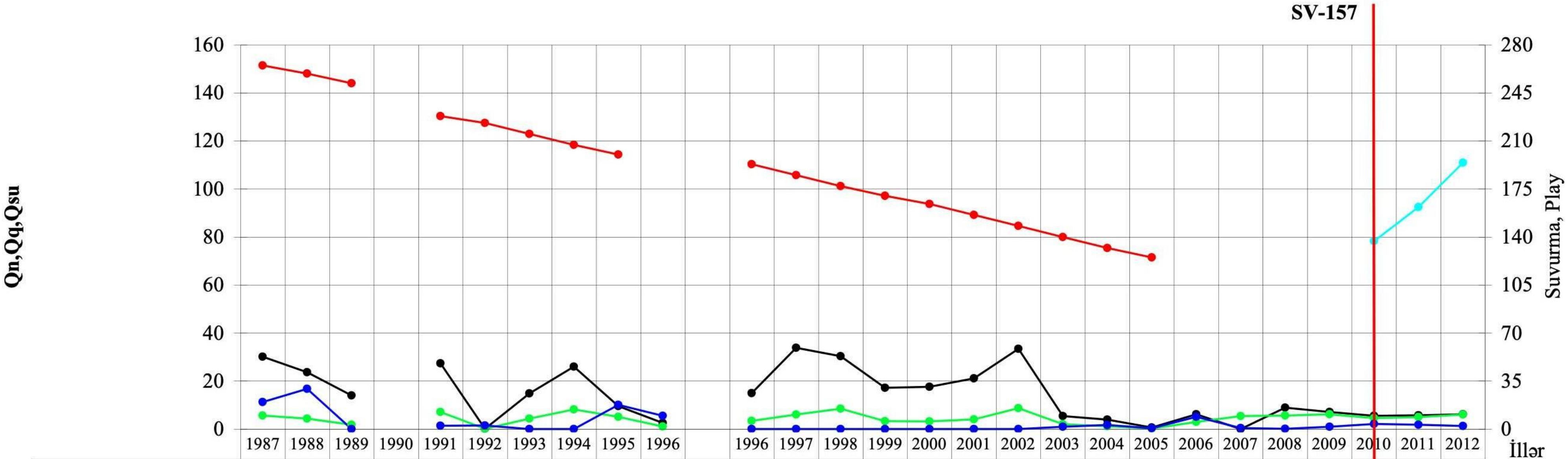
The effect of water pumped from wells No. 127 and 157 manifests itself in the development dynamics of exploitation wells No. 125, 255, 267 and 126, 114, respectively. Development dynamics of affected wells No. 126 and 114 are given (Figures 3.5 - 3.6).

The influence of water well No. 278 located in the same block (VI b) in the northern wing of the deposit is visible in the development dynamics of production well No. 281. This does not apply to the affected production well No. 226 located in the same block. The reason for this can be explained by the fact that the "peaks" of these wells with the same logging indicators do not match (Figures 3.7 - 3.8).

The X horizon is currently being pumped with water through 5 injection wells. 2 of the wells are located in the southern wing of the field, and 3 in the northern wing. From the beginning of development (as of 01.04.2013), the volume of water pumped into this horizon was 13274.7 thousand m $^3$, and for the first quarter it was 261.1 thousand m $^3$. From the beginning of the impact on the yield from injection on the X horizon, it was 1971.4 thousand t, and the quarter was 10.6 thousand t. The coefficient of injection is 0.281 from the beginning of the impact, and 0.879 quarterly.

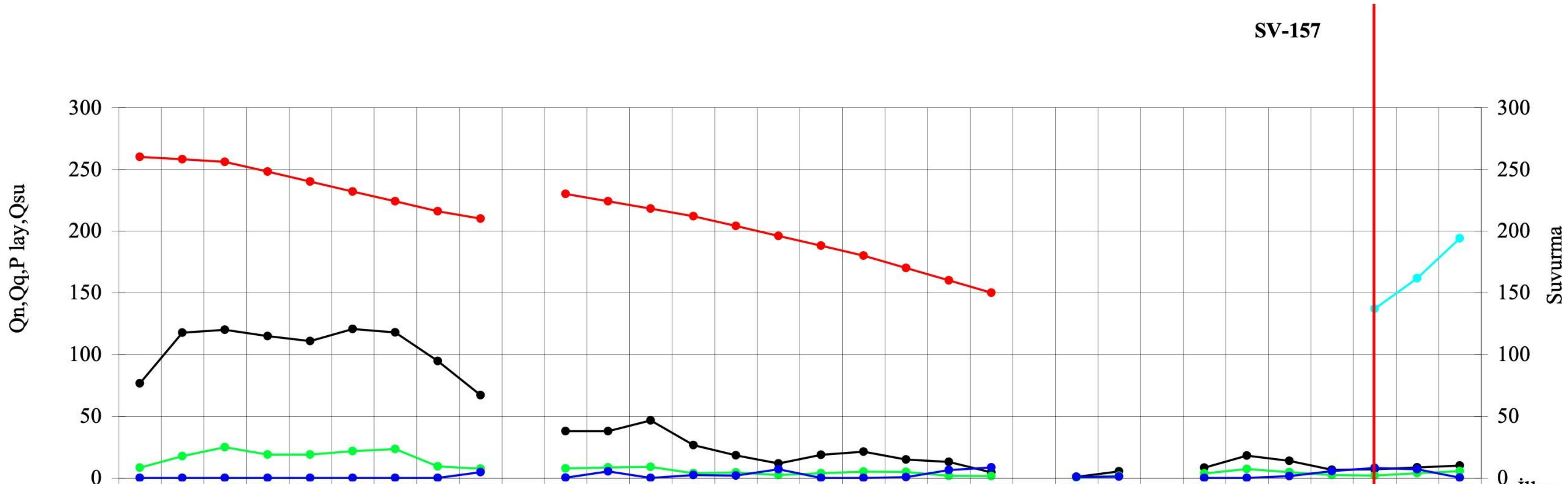
The water injection process was mainly carried out in the southern area, the amount of water injected into this area (10287.9 thousand m $^3$)· is 29.6% of the total injected water (34753.0 thousand m $^3$). The dynamics of the injection well No. 124 and the affected well No. 261, located in the XIII tectonic block of the southern wing, are given (Figure 3.9). As you can see from the picture, since they are located in the same block, the effect of injected water is evident in the development dynamics.

Let's examine the effect of injection wells No. 86 and 87 on production wells No. 223 and 95 located in the northern wing of the field. As can be seen from the development dynamics of wells No. 223 and 95, the influence of injection wells is not noticeable in the corresponding wells.



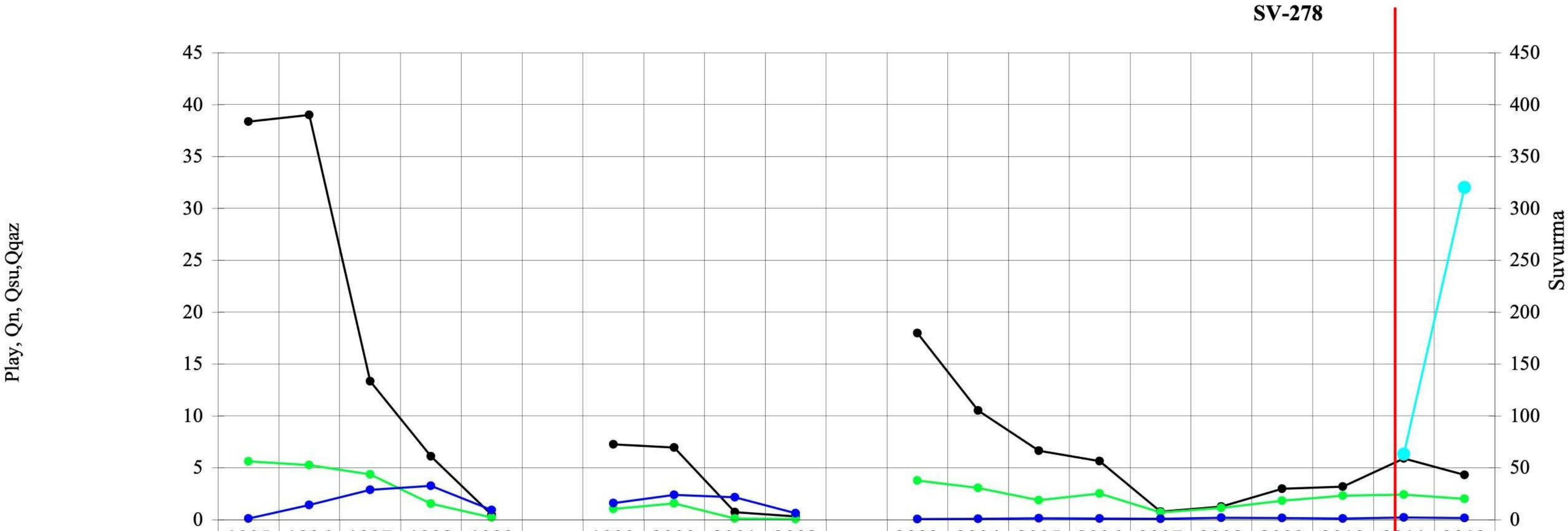

| | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qn, min t | 30,1 | 23,6 | 14 | | 27,4 | 0,1 | 14,8 | 26 | 9,5 | 2,5 | | 14,9 | 33,8 | 30,3 | 17,2 | 17,6 | 21,1 | 33,4 | 5,4 | 3,9 | 0,6 | 6,1 | 0 | 8,9 | 7,1 | 5,5 | 5,7 | 6,2 |
| Qqaz, mln m3 | 5,6 | 4,4 | 1,8 | | 7,1 | 0,1 | 4,3 | 8,2 | 5,1 | 1,1 | | 3,4 | 6 | 8,5 | 3,3 | 3,2 | 4 | 8,7 | 2 | 1,2 | 0,2 | 3,0 | 5,4 | 5,6 | 6,1 | 4,6 | 5 | 6 |
| Su, min t | 11,2 | 16,7 | 0 | | 1,4 | 1,5 | 0 | 0 | 10,1 | 5,5 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1,7 | 0,3 | 5,1 | 0,4 | 0,1 | 1 | 2,1 | 1,8 | 1,3 |
| Play,atm | 265 | 259 | 252 | | 228 | 223 | 215 | 207 | 200 | | | 193 | 185 | 177 | 170 | 164 | 156 | 148 | 140 | 132 | 125 | | | | | | | |
| suvurma,min m3(157) | | | | | | | | | | | | | | | | | | | | | | | | | | 137 | 161,8 | 194 |

Figure 3.5. Development dynamics of well No 114




| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | | 2005 | 2006 | | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qn, min t | 76,6 | 117,6 | 120,1 | 114,9 | 110,9 | 120,6 | 117,9 | 94,7 | 67,1 | | 37,8 | 37,8 | 46,5 | 26,6 | 18,3 | 11,6 | 18,8 | 21,3 | 14,8 | 12,9 | 4,4 | | 0,9 | 5,3 | | 8,2 | 18,0 | 13,9 | 6,5 | 6,98 | 8,5 | 10 |
| Qqaz, mln. m3 | 8,3 | 17,6 | 24,8 | 18,9 | 19 | 21,6 | 23,4 | 9,4 | 7,5 | | 7,7 | 8,5 | 9 | 3,9 | 4,5 | 2,3 | 3,8 | 5,2 | 4,8 | 1,8 | 1,5 | | 0,3 | 1,8 | | 3,7 | 7,2 | 4,6 | 2,3 | 2 | 3,9 | 5,6 |
| Su, min t | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4,7 | | 0,3 | 5,3 | 0 | 2,3 | 2 | 7 | 0 | 0 | 0,6 | 6,4 | 8,6 | | 0,8 | 1,1 | | 0 | 0,02 | 1,4 | 5,5 | 8,1 | 7 | 0,3 |
| Play,atm | 260 | 258 | 256 | 248 | 240 | 232 | 224 | 216 | 210 | | 230 | 224 | 218 | 212 | 204 | 196 | 188 | 180 | 170 | 160 | 150 | | | | | | | | | | | |
| Suvurma,min m3(q157) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 137 | 161,8 | 194 |

Figure 3.6. Development dynamics of well No 126




| | 1995 | 1996 | 1997 | 1998 | 1999 | | 1999 | 2000 | 2001 | 2002 | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qn, min t | 38,4 | 39,0 | 13,3 | 6,1 | 0,5 | | 7,3 | 6,9 | 0,7 | 0,3 | | 18,0 | 10,5 | 6,7 | 5,6 | 0,8 | 1,3 | 3,0 | 3,2 | 5,9 | 4,3 |
| Qq, mln. m3 | 5,6 | 5,3 | 4,4 | 1,5 | 0,2 | | 1,0 | 1,6 | 0,1 | 0,1 | | 3,8 | 3,1 | 1,9 | 2,5 | 0,7 | 1,1 | 1,8 | 2,3 | 2,4 | 2,0 |
| Play, atm | | | | | | | | | | | | | | | | | | | | | |
| Qsu, min t | 1,0 | 14,1 | 28,8 | 32,6 | 9,2 | | 15,8 | 23,8 | 21,5 | 6,2 | | 0,5 | 0,9 | 1,2 | 1,1 | 0,9 | 1,8 | 1,6 | 0,9 | 2,0 | 1,6 |
| Suvurma, min m3(q278) | | | | | | | | | | | | | | | | | | | | 63,1 | 319,9 |

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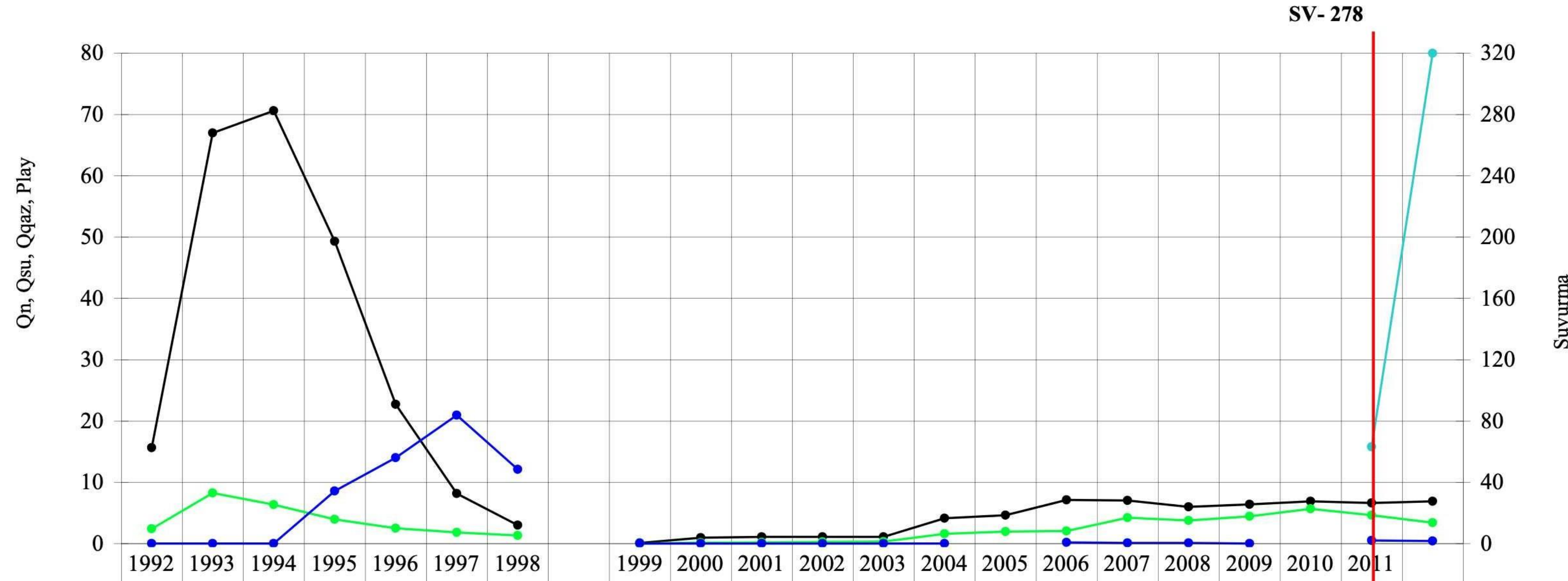
Figure 3.7. Development dynamics of well No 226




| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neft, min t | 15,6 | 67,0 | 70,6 | 49,3 | 22,7 | 8,2 | 3,0 | | 0,1 | 0,9 | 1,1 | 1,1 | 1,1 | 4,1 | 4,6 | 7,1 | 7,0 | 6,0 | 6,4 | 6,9 | 6,6 | 6,9 |
| Qaz, mln m3 | 2,4 | 8,3 | 6,4 | 4,0 | 2,5 | 1,8 | 1,3 | | 0,0 | 0,1 | 0,2 | 0,3 | 0,3 | 1,6 | 2,0 | 2,0 | 4,2 | 3,8 | 4,4 | 5,7 | 4,6 | 3,4 |
| Su, min t | 0,0 | 0,0 | 0,0 | 8,6 | 14,0 | 20,9 | 12,1 | | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | | 0,2 | 0,1 | 0,1 | 0,0 | | 0,5 | 0,4 |
| Play, atm | | | | | | | | | | | | | | | | | | | | | | |
| Suvurma(278) | | | | | | | | | | | | | | | | | | | | | 63,1 | 319,9 |

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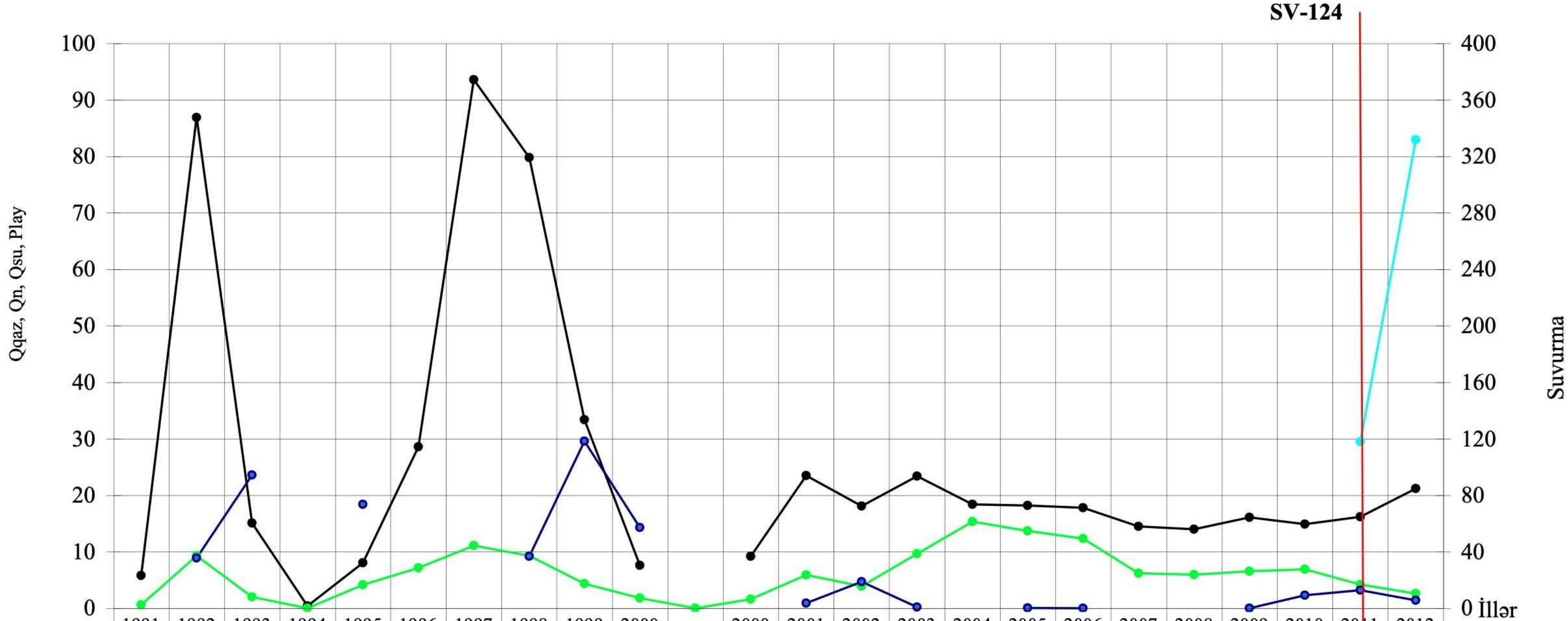
Figure 3.8. Development dynamics of well No 281




| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qn, min t | 5,8 | 86,9 | 15,1 | 0,4 | 8,04 | 28,6 | 93,6 | 79,8 | 33,4 | 7,6 | | 9,2 | 23,5 | 18,1 | 23,4 | 18,4 | 18,2 | 17,8 | 14,5 | 14 | 16,1 | 14,9 | 16,2 | 21,2 |
| Qqaz, min m3 | 0,62 | 9,27 | 2,01 | 0,00 | 4,13 | 7,16 | 11,10 | 9,29 | 4,33 | 1,80 | 0,00 | 1,60 | 5,88 | 3,90 | 9,67 | 15,33 | 13,67 | 12,35 | 6,18 | 5,93 | 6,54 | 6,87 | 4,20 | 2,60 |
| Qsu, min t | | 8,9 | 23,6 | | 18,4 | | | 9,2 | 29,6 | 14,3 | | | 0,9 | 4,7 | 0,2 | | 0,04 | 0,02 | | | 0,02 | 2,3 | 3,2 | 1,4 |
| Play, atm | | | | | | | | | | | | | | | | | | | | | | | | |
| Suvurma,min m3(q124) | | | | | | | | | | | | | | | | | | | | | | | 118 | 331,8 |

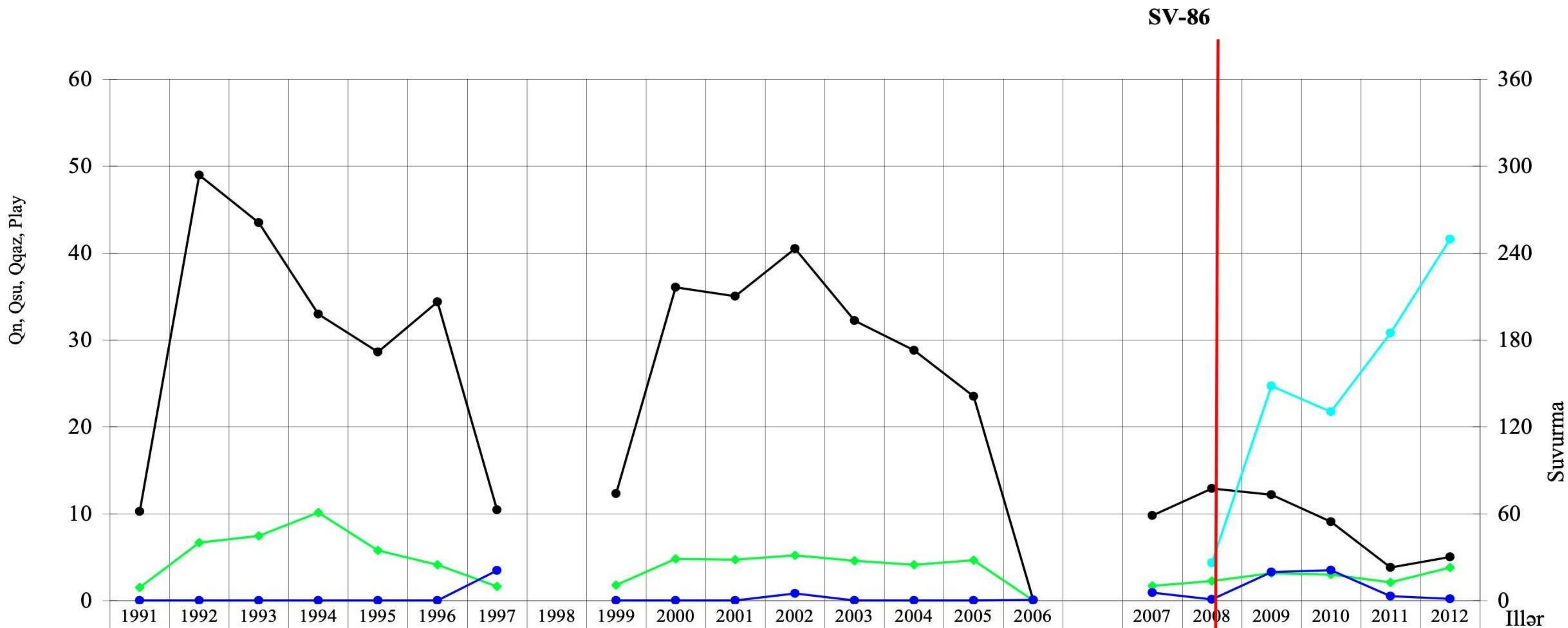
Figure 3.9. Development dynamics of well No 261

This is the length passing between the affected wells and the non-conductivity of the fault (the fault amplitude is more than 100-m) (Figures 3.10 - 3.11).

The lack of influence of water well No. 227 on production wells No. 161, 104, 108, 219, 102, 182 and 223 can be explained by the fact that this well is located at a sufficiently far distance.

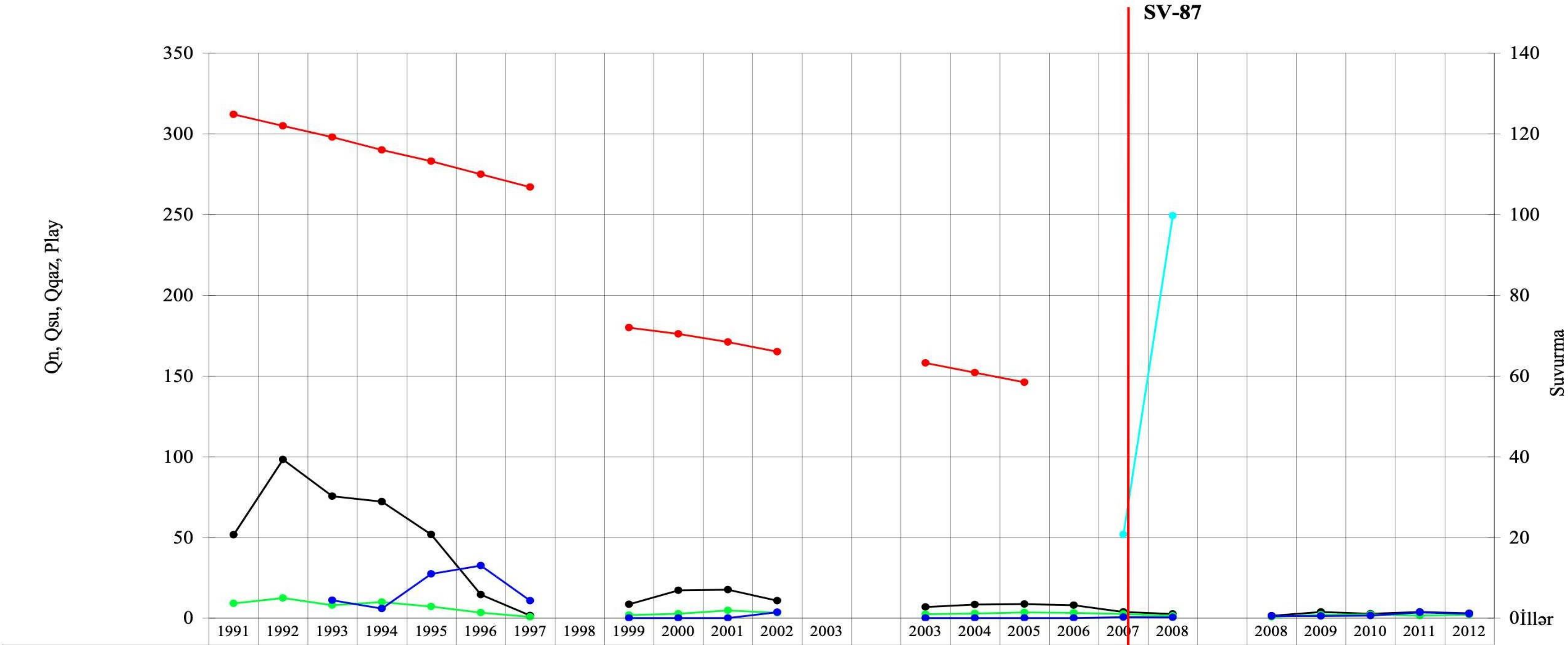
FLD is currently supplied with water through 3 injection wells. 2 of the wells are located in the XV tectonic block of the field, and 1 in the XIII tectonic block. From the beginning of development (as of 01.04.2013), the volume of water pumped into this horizon was 18829.4 thousand m $^3$, and for the first quarter it was 169.3 thousand m $^3$. From the beginning of the impact on the yield from injection on FLD, it was 5190.8 thousand t, and the quarter was 2.5 thousand t. The injected water coefficient is 0.121 from the beginning of the impact, and 0.136 quarterly. The injection process was mainly carried out in the southern area, the amount of water injected into this area (14009.9 thousand m $^3$) is 40.3% of the total injected water (34753.0 thousand m $^3$).

The dynamics of well No. 122 and affected wells No. 117 and 256 located in XIII tectonic block of the southern wing are given (Figures 3.12 - 3.13). As can be seen from the picture, since the injection well No. 122 is located in the same block as the exploitation wells No. 117 and 256, the effect of injected water is evident in the development dynamics. When investigating the impact of injection wells No. 159 and 417, located in the southern wing of the field, on production well No. 117, it was found that the influence of injection wells on the respective wells is not noticeable. This can be explained by the lack of permeability of the longitudinal fracture passing between the affected and affected wells (the fracture amplitude is more than 100-m).



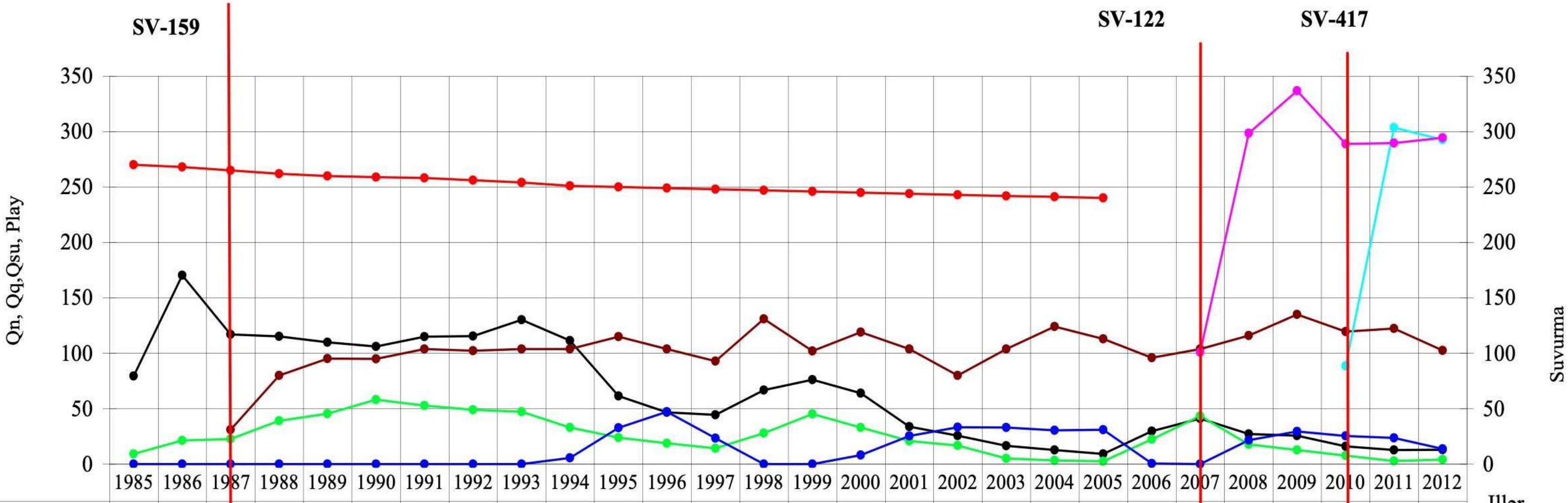

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qn, min t | 10,24 | 48,96 | 43,47 | 32,97 | 28,61 | 34,37 | 10,42 | | 12,28 | 36,03 | 35,02 | 40,48 | 32,22 | 28,79 | 23,49 | 0,02 | | 9,78 | 12,87 | 12,16 | 9,06 | 3,8 | 5 |
| Qq, mln m3 | 1,49 | 6,65 | 7,44 | 10,12 | 5,76 | 4,12 | 1,61 | | 1,77 | 4,78 | 4,7 | 5,19 | 4,59 | 4,12 | 4,64 | 0,007 | | 1,67 | 2,25 | 3,13 | 3,003 | 2,1 | 3,8 |
| Qsu, min t | 0 | 0 | 0 | 0 | 0 | 0 | 3,45 | | 0 | 0 | 0 | 0,814 | 0 | 0 | 0 | 0,064 | | 0,912 | 0,14 | 3,27 | 3,5 | 0,5 | 0,2 |
| Play, atm | | | | | | | | | | | | | | | | | | | | | | | |
| Suvurma, min m3(q86) | | | | | | | | | | | | | | | | | | | 25,9 | 148 | 130,4 | 184,6 | 249,5 |

Figure 3.10. Development dynamics of well No 223



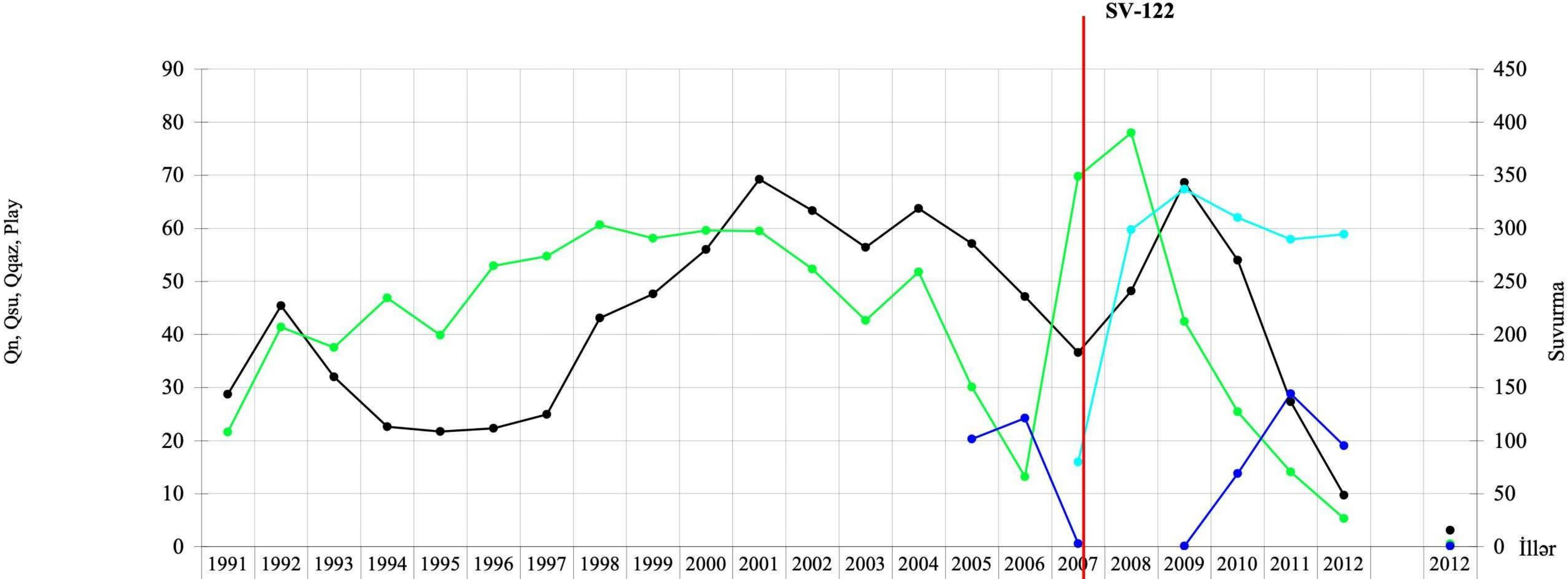

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qn, mln t | 51,6 | 98,2 | 75,5 | 72,1 | 51,8 | 14,5 | 1,6 | | 8,5 | 17,2 | 17,6 | 10,7 | | | 6,9 | 8,4 | 8,6 | 7,9 | 3,7 | 2,53 | | 1,46 | 3,8 | 2,69 | 3,7 | 2,9 |
| Qq, mln m3 | 9 | 12,4 | 8 | 9,9 | 7,1 | 3,3 | 0,7 | | 1,8 | 2,7 | 4,7 | 3,2 | | | 2,4 | 2,8 | 3,5 | 3,2 | 2,5 | 1,42 | | 0,64 | 2,08 | 2,29 | 1,6 | 2,1 |
| Play, atm | 312 | 305 | 298 | 290 | 283 | 275 | 267 | | 180 | 176 | 171 | 165 | | | 158 | 152 | 146 | | | | | | | | | |
| Qsu, mln t | | | 11 | 5,8 | 27,3 | 32,5 | 10,8 | | 0 | 0 | 0 | 3,6 | | | 0 | 0 | 0 | 0 | 0,6 | 0,482 | | 1,22 | 1,303 | 1,53 | 3,5 | 2,7 |
| Suvurma, mln m3(q87) | | | | | | | | | | | | | | | | | | | 20,7 | 99,7 | | | | | | |

Figure 3.11. Development dynamics of well
No 95




| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qn,mln t | 79,5 | 170 | 117 | 115 | 110 | 106 | 115 | 116 | 130 | 112 | 61,3 | 46,6 | 44,3 | 66,7 | 76,2 | 63,9 | 33,7 | 25,6 | 16,4 | 12,6 | 9,2 | 29,6 | 41,1 | 27,1 | 25,7 | 15,9 | 12,8 | 13 |
| Qqaz,mln m3 | 9,1 | 21,3 | 22,5 | 39,1 | 45,4 | 58 | 52,7 | 49,1 | 47,2 | 33,1 | 23,9 | 18,9 | 14,3 | 28 | 45,3 | 32,9 | 20,9 | 16,8 | 5 | 3,2 | 2,6 | 22,4 | 43,4 | 17,7 | 12,7 | 7,7 | 2,9 | 4 |
| Su,mln t | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5,6 | 32,7 | 47,1 | 23,4 | 0 | 0 | 8,2 | 25,5 | 33,2 | 33,1 | 30,5 | 30,9 | 0,4 | 0 | 21,5 | 29,4 | 25,5 | 23,5 | 13,8 |
| Play,atm | 270 | 268 | 265 | 262 | 260 | 259 | 258 | 256 | 254 | 251 | 250 | 249 | 248 | 247 | 246 | 245 | 244 | 243 | 242 | 241 | 240 | | | | | | | |
| Suvurma (q159) | | | 31 | 80 | 95,2 | 94,9 | 104 | 102 | 104 | 104 | 115 | 104 | 93 | 131 | 102 | 119 | 104 | 80 | 104 | 124 | 113 | 96 | 104 | 116 | 135 | 120 | 122 | 103 |
| Suvurma (q417) | | | | | | | | | | | | | | | | | | | | | | | | | | 88,7 | 304 | 293 |
| Suvurma (q122) | | | | | | | | | | | | | | | | | | | | | | | 101 | 299 | 337 | 289 | 290 | 294 |

Figure 3.12. Development dynamics of well No 117




| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neft,min t | 28,7 | 45,4 | 32,0 | 22,6 | 21,7 | 22,3 | 24,9 | 43,1 | 47,6 | 56,0 | 69,2 | 63,3 | 56,4 | 63,7 | 57,1 | 47,1 | 36,6 | 48,2 | 68,6 | 54,0 | 27,3 | 9,7 | | 3,1 |
| Qaz,mln. m3 | 21,6 | 41,4 | 37,5 | 46,9 | 39,9 | 52,9 | 54,8 | 60,7 | 58,1 | 59,6 | 59,5 | 52,3 | 42,6 | 51,7 | 30,1 | 13,2 | 69,8 | 78,0 | 42,4 | 25,4 | 14,1 | 5,3 | | 0,5 |
| Su,min t | | | | | | | | | | | | | | | 20,3 | 24,2 | 0,5 | | 0,1 | 13,8 | 28,8 | 19,0 | | 0,1 |
| Play,atm | | | | | | | | | | | | | | | | | | | | | | | | |
| Suvurma, min m3(122) | | | | | | | | | | | | | | | | | 79,7 | 298,6 | 336,8 | 310,0 | 289,5 | 294,4 | | |

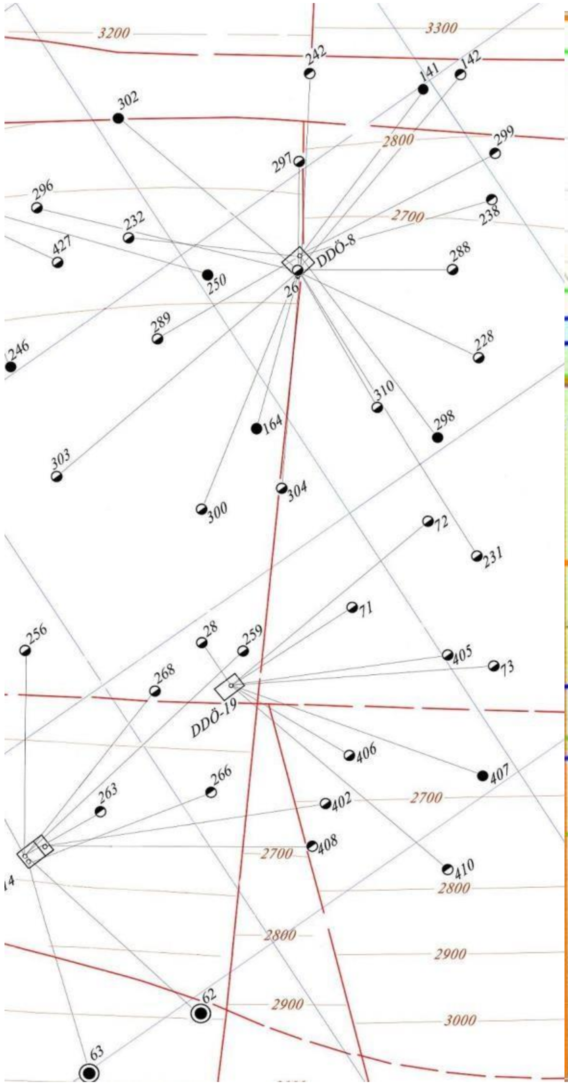
Figure 3.13. Development dynamics of well No 256

### 3.1.4 Water Injection Operations carried out by Bp.

In the north-eastern part of the field, the BP company started the operation from 19.04.2008, and from 29.06.2008, the water injection process. The injection process was carried out through 2 wells, FO3 and GO3, from the north-eastern part of FLD (Figure 3.14). Water Injection on well No. GO3 was carried out in 08.2008 with the volume of water injected daily being 4435.8 $m^3$. 7657866.70 $m^3$ through this well from the beginning of development water is pumped. Water injection for well No. FO3 started in 09.2008. The volume of water injected daily was 174.9 $m^3$. 3974761.19 $m^3$ through this well from the beginning of development water is pumped. Information is provided on injection wells No. FO3 and GO3 drilled in the FLD located in the deep-water part of the Gunashli field (Table 3.2). Changes in formation pressure over the years from the period when BP started operation for the wells located in DSOs No. 8 and 19 and affected by injection wells No. FO3 and GO3 and development dynamics of some production wells affected by injection wells are given (Table 1.9) and (Figure 3.15- 3.20).

| Number of wells | Volume of injected water, $m^3$ | | | | | | Total from the beginning of development, $m^3$ |
|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | |
| F03 | 455783.93 | 1851912,38 | 923143.02 | 100778.69 | 593857.2 | 49285.97 | 3974761,19 |
| G03 | 866383.76 | 2609167.47 | 2253275.85 | 285203.54 | 1299948.08 | 343888 | 7657866.70 |
| total | 1322167.69 | 4461079.85 | 3176418.87 | 385982,23 | 1893805.28 | 393173.97 | 11632627.89 |

Table 1.8 Information about injection wells No. FO3 and GO3



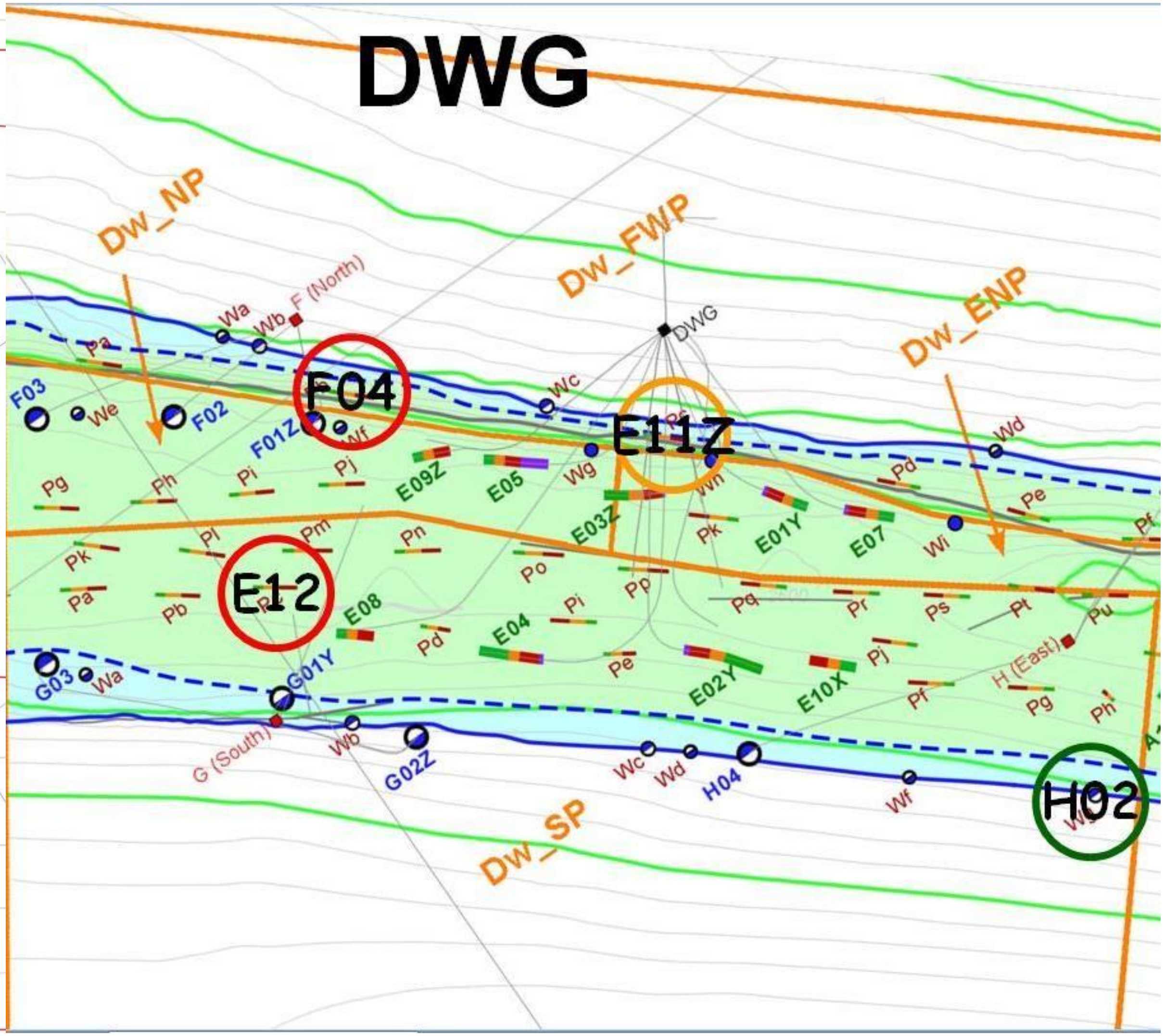



Fig. 3.14 Location scheme of injection wells No. FO3 andGO3

| WHO no | Well no | Horizon | History | Pqd, atm | Manometer release depth, m | | Play, atm |
|---|---|---|---|---|---|---|---|
| | | | | | Down | Up | |
| 8 | 299 | FLD | 06.08.2008 | 178.7 | 2850 | 2750 | 208.2 |
| | | | 22.09.2008 | 180 | 2850 | 2750 | 208 |
| | | | 30.04.2009 | 211.5 | 2800 | 2600 | 224.8 |
| | | | 04.07.2009 | 212.3 | 2800 | 2600 | 226.9 |
| 19 | 71 | FLD | 01.08.2008 | 178.5 | 2650 | 2550 | 209.2 |
| | | | 14.06.2009 | 183.1 | 2650 | 2450 | 206.9 |
| | | | 17.08.2009 | 186 | 2650 | 2450 | 208.8 |
| | | | 02.11.2009 | 188.8 | 2650 | 2450 | 211.2 |
| | 405 | FLD | 10.07.2006 | 197.2 | 2800 | 2600 | 233.2 |
| | | | 18.04.2009 | 209.2 | 2750 | 2550 | 224.9 |
| | | | 12.07.2009 | 212.9 | 2750 | 2550 | 229.9 |
| | 407 | FLD | 07.06.2009 | 236.2 | 2850 | 2650 | 245.2 |
| | | | 15.08.2009 | 243.7 | 2850 | 2650 | 250.9 |
| | 410 | FLD | 27.08.2006 | 232.1 | 2950 | 2800 | 250 |
| | | | 09.06.2009 | 232.2 | 2900 | 2700 | 244.6 |
| | | | 23.08.2009 | 239.6 | 2900 | 2700 | 247.3 |
| | | | 12.11.2009 | 243.56 | 2900 | 2700 | 252.4 |

Table 1.9 Changes in formation pressure over the years for the affected wells

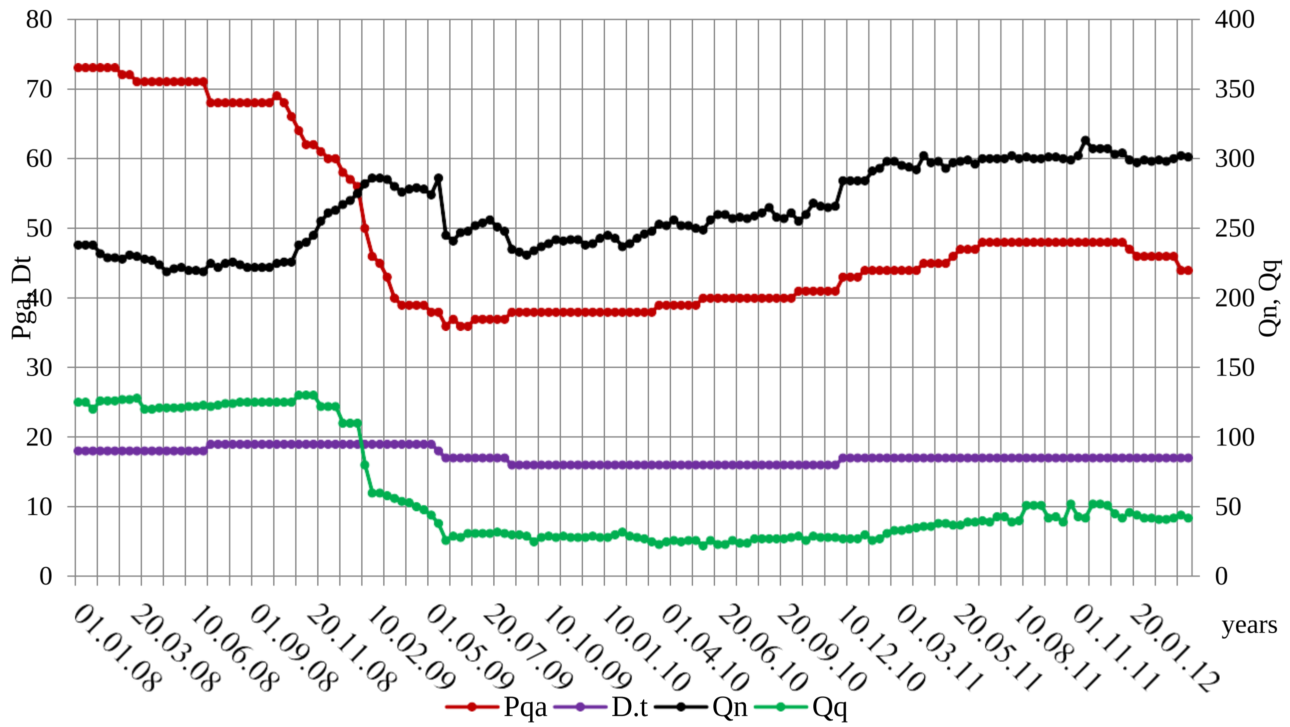



Fig. 3.15 Development dynamics of well No. 228

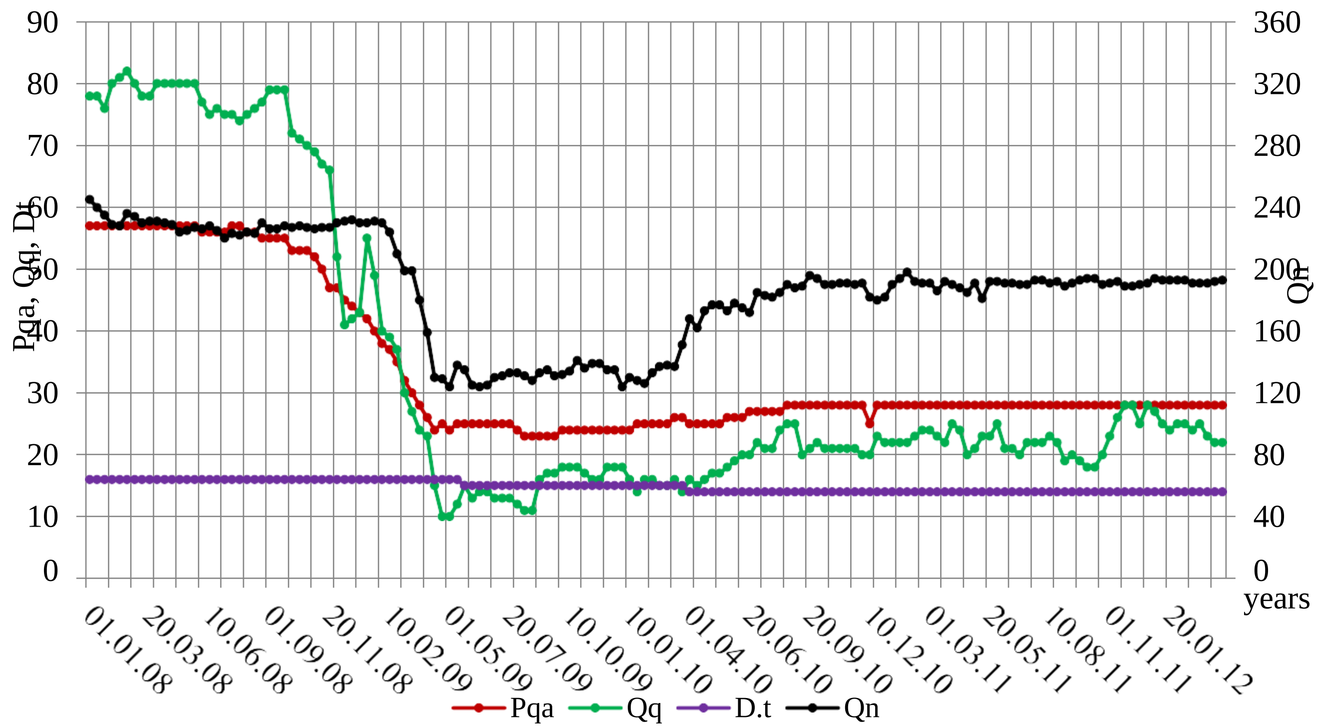



Fig. 3.16 Development dynamics of well No. 26

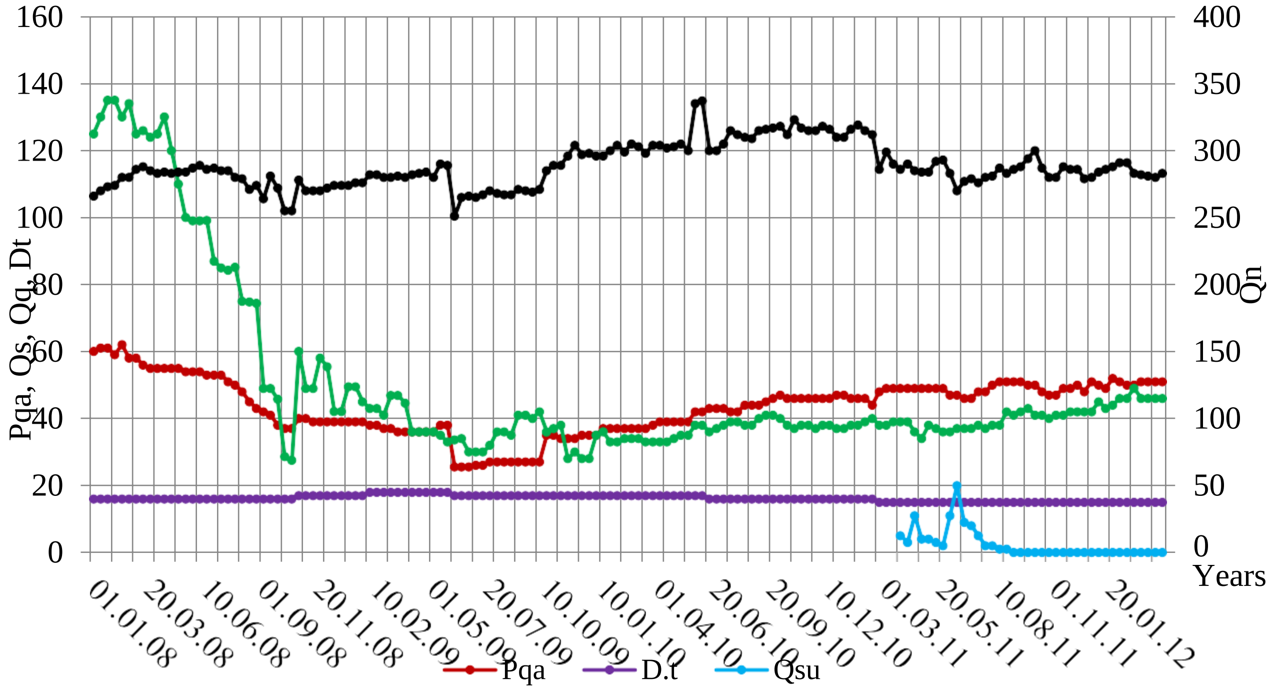



Fig. 3.17 Development dynamics of well No. 259

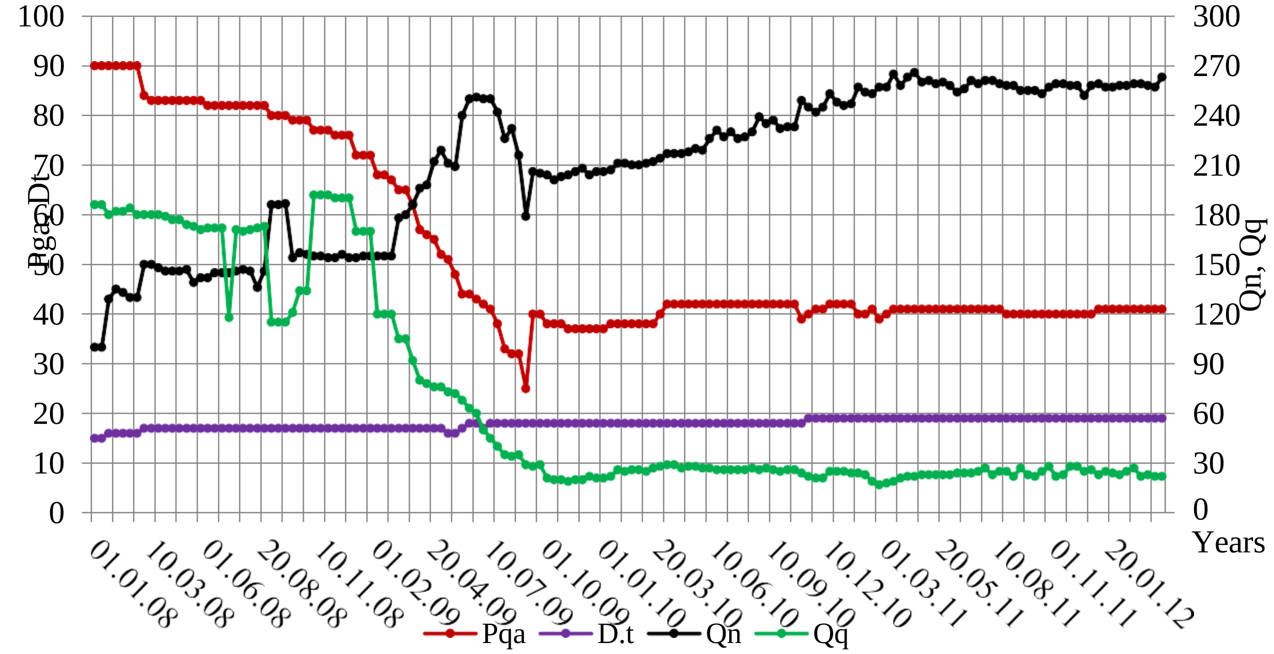



Fig. 3.18 Development dynamics of well No. 300

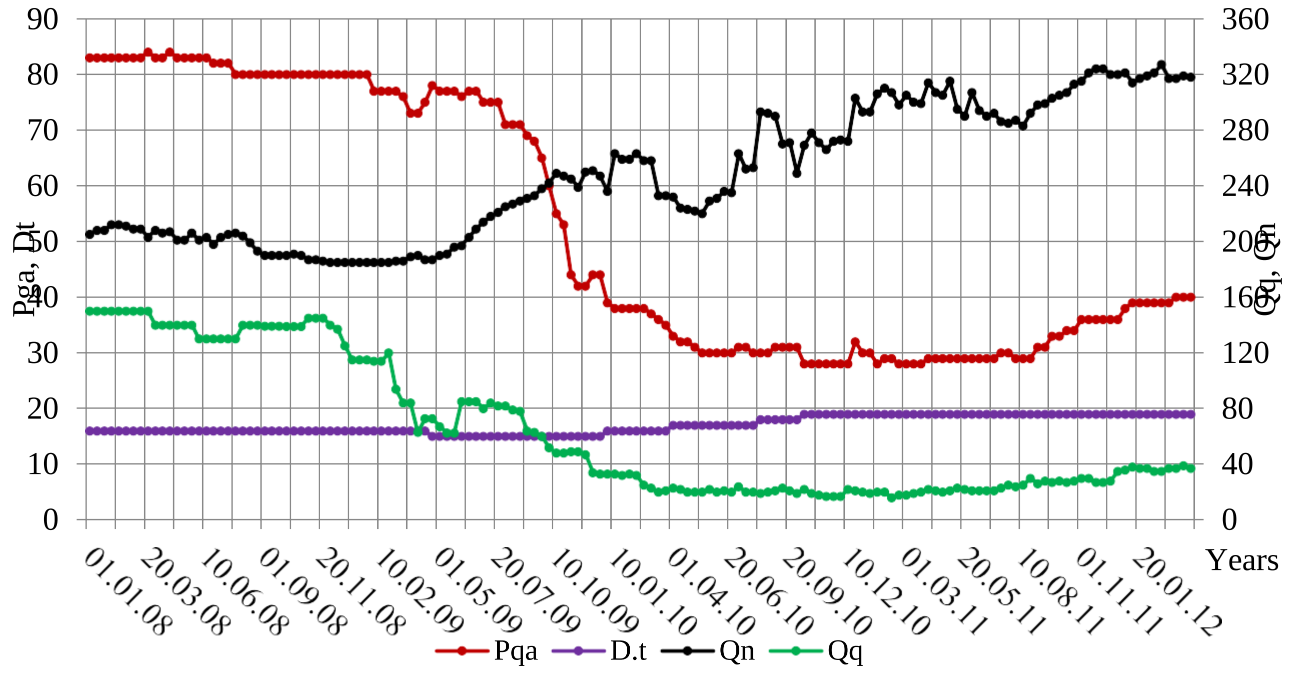



Fig. 3.19 Development dynamics of well No. 289

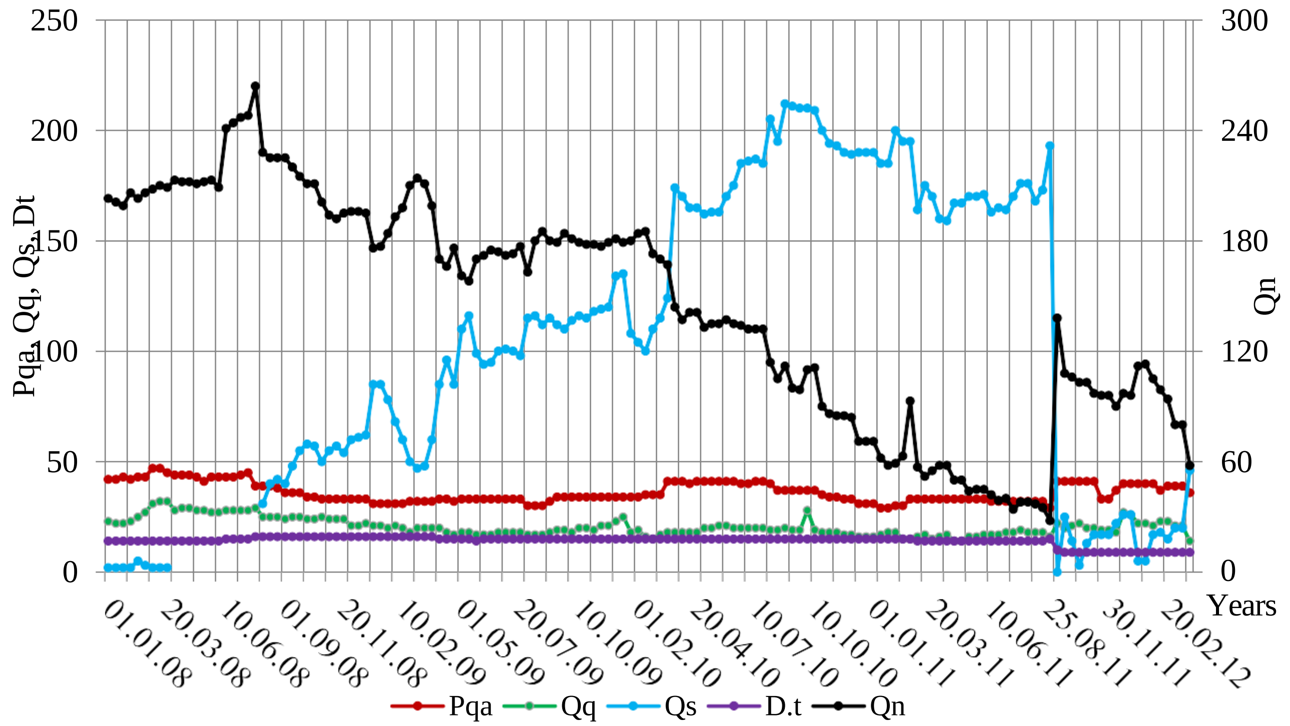



Fig. 3.20 Development dynamics of well No. 402

3.2 Appraisal and evaluation of water injection.

The presence of 18 oil and gas horizons and formations in the section of the Gunashli field was determined based on drilling and CGT data. All oil and gas condensate layers belong to the type of layer and tectonic screened objects, NSK (KSK) have different absolute depths within blocks. A large number of oil-rich layers have been identified in the geological section of the field, and in order to efficiently develop these oil-rich layers, those layers are oil-rich (VII, VIII, IX, X, FLD, QÜG), gas-condensate (IV, V, VI, QalD-3) and have an oil border. consists of horizons with gas condensate (QUQ, QA). The discovery of the Gunashli field was connected with exploration well No. 4 in 1979; of the X horizon of the BLD of the well 230 t/day oil fountain was obtained from the 3455- interval during the test works. 3423 m. Then, in November 1980, 320 t/day of oil was obtained as a result of FLD testing in exploration well No. 6. The development of the Gunashli field started in 1980 and is still ongoing. Despite the fact that the field has been in development for 32 years, it has been determined that there are still large quantities of extractable residual oil reserves in individual operational facilities. At present, the residual oil reserves are concentrated in the lower and upper departments of the MG sediments on the objects. In order to analyze the development conditions during the operation period for 9 operational objects, multi-volume geological-physical and mining operation data were collected, investigated, and systematized. These data are systematized in the form of tables collected separately for each operational objects and given both for objects and for the field as a whole 156874.8 thousand tons of oil, 171564.5 thousand tons of liquid, 45677.3 minim $^{3}$ of dissolved gas, 33717.5 minim $^{3}$ of free gas, 3206.1 thousand t condensate is removed. During the first quarter of 2013, oil production was 1153.4 thousand tons, liquid production was 1378.9 thousand tons, and dissolved gas production was $^{268.5}$ million cubic meters. During the first quarter of 2013, the free gas production of the field was 1193 minim $^{3}$, and the condensate production was 64.7 thousand tons. The current gas factor is 230 m $^{3}$ /t, the dilution of the product is 17%, the rate of absorption was 74.1%. The average daily production of one well is 74 t of oil and 88.6 t of liquid. The indicators of the development of the deposit by horizons are given (Table 2.0).

The dynamics of the main performance indicators for the field are given for oil (Table 2.0 and Figure 4.0), and for gas and condensate. Below is an analysis of the current state of development of the main operational objects of the field (IX, X, FLD). The IX horizon of the Balakhani formation has been in operation since 1992. This horizon is mainly used due to wells returned from lower horizons, that is, free wells are not drilled into this horizon.

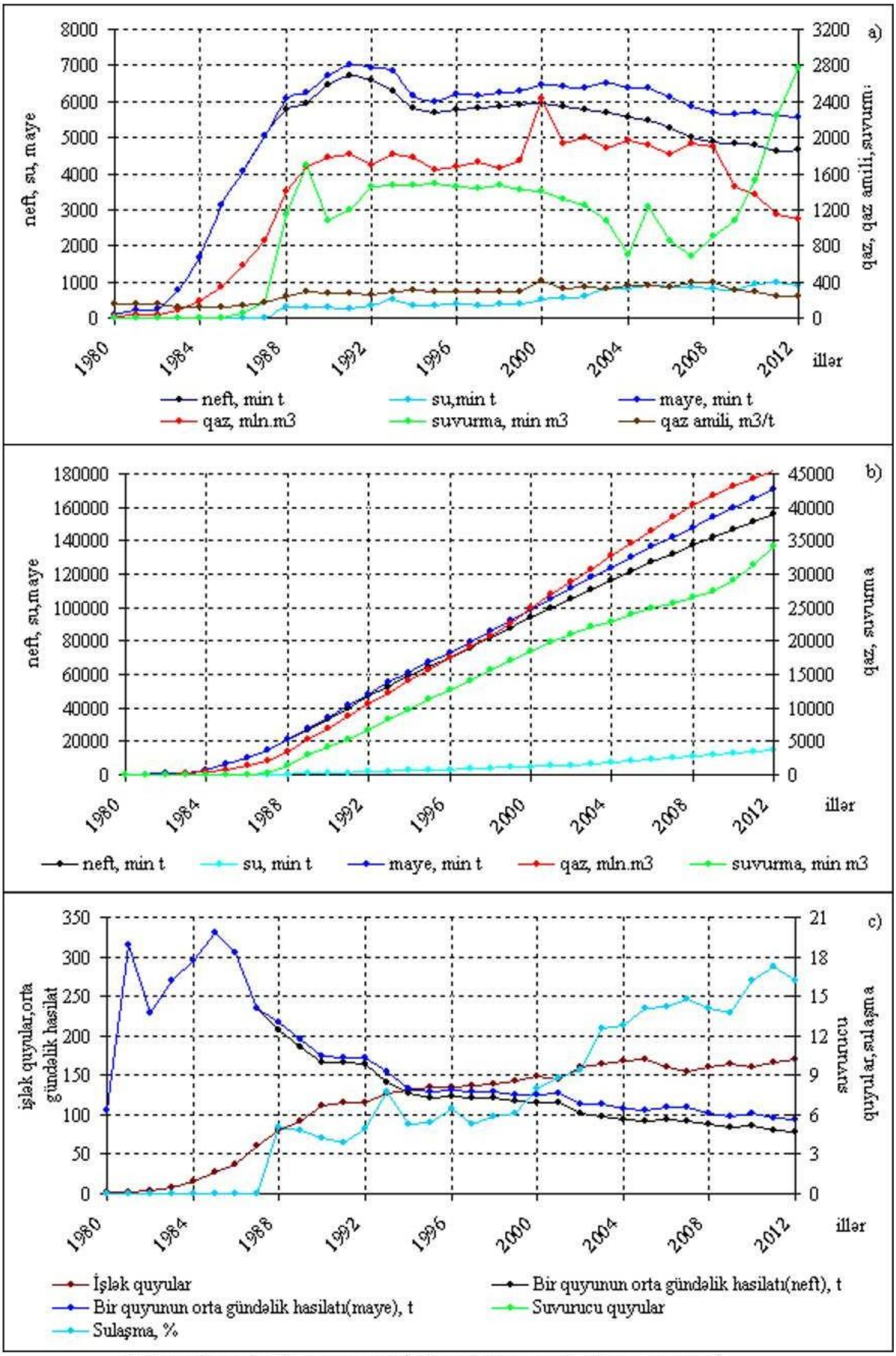
From the beginning of development to 01.04.2013, 5569.1 thousand tons of oil, 6498.5 thousand tons of liquids, 2437.3 million cubic meters $^{of}$ dissolved gas, 266.2 million cubic meters $^{of}$ free gas, 58.4 thousand tons of condensate was produced. During the first quarter of 2013, 57.7 thousand tons of oil, 72.9 thousand tons of liquids, 41 minim $^{3}$ of dissolved gas removed. The current gas factor was 674 m $^{3}$ /t, the dilution of the product was 21%, and the rate of utilization of ICE was 63.2%. Average daily oil production of one well is 16.0 t, and liquid production is 21.3 t. The dynamics of development indicators, development, aggregate production and drainage maps for the IX horizon are given. The development of the X horizon began in 1980. As in FLD, the deposit development process started mainly from the south-west wing parts of the fold.

33960.3 thousand tons of oil, 35890.7 thousand tons of liquids, 12243.2 minim $^{3}$ of dissolved gas, 28.2 thousand tons of condensate and 118.8 million m$^{3\ of}$ free gas were produced. During the first quarter of 2013, oil production was 199.6 thousand tons, liquid production was 230.3 thousand tons, and dissolved gas production was 61.3 million tons. m$^{3}$. Average daily oil production per well is 47.2 t, and liquid production is 54.4 t. The current gas factor was 305 m3/t, the dilution of the product was 13.3%, the rate of absorption was 72%.

Table 1.1

| Horizon | Primary oil reserves, thousand t | | Oil production, thousand tons | | Residual oil reserves, thousand tons | | Oil yield coefficient, unit part | | Liquid extraction, thousand tons | | injection, thousand $m^3$ | | Gas production, mln.$m^3$ | | Gas factor, $m^3$/t | Working well fund | | Average daily production of a well, t | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | balance | removable | During the first quarter | from the beginning of development | balance | removable | current | the end | During the first quarter | from the beginning of development | During the first quarter | from the beginning of development | During the first quarter | from the beginning of development | | extraction | sprinkler | oil | fluid |
| VII | 1361 | 450 | | 1,2 | 1359.8 | 448.8 | 0.001 | 0.331 | 0 | 15.2 | | | | 1.8 | | | | | |
| VIII | 4556 | 1503 | 26.2 | 781.4 | 3774.6 | 721.6 | 0.172 | 0.330 | 42.9 | 1117.6 | | | 9.7 | 313.4 | 370 | 6 | | 48.5 | 79.4 |
| IX | 21462 | 8799 | 57.7 | 5569.1 | 15892.9 | 3229.9 | 0.259 | 0.410 | 72.9 | 6498.5 | 259.9 | 2648.9 | 41 | 2437.3 | 674 | 40 | 7 | 16.0 | 20.3 |
| X | 89040 | 47104 | 199.6 | 33960.3 | 55079.7 | 13143.7 | 0.381 | 0.529 | 230.3 | 35890.7 | 261.1 | 13274.7 | 61.3 | 12243.2 | 305 | 47 | 5 | 47.2 | 54.4 |
| FLD | 236316 | 141788 | 834.4 | 110141,1 | 126174.9 | 31646.9 | 0.466 | 0.600 | 969.7 | 119230.9 | 169.3 | 18829.4 | 143.4 | 27559.3 | 170 | 74 | 3 | 125.3 | 145.6 |
| KÜG | 478 | 144 | 0.8 | 143.4 | 334.6 | 0.6 | 0.300 | 0.301 | 1 | 180.6 | | | 0.5 | 65.6 | 714 | 1 | | 8,9 | 11.1 |
| QQ | 17858 | 8572 | 4.3 | 4915.9 | 12942.1 | 3656.1 | 0.275 | 0.480 | 22.8 | 6861.8 | | | 1.6 | 2712.8 | 380 | 2 | | 23.9 | 126.7 |
| QA | 6576 | 3097 | 30.4 | 1361.2 | 5214.8 | 1735.8 | 0.207 | 0.471 | 39.3 | 1767.8 | | | 10.9 | 343.5 | 379 | 3 | | 112.6 | 145.6 |
| QLD | | | 0 | 1.3 | | | | | | 1.4 | | | 0 | 0.2 | | | | | |
| Total per bed | 377647 | 211457 | 1153.4 | 156874.9 | 220772,1 | 54582.1 | 0.415 | 0.560 | 1378.9 | 171564.5 | 690.3 | 34753 | 268.4 | 45677.3 | 233 | 173 | 15 | 74.1 | 88.6 |

Table 2.0 Development indicators on horizons




a) Annual production curves; b) Cumulative production curves; c) Information on wells

Source: SOCAR,

Figure 4.0 Dynamics of technological indicators of field development

## 3.2 Appraisal and evaluation of water injection in FLD Zone

The effect of 3 injection wells in the working fund on FLD was investigated. As a result, wells No. 417, 129 were removed from the injection fund and, taking into account that the upper objects of well No. 122 had positive logging indicators, they were returned to the X horizon and operated as production wells, and 5 production wells (67, 17, 111, 121, 274) were transferred to the injection fund. is offered. The wells selected to inject water into FLD, the volume of water to be pumped daily, operational indicators and measures to increase the efficiency of injection are given (Tables 4.9-4.10).

wells provided for by FLD to reach the operational well and the area of flooding have been calculated (Table 4.1).

| | Well no | WHO | Filter, m | | Current production | | | Cumulative production from the beginning of development | | | Daily life _ _ _ will be shot of water all , _ _ $m^3/g$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | current | Intended to shoot water | oil, t/g | water, $m^3/g$ | gas, $m^3/g$ | oil, thousand tons | water, thousand $m^3$ | gas, mln.$m^3$ | |
| 1 | 67 | 4 | 3446-3439 | 3535-3492 3446-3439 | 20 | 65 | 7497 | 149 | 397.4 | 72.1 | 1200 |
| 2 | 17 | 2 | 3047-3036 | 3149-3104 3070-3080 3047-3036 | GAITS is waiting | | | 1332.9 | 8.2 | 201.9 | 1200 |
| 3 | 111 | 3 | 2853-2847 | 2955-2942 2936-2905 2853-2847 | 11 | 13 | 7601 | 1355.5 | 103.3 | 262.5 | 700 |
| 4 | 121 | 3 | 2900-2897 2894-2888 2885-2882 | 2900-2882 2908-2914 2965-2975 2992-3014 | GAYTS works | | | 752.5 | 246.1 | 124.7 | 1200 |
| 5 | 274 | 15 | 3050-3027 | 3128-3120 3097-3080 | 20 | 13 | 6500 | 566 | 38.8 | 138.8 | 350 |

Table 4.1 Selected to inject water into the Fasila formation.

| Intended irrigation wells | WHO | Affected production wells | volume of water to be pumped daily, $m^3$ | Production | | | | | | | | | The volume of water pumped from the beginning of development, thousand $m^3$ | The volume of water injected at the moment, $m^3$/d | Compensation factor (according to the working irrigation fund) | Compensation factor (for proposed new irrigation wells) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | daily | | | monthly | | | From the beginning of development | | | | | | |
| | | | | oil, t | water, $m^3$ | volume of liquid in bed conditions, $m^3$ | oil, t | water, $m^3$ | volume of liquid in bed conditions, thousand $m^3$ | oil, thousand tons | water, thousand $m^3$ | volume of liquid in bed conditions, thousand $m^3$ | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | 4 | 68 | | 111 | 97 | 268.5 | 3441 | 3007 | 8324.5 | 947.6 | 210.9 | 1675.3 | | | | |
| 67 | 4 | 134 | 1200 | 100 | 97 | 251.5 | 3100 | 3007 | 7797.6 | 1769.3 | 57 | 2791.2 | | | | |
| | 11 | 209 | | 62 | 41 | 136.8 | 1922 | 1271 | 4241.2 | 52.1 | 22.1 | 102.6 | | | | |
| Total | | 3 | | 273 | 235 | 656.9 | 8463 | 7285 | 20363.3 | 2769 | 290 | 4569.1 | | | | |
| | 11 | 178 | | 46 | | 71.1 | 1426 | 0 | 2203.7 | 523.2 | 2.9 | 811.4 | | | | |
| 17 | 10 | 187 | | 19 | | 29.4 | 589 | 0 | 910.2 | 130.8 | 21.6 | 223.7 | | | | |
| | 10 | 181 | 1200 | 45 | 1 | 70.5 | 1395 | 31 | 2186.8 | 1092.1 | 16.7 | 1704.4 | | | | |
| | 5 | 213 | | 20 | | 30.9 | 620 | 0 | 958.1 | 117.3 | 39.1 | 220.4 | | | | |
| Total | | 4 | | 130 | 1 | 201.9 | 4030 | 31 | 6258.8 | 1863.4 | 80.3 | 2959.9 | 18829.4 | 1879 | 0.120 | |
| | 15 | 93 | | 119 | 2 | 185.9 | 3689 | 62 | 5762.8 | 669.8 | 11.8 | 1046.9 | | | | |
| | 15 | 285 | | 95 | | 146.8 | 2945 | 0 | 4551.1 | 485.2 | 32.5 | 782.3 | | | | |
| | 15 | 279 | | 171 | 1 | 265.3 | 5301 | 31 | 8222.9 | 1073.6 | 3.5 | 1662.6 | | | | |
| 274 | 15 | 89 | 350 | 103 | 65 | 224.2 | 3193 | 2015 | 6949.3 | 493.6 | 85.4 | 848.2 | | | | |
| | 15 | 273 | | 38 | 43 | 101.7 | 1178 | 1333 | 3153.4 | 312.6 | 74.4 | 557.5 | | | | |
| | 15 | 271 | | 19 | 78 | 107.4 | 589 | 2418 | 3328.2 | 465.1 | 44.7 | 763.4 | | | | |
| | 5 | 216 | | 27 | 61 | 102.7 | 837 | 1891 | 3184.5 | 1293.9 | 146.5 | 2146.0 | | | | |
| | 5 | 85 | | 41 | 74 | 137.4 | 1271 | 2294 | 4258.1 | 125.3 | 113.4 | 307.0 | | | | |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | 8 | | 613 | 324 | 1271.3 | 19003 | 10044 | 39410.3 | 4919.1 | 512.2 | 8113.9 | | | | |
| | 3 | 117 | | 24 | 43 | 80.1 | 744 | 1333 | 2482.7 | 1793.3 | 386.6 | 3157.9 | | | | |
| 111 | 10 | 167 | 700 | 27 | 12 | 53.7 | 837 | 372 | 1665.5 | 459 | 7 | 716.3 | | | | |
| | 10 | 61 | | 42 | 9 | 73.9 | 1302 | 279 | 2291.0 | 15.8 | 2.1 | 26.5 | | | | |
| Total | | 3 | | 93 | 64 | 207.7 | 2883 | 1984 | 6439.2 | 2268.1 | 395.7 | 3900.7 | | | | |
| | 14 | 263 | | 32 | 47 | 96.5 | 992 | 1457 | 2990.0 | 1807.3 | 214 | 3006.9 | | | | |
| 121 | 14 | 301 | 1200 | 158 | 1 | 245.2 | 4898 | 31 | 7600.1 | 50.6 | 0.1 | 78.3 | | | | |
| | 14 | 305 | | 70 | 65 | 173.2 | 2170 | 2015 | 5368.4 | 70.7 | 16.6 | 125.9 | | | | |
| Total | | 3 | | 260 | 113 | 514.8 | 8060 | 3503 | 15958.5 | 1928.6 | 230.7 | 3211.1 | | | | |
| | 13 | 427 | | 208 | | 321.4 | 6448 | 0 | 9964.4 | 485.5 | 0.5 | 750.8 | | | | |
| | | 250 | | 146 | | 225.6 | 4526 | 0 | 6994.2 | 244.5 | | 377.8 | | | | |
| | | 141 | | 89 | 132 | 269.5 | 2759 | 4092 | 8355.6 | 915.4 | 69.5 | 1484.1 | | | | |
| | | 142 | | 71 | 2 | 111.7 | 2201 | 62 | 3463.3 | 603.6 | 12 | 944.8 | | | | |
| | | 297 | | 104 | 47 | 207.7 | 3224 | 1457 | 6439.2 | 1080.3 | 107.1 | 1776.5 | | | | |
| | | 288 | | 289 | 30 | 476.6 | 8959 | 930 | 14774.8 | 1798.6 | 4.8 | 2784.3 | | | | |
| | | 26 | | 184 | | 284.3 | 5704 | 0 | 8814.7 | 1357.1 | 0.2 | 2097.4 | | | | |
| | | 296 | | 211 | | 326.1 | 6541 | 0 | 10108,1 | 885.4 | 23.2 | 1391.5 | | | | |
| | | 232 | | 161 | | 248.8 | 4991 | 0 | 7712.8 | 445.8 | 0.1 | 689.0 | | | | |
| F03 | 8 | 289 | 2969 | 336 | | 519.2 | 10416 | 0 | 16096.4 | 1804.9 | | 2789.2 | | | | |
| | | 164 | | 260 | | 401.8 | 8060 | 0 | 12455.5 | 255 | | 394.1 | | | | |
| | | 300 | | 254 | | 392.5 | 7874 | 0 | 12168.1 | 426.9 | | 659.7 | | | | |
| | | 304 | | 261 | | 403.3 | 8091 | 0 | 12503,4 | 1812.9 | 0.6 | 2802.2 | | | | |
| | | 310 | | 277 | | 428.1 | 8587 | 0 | 13269.9 | 870.5 | 0.4 | 1345.6 | | | | |
| | | 228 | | 279 | | 431.2 | 8649 | 0 | 13365.7 | 591 | 0.2 | 913.5 | | | | |
| | | 298 | | 375 | | 579.5 | 11625 | 0 | 17964.7 | 1125.7 | 0.2 | 1739.8 | | | | |
| | 19 | 72 | | 242 | | 374.0 | 7502 | 0 | 11593.2 | 599.4 | 0.2 | 926.5 | | | | |
| Total on F03 | | 17 | | 3747 | 211 | 6001.4 | 116157 | 6541 | 186044,1 | 15302.5 | 219 | 23866.7 | | | | |
| | 8 | 231 | | 278 | | 429.6 | 8618 | 0 | 13317.8 | 1441.7 | | 2227.9 | | | | |

Table 4.2. Operational indicators of the Gunashli field FLD and measures to increase the efficiency of injection

| Irrigation wells | Volume of water injected daily (Qs), $m^3/g$ | Affected production wells | Production of production wells ( on semi -liquid), $m^3/g$ | Layer thickness (h), m | | | Porosity, ( m ) | Effective porosity, ( $m_1$ ) | The distance between irrigation and service wells ( 2L ), m | Qs/Qis | ln (Qs/Qs) | $(2L)^2$ | Qs-Qis | The time it takes for the injected water to reach the operational well | | Irrigation area , $m^2$ | Watering radius, m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sprinkler | exploitation | Average price, ( h ) | | | | | | | | day | year | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 67 | 1200 | 68 | 208 | 50 | 78 | 64 | 0.26 | 0.13 | 583.5 | 5.8 | 1.75 | 340472,3 | 992 | 1594 | 4.4 | 229874 | 271 |
| | 1200 | 134 | 197 | 50 | 80 | 65 | 0.26 | 0.13 | 799.7 | 6.1 | 1.81 | 639520,1 | 1003 | 3100 | 8.5 | 440284 | 374 |
| | 1200 | 209 | 103 | 50 | 25 | 38 | 0.26 | 0.13 | 1258.4 | 11.7 | 2.46 | 1583570.6 | 1097 | 5576 | 15.3 | 1354551 | 657 |
| 17 | 1200 | 178 | 46 | 66 | 12 | 39 | 0.26 | 0.13 | 994.4 | 26.1 | 3.26 | 988831.4 | 1154 | 4512 | 12.4 | 1068014 | 583 |
| | 1200 | 187 | 19 | 66 | 19 | 42.5 | 0.26 | 0.13 | 686 | 63.2 | 4.15 | 470596.0 | 1181 | 2907 | 8.0 | 631308 | 448 |
| | 1200 | 181 | 46 | 66 | 14 | 40 | 0.26 | 0.13 | 755.5 | 26.1 | 3.26 | 570780.3 | 1154 | 2671 | 7.3 | 616486 | 443 |
| | 1200 | 213 | 20 | 66 | 6 | 36 | 0.26 | 0.13 | 904.9 | 60.0 | 4.09 | 818844.0 | 1180 | 4235 | 11.6 | 1085813 | 588 |
| 274 | 350 | 93 | 121 | 48 | 61 | 54.5 | 0.26 | 0.13 | 207.4 | 2.9 | 1.06 | 43014.8 | 229 | 450 | 1,2 | 22238 | 84 |
| | 350 | 285 | 95 | 48 | 35 | 41.5 | 0.26 | 0.13 | 554.8 | 3.7 | 1.30 | 307803.0 | 255 | 2705 | 7.4 | 175456 | 236 |
| | 350 | 279 | 172 | 48 | 35 | 41.5 | 0.26 | 0.13 | 371.9 | 2.0 | 0.71 | 138309.6 | 178 | 948 | 2.6 | 61531 | 140 |
| | 350 | 89 | 168 | 48 | 37 | 42.5 | 0.26 | 0.13 | 138.6 | 2.1 | 0.73 | 19210.0 | 182 | 136 | 0.6 | 8635 | 52 |
| | 350 | 273 | 81 | 48 | 39 | 49.3 | 0.26 | 0.13 | 238.7 | 4.3 | 1.46 | 56977.7 | 269 | 633 | 1.7 | 34552 | 105 |
| | 350 | 216 | 88 | 48 | 48 | 48 | 0.26 | 0.13 | 409.4 | 4.0 | 1.38 | 167608.4 | 262 | 1755 | 4.8 | 98446 | 177 |
| | 350 | 271 | 97 | 48 | 35 | 41.5 | 0.26 | 0.13 | 479.6 | 3.6 | 1.28 | 230016,2 | 253 | 2004 | 5.5 | 130040 | 204 |
| | 350 | 85 | 115 | 48 | 62 | 55 | 0.26 | 0.13 | 764.8 | 3.0 | 1.11 | 584919.0 | 235 | 6308 | 17.3 | 308789 | 314 |
| | 700 | 117 | 67 | 50 | 8 | 29 | 0.26 | 0.13 | 538.5 | 10.4 | 2.35 | 289982,3 | 633 | 1291 | 3.5 | 239627 | 276 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 111 | 700 | 167 | 39 | 50 | 15 | 32.5 | 0.26 | 0.13 | 423.2 | 17.9 | 2.89 | 179098,2 | 661 | 1053 | 2.9 | 174415 | 236 |
| | 700 | 61 | 51 | 50 | 10 | 30 | 0.26 | 0.13 | 672 | 13.7 | 2.62 | 451584.0 | 649 | 2264 | 6.2 | 406294 | 360 |
| 121 | 1200 | 263 | 79 | 48 | 6 | 27 | 0.26 | 0.13 | 717.9 | 15.2 | 2.72 | 515380.4 | 1121 | 1398 | 3.8 | 478017 | 390 |
| | 1200 | 301 | 159 | 48 | 26 | 37 | 0.26 | 0.13 | 893.4 | 7.5 | 2.02 | 798163.6 | 1041 | 2374 | 6.5 | 592238 | 434 |
| | 1200 | 305 | 135 | 48 | 30 | 39 | 0.26 | 0.13 | 1056.1 | 8,9 | 2.18 | 1115347,2 | 1065 | 3694 | 10.1 | 874428 | 528 |

The time for the injected water to reach the operational well_ $t_0=(2L)^2 * m_1 * h * \ln(Qs/Qis)/3.14*(Qs-Qis)$

Effective porosity _ $m_1 = m * \varphi$

Wetting area_ $S= Qs*t_0/h*m$

Wetting radius_ $R=(S/3.14)^{0.5}$



Table 4.3 Dynamics of oil production for wells covered by well No.1, 67, 17, 274, 111, 121

Since the volume of water injected into the formation does not compensate for the volume of fluid withdrawn decrease in formation pressure, working of the central zone mainly in the dissolved gas mode, causes an increase in the gas factor and a decrease in production. In the current report, taking these into account, it is taken into account that the volume of injected water compensates the volume of extracted fluid in the formation's conditions to the maximum extent.

It should be noted that the areas covered by residual oil reserves on the FLD and FLD facilities roughly coincide in the plan. Considering this, it can be considered effective to carry out the injection process on the full thickness of FLD. The reason for this is that current layer pressures in FLD and FLD facilities are relatively close. On the other hand, distribution of water pumped on FLD can be considered according to the volume of current production of FLD (figure 4.7).

In order to regulate the regular movement of the oil-water contour, it is necessary to control the production of the wells located in the direction of the active movement of the contour waters, and the placement of wells injecting water into the formation along a circular line that can ensure the creation of a front. For this, it is recommended to apply the method of adjusting the direction of percolation of the water injected into the layer. The injection wells provided for in the initial version are shown on the water injection maps constructed along the horizons of the field (Figures 4.8-4.10).

Current conditions of operational injection wells in the field and their importance in injection were investigated. In order to increase the receptivity of the injection wells, the positive effect of the treatment of seawater at the required level and the preparation of chemical reagents (SFM, alkaline polymer and acids) in a mixture of 30-60% to the final oil yield of the formations should be taken into account.

In addition to the improvement of the injection system in order to improve the development of the Gunashli field and achieve the final oil recovery rate stipulated in the project documents, other geological- technical and technological measures (returning to the upper horizons, switching to the gas lift operation method, cementing works against waterlogging, etc.) should be attributed.

As can be seen from the table, the oil obtained without injection was 1089.09 thousand t, and the oil production obtained with injection was 1268.99 thousand t. Additional oil obtained due to injection was 179.89 thousand tons, which is 16.5% of oil production obtained without injection.

The operational wells No. 178, 187, 181, and 213 are affected by well No. 17, which is proposed as a sprinkler. The forecast of oil production from production wells covered by this well during the years 2013- 2022 is given in two variants: without the injection process and with the injection process (Table 4.32 and Figure 4.3).

As can be seen from the table, the oil obtained without injection was 320.63 thousand t, and the oil production obtained with injection was 370.69 thousand t. Additional oil obtained due to injection was 50.05 thousand tons, which is 15.6% of oil production obtained without injection.

61, 117 and 167 production wells affected by well No. 111, which is proposed as a sprinkler. During the years 2013 - 2022, the oil production from the production wells covered by this well: without the water injection process.

Table 4.31

Water injection well No. 67 under
FLD forecast indicators.

| Years | Producing wells covered by the planned water injection well No. 67 - No. 68, 134,209 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without injection | with water injection | the difference | at the expense of water injection, % |
| 2012 | 116.90 | | | |
| 2013 | 115.39 | 115.39 | 0.00 | 0.0 |
| 2014 | 113.90 | 116,18 | 2.28 | 2.0 |
| 2015 | 112.43 | 124.80 | 12.37 | 11.0 |
| 2016 | 110.98 | 128.73 | 17.76 | 16.0 |
| 2017 | 109.54 | 132.55 | 23.00 | 21.0 |
| 2018 | 108,13 | 134.08 | 25.95 | 24.0 |
| 2019 | 106.73 | 134.48 | 27.75 | 26.0 |
| 2020 | 105.35 | 131.69 | 26,34 | 25.0 |
| 2021 | 103.99 | 127.91 | 23.92 | 23.0 |
| 2022 | 102.65 | 123.18 | 20.53 | 20.0 |
| Total | 1089.09 | 1268.99 | 179.89 | 16.5 |

Water injection for well No. 67 dating from the year 2012 through 2022 covers extensively the oil production for these years when water injection was applied and without it being applied and the differences. From the table it can be seen that without injection the year 2012 saw the highest with 0% expense in production and 2018 saw an increase and had the highest number when water injection was carried out.

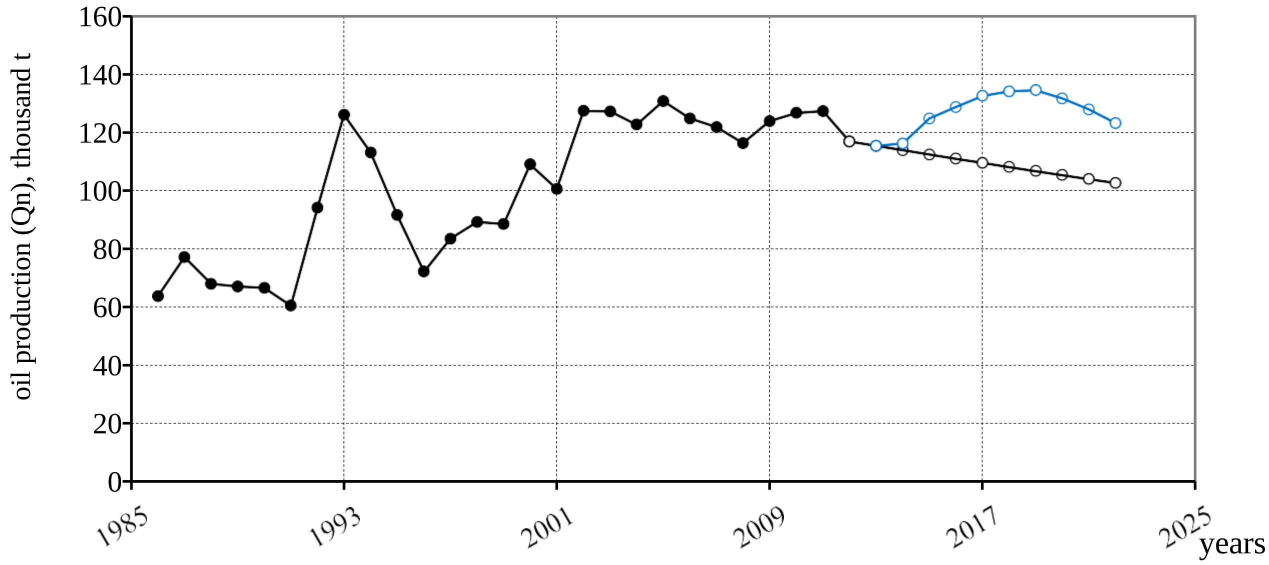



Fig. 4.1 FLD. Oil on the wells covered by well No. 67 dynamics of production

Table 4.32

Water injection well No. 17 envisaged under FLD forecast indicators

| Years | Producing wells covered by the planned water injection well No. 17 - No. 178, 187, 181, 213 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without injection | with water injection | the difference | at the expense of water injection, % |
| 2012 | 39.50 | 39.50 | | |
| 2013 | 38.60 | 38.60 | 0.00 | 0.0 |
| 2014 | 39,36 | 40,15 | 0.79 | 2.0 |
| 2015 | 37.07 | 41,15 | 4.08 | 11.0 |
| 2016 | 34.91 | 40,50 | 5.59 | 16.0 |

| | | | | |
|---|---|---|---|---|
| 2017 | 32.88 | 39.78 | 6.90 | 21.0 |
| 2018 | 30.96 | 38,40 | 7.43 | 24.0 |
| 2019 | 29,16 | 36.74 | 7.58 | 26.0 |
| 2020 | 27,46 | 34,33 | 6.87 | 25.0 |
| 2021 | 25.86 | 31.81 | 5.95 | 23.0 |
| 2022 | 24,36 | 29,23 | 4.87 | 20.0 |
| Total | 320.63 | 370.69 | 50.05 | 15.6 |

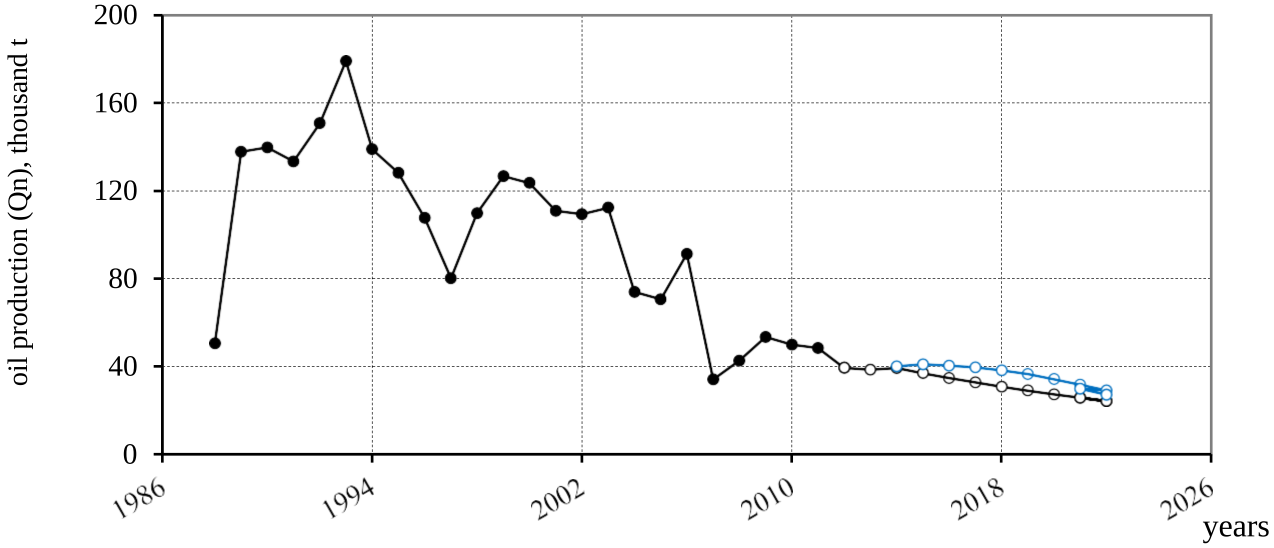



Fig. 4.2 FLD. Dynamics of oil production for wells covered by well No. 17 injection process (Table 4.33 and Figure 4.31).

As can be seen from the table, the oil obtained without water injection was 338.62 thousand tons, and the oil production obtained with injection was 394.04 thousand tons. Additional oil obtained due to water injection was 55.41 thousand tons, which is 16.4% of oil production obtained without water injection. 263, 301, and 305 production wells affected by well No. 121 proposed as a sprinkler. The forecast of oil production from the operational wells covered by this well during 2013-2022 is given in two variants: without the injection process and with the water injection process (Table 4.34).

As can be seen from the table, oil obtained without injection was 931.63 thousand t, and oil production obtained with water injection was 1086.73 thousand t. Additional oil obtained due to water injection was 155.1 thousand tons, which is 16.6% of oil production obtained without injection (Figure 4.32).

The forecast of the oil production from the operational wells under the influence of the total planned injection during 2013-2022: without the injection process and with the water injection process is given (Table 4.35).

As can be seen from the table, the total amount of oil obtained without water injection from operational wells under the influence of FLD was 2679.98 thousand t, and oil production obtained with water injection was 3120.44 thousand t. Additional oil obtained due to injection was 440.46 thousand tons, which is 16.44% of oil production obtained without water injection (Figure 4.33).

The forecast of oil production obtained from operational wells in the Gunashli field in the horizons intended for injection and operational wells under their influence during 2013-2022: without injection and with injection (Table 4.36 and Figure 4.22).

As can be seen from the table, the oil obtained without injection from working injection wells and operational wells under their influence is 1371.4 thousand t, oil obtained with injection.

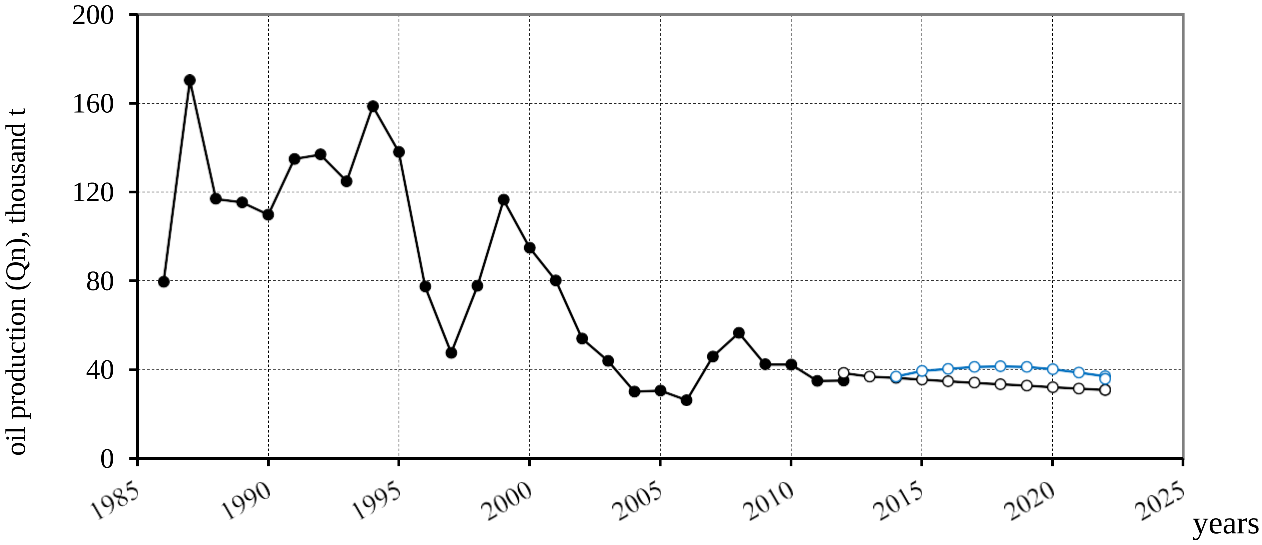


Table 4.33 Water injection well provided under
FLD forecast indicators

| Years | Production wells covered by the intended water injection well No. 111 - No. 117,167,61 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without injection | with water injection | the difference | at the expense of water injection, % |
| 2012 | 38.50 | | | |
| 2013 | 36.99 | 36.99 | 0.00 | 0.0 |
| 2014 | 36,26 | 36.98 | 0.73 | 2.0 |
| 2015 | 35,54 | 39,45 | 3.91 | 11.0 |
| 2016 | 34.84 | 40,41 | 5.57 | 16.0 |
| 2017 | 34,15 | 41,32 | 7.17 | 21.0 |
| 2018 | 33,47 | 41.50 | 8.03 | 24.0 |
| 2019 | 32.81 | 41,34 | 8.53 | 26.0 |
| 2020 | 32,16 | 40,20 | 8.04 | 25.0 |
| 2021 | 31,52 | 38.77 | 7.25 | 23.0 |
| 2022 | 30.90 | 37.08 | 6.18 | 20.0 |
| Total | 338.62 | 394.04 | 55,41 | 16.4 |

Fig. 4.3 Interval formation. Dynamics of oil production for wells covered by well No. 111

Table 4.34 Water injection well No. 121 envisaged under
FLD forecast indicators

| Years | Producing wells covered by the intended water injection well No. 121 - No. 263, 301, 305 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without water injection | with water injection | the difference | at the expense of water injection, % |
| 2012 | 96.80 | 96.80 | | |
| 2013 | 96.12 | 96.12 | 0.00 | 0.0 |
| 2014 | 95.45 | 97.36 | 1.91 | 2.0 |
| 2015 | 94.79 | 105.22 | 10.43 | 11.0 |
| 2016 | 94.13 | 109.19 | 15.06 | 16.0 |
| 2017 | 93.47 | 113.10 | 19.63 | 21.0 |
| 2018 | 92.82 | 115,10 | 22,28 | 24.0 |
| 2019 | 92,17 | 116,14 | 23.96 | 26.0 |
| 2020 | 91.53 | 114,41 | 22.88 | 25.0 |
| 2021 | 90.89 | 111.79 | 20.90 | 23.0 |
| 2022 | 90.26 | 108,31 | 18.05 | 20.0 |
| Total | 931.63 | 1086.73 | 155.10 | 16.6 |

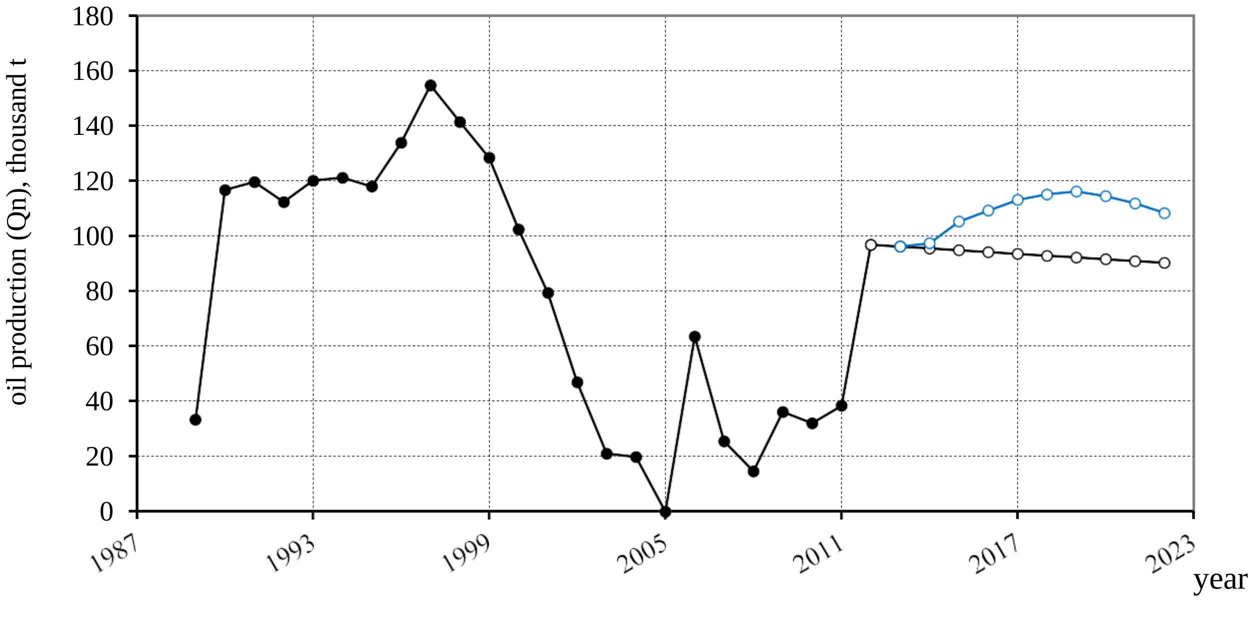


Fig. 4.32 Dynamics of oil production for wells covered by well No. 121

Table 4.35 Water injection wells envisaged under
FLD forecast indicators

| Years | On the wells covered by the proposed water injection wells | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without water injection | with water injection | the difference | at the expense of water injection, % |
| 2012 | 291.70 | 291.70 | | 0.00 |
| 2013 | 287.11 | 287.11 | 0.00 | 0.00 |
| 2014 | 284.97 | 290.67 | 5.70 | 2.00 |
| 2015 | 279.83 | 310.61 | 30.78 | 11.00 |
| 2016 | 274.85 | 318.83 | 43.98 | 16.00 |
| 2017 | 270.04 | 326.75 | 56,71 | 21.00 |
| 2018 | 265.38 | 329.07 | 63,69 | 24.00 |
| 2019 | 260.87 | 328.70 | 67,83 | 26.00 |
| 2020 | 256.50 | 320.63 | 64,13 | 25.00 |
| 2021 | 252.27 | 310.29 | 58.02 | 23.00 |
| 2022 | 248.16 | 297.79 | 49,63 | 20.00 |
| Total | 2679.98 | 3120.44 | 440.46 | 16.44 |

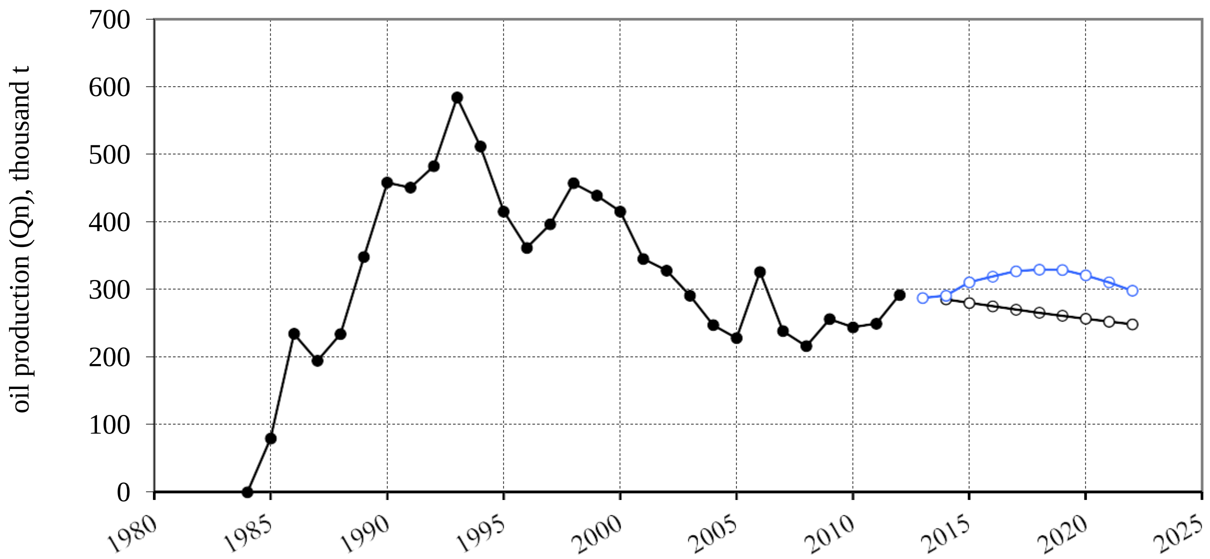


Fig. 4.33 Dynamics of oil production for wells covered by FLD water injection wells

## 3.3 Appraisal and evaluation of water injection in Balaxany X Zone

As can be seen from the table, the oil obtained without water injection was 810.77 thousand tons, and the oil production obtained with water injection was 949.81 thousand tons. Additional oil obtained due to water injection was 139.03 thousand tons, which is 17.1% of oil production obtained without water injection.

219, 182, 272, 102, 108 and 2 operational wells affected by well No. 223, proposed as a sprinkler. The forecast of oil production from production wells covered by this well during the years 2013-2022 is given in two variants: without the water injection process and with the water injection process (Table 4.25 and Figure 4.23).

As can be seen from the table, the oil obtained without water injection was 845.12 thousand tons, and the oil production obtained with water injection was 990.05 thousand tons. Additional oil obtained due to injection was 144.92 thousand tons, which is 17.1% of oil production obtained without injection.

277, 248, and 283 are operational wells affected by well No. 99, which is proposed as a sprinkler. The forecast of oil production from production wells covered by this well during 2013-2022 is given in two variants: without the water injection process and with the water injection process (Table 4.26 and Figure 4.24).

As can be seen from the table, the oil obtained without water injection n was 235.65 thousand t, andthe oil production obtained with water injection was 273.71 thousand t. Additional oil obtained due to water injection was 38.07 thousand tons, which is 16.2% of oil production obtained without water injection.

194, 195, 196, 198 and 199 are affected by well 153, which is proposed as a sprinkler. The forecast of oil production from production wells covered by this well during 2013-2022 is given in two variants: without the water injection process and with the water injection process (Table 4.27 and Figure 4.25).

Table 4.35

water injection well No. 291 intended for horizon X
forecast indicators

| Years | Producing wells covered by the planned water injection well No. 291 - No. 106, 105, 170, 177 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without water injection | with water injection | the difference | at the expense of water injection, % |
| 2012 | 73,80 | 73,80 | | |
| 2013 | 81,81 | 81,81 | 0.00 | 0.0 |
| 2014 | 81.65 | 84,10 | 2.45 | 3.0 |
| 2015 | 81.48 | 88.00 | 6.52 | 8.0 |

| | | | | |
|---|---|---|---|---|
| 2016 | 81,32 | 94.33 | 13.01 | 16.0 |
| 2017 | 81,16 | 97.39 | 16,23 | 20.0 |
| 2018 | 81.00 | 99.62 | 18.63 | 23.0 |
| 2019 | 80,83 | 100.23 | 19,40 | 24.0 |
| 2020 | 80.67 | 100.84 | 20,17 | 25.0 |
| 2021 | 80,51 | 101.44 | 20.93 | 26.0 |
| 2022 | 80.35 | 102.04 | 21.69 | 27.0 |
| Total | 810.77 | 949.81 | 139.03 | 17.1 |

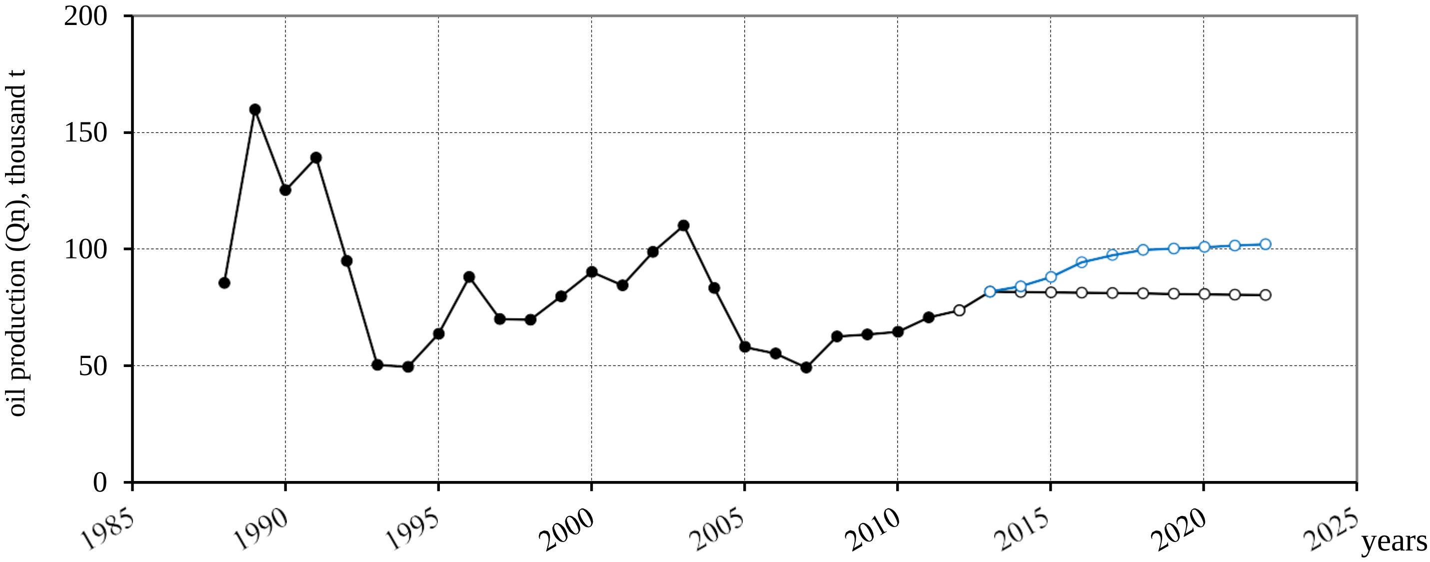



Fig. 4.4 X horizon. Oil in the wells covered by well No. 291 dynamics of production

Table 4.36

water injection well No. 223 intended for horizon X forecast indicators

| Years | Producing wells covered by the planned injection well No. 223 - No. 182,272,2,102,108 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without water injection | with water injection | the difference | at the expense of water injection, % |
| 2012 | 85.45 | 85.45 | | 0.0 |
| 2013 | 85,27 | 85,27 | 0.00 | 0.0 |
| 2014 | 85,10 | 87.66 | 2.55 | 3.0 |
| 2015 | 84,93 | 91.73 | 6.79 | 8.0 |
| 2016 | 84.76 | 98.33 | 13.56 | 16.0 |

| | | | | |
|---|---|---|---|---|
| 2017 | 84.60 | 101.51 | 16.92 | 20.0 |
| 2018 | 84.43 | 103.84 | 19,42 | 23.0 |
| 2019 | 84,26 | 104.48 | 20,22 | 24.0 |
| 2020 | 84.09 | 105.11 | 21.02 | 25.0 |
| 2021 | 83,92 | 105.74 | 21.82 | 26.0 |
| 2022 | 83.75 | 106,37 | 22.61 | 27.0 |
| Total | 845.12 | 990.05 | 144.92 | 17.1 |

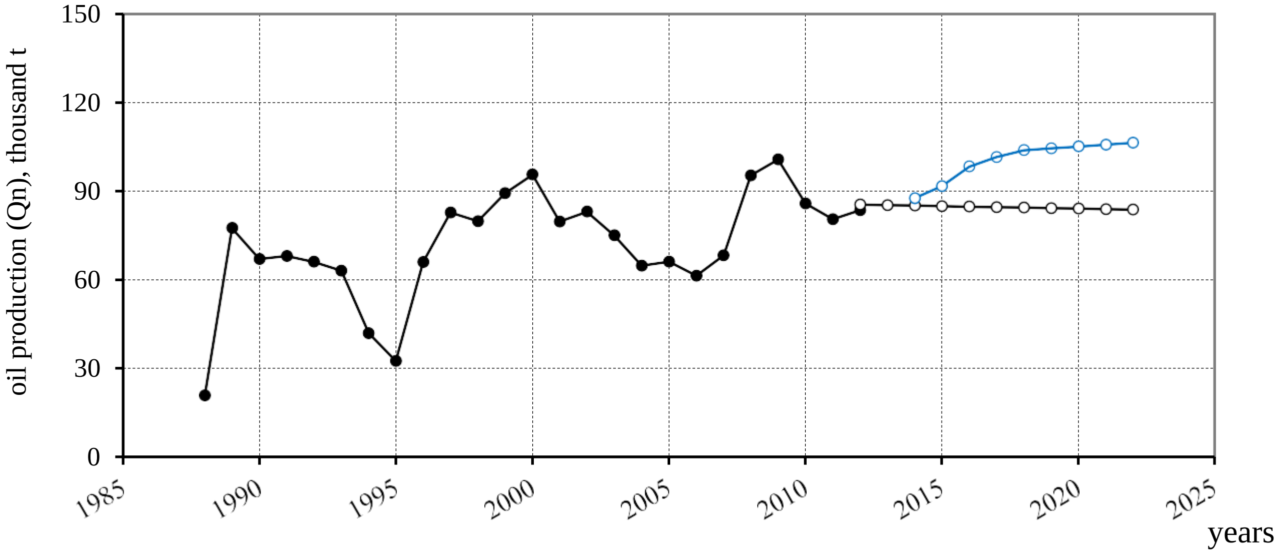



Fig. 4.41 X horizon. Dynamics of oil production for wells covered by well No. 223

Table 4.36

water injection well No. 99 intended for horizon X forecast indicators

| Years | Producing wells covered by the intended water injection well No. 99 - No. 277,248,283 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without water injection | with water injection | the difference | at the expense of water injection, % |
| 2012 | 29,17 | 29,17 | | |
| 2013 | 28.03 | 28.03 | 0.00 | 0.0 |
| 2014 | 26.93 | 27.74 | 0.81 | 3.0 |
| 2015 | 25.87 | 27.94 | 2.07 | 8.0 |
| 2016 | 24.86 | 28.83 | 3.98 | 16.0 |

| | | | | |
|---|---|---|---|---|
| 2017 | 23.88 | 28.66 | 4.78 | 20.0 |
| 2018 | 22.95 | 28,22 | 5.28 | 23.0 |
| 2019 | 22.05 | 27,34 | 5.29 | 24.0 |
| 2020 | 21,18 | 26,48 | 5.30 | 25.0 |
| 2021 | 20.35 | 25.64 | 5.29 | 26.0 |
| 2022 | 19.55 | 24.83 | 5.28 | 27.0 |
| Total | 235.65 | 273.71 | 38.07 | 16.2 |

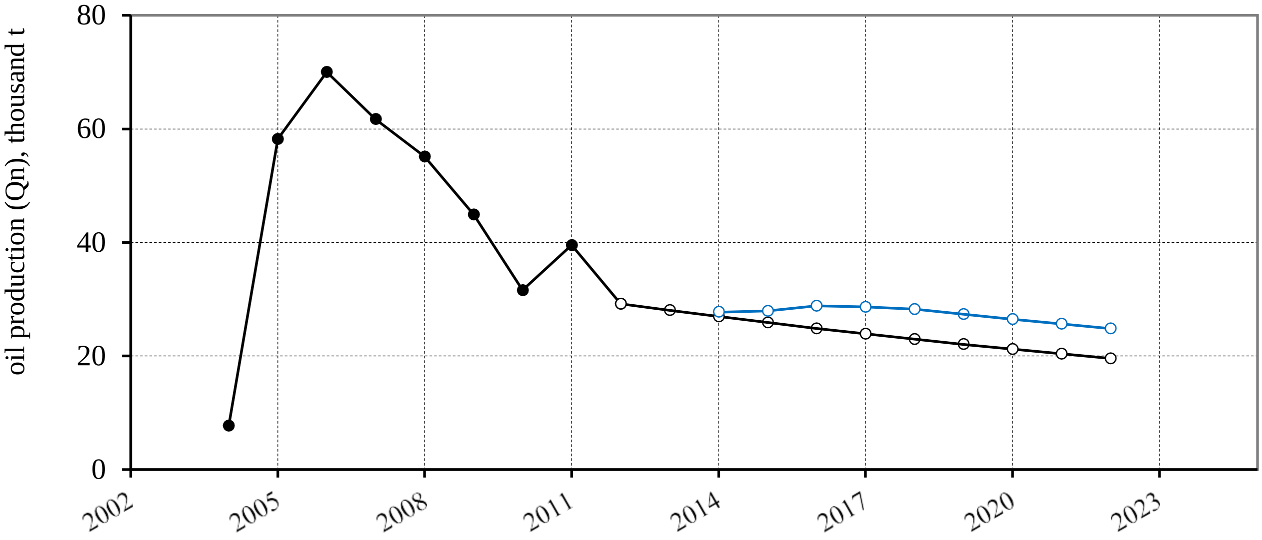



Fig. 4.42 X horizon. Dynamics of oil production for wells covered by well No. 99

Table 4.37

water injection well No. 153 planned for the X horizon forecast indicators

| Years | Producing wells covered by the intended water injection well No. 153 - No. 194,195,196,198,199 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without water injection | with water injection | the difference | at the expense of water injection, % |
| 2012 | 58,80 | 58,80 | | |
| 2013 | 55.99 | 55.99 | 0.00 | 0.0 |
| 2014 | 53,31 | 54.91 | 1.60 | 3.0 |
| 2015 | 50,76 | 54,82 | 4.06 | 8.0 |
| 2016 | 48,33 | 56.07 | 7.73 | 16.0 |
| 2017 | 46.02 | 55,23 | 9.20 | 20.0 |
| 2018 | 43,82 | 53.90 | 10.08 | 23.0 |

| | | | | |
|---|---|---|---|---|
| 2019 | 41.73 | 51.74 | 10.01 | 24.0 |
| 2020 | 39.73 | 49,66 | 9.93 | 25.0 |
| 2021 | 37.83 | 47,67 | 9.84 | 26.0 |
| 2022 | 36.02 | 45.75 | 9.73 | 27.0 |
| Total | 453.56 | 525.75 | 72,19 | 15.9 |

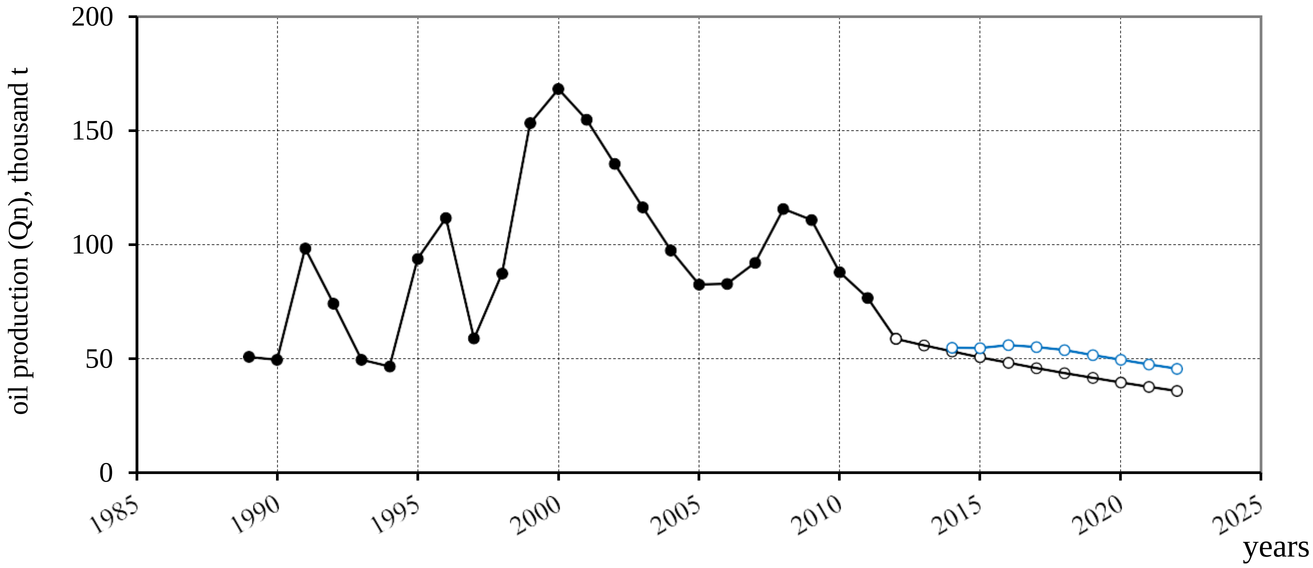



Fig. 4.43 X horizon. Oil in the wells covered by well No. 153 dynamics of production

As can be seen from the table, the oil obtained without water injection was 453.56 thousand t, and the oil production obtained with water injection was 525.75 thousand t. Additional oil obtained due to injection was 72.19 thousand tons, which is 15.9% of oil production obtained without water injection.

The forecast of the oil production from the operational wells in total operation and the operating wells under their influence during the years 2013-2022: without the water injection process and with the water injection process is given (Table 4.28 and Figure 4.26).

## 3.4 Appraisal and evaluation of water injection in Balaxany IX Zone

Sunny Currently, the water injection process is carried out through 7 wells on the IX horizon of the field. Considering, the lack of influence of injection wells No. 123 and 125 on the surrounding wells, it was recommended to remove these wells from the water injection fund, and to keep 5 wells (Nos. 280, 278, 214, 157, 127) in the water injection fund. It is considered appropriate to use the II impact (water injection) method to absorb residual extractable oil reserves on the IX horizon.

Table 4.38

Injection well No. 280 operating on the IX

horizon forecast indicators

| Years | Production wells covered by the operating water injection well No. 280 - No. 98, 275, 282 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without water injection | with water injection | the difference | due to water injection, % |
| 2012 | 16.40 | 17.55 | 1.15 | 7.0 |
| 2013 | 16.01 | 17.77 | 1.76 | 11.0 |
| 2014 | 15.63 | 17.97 | 2.34 | 15.0 |
| 2015 | 15,26 | 18,15 | 2.90 | 19.0 |
| 2016 | 14.89 | 17.87 | 2.98 | 20.0 |
| 2017 | 14.54 | 17.59 | 3.05 | 21.0 |
| 2018 | 14,19 | 17,31 | 3.12 | 22.0 |
| 2019 | 13.85 | 17.04 | 3.19 | 23.0 |
| 2020 | 13.52 | 16.50 | 2.98 | 22.0 |
| 2021 | 13,20 | 15.97 | 2.77 | 21.0 |
| 2022 | 12.89 | 15.47 | 2.58 | 20.0 |
| Total | 143.99 | 171.66 | 27.67 | 19.2 |

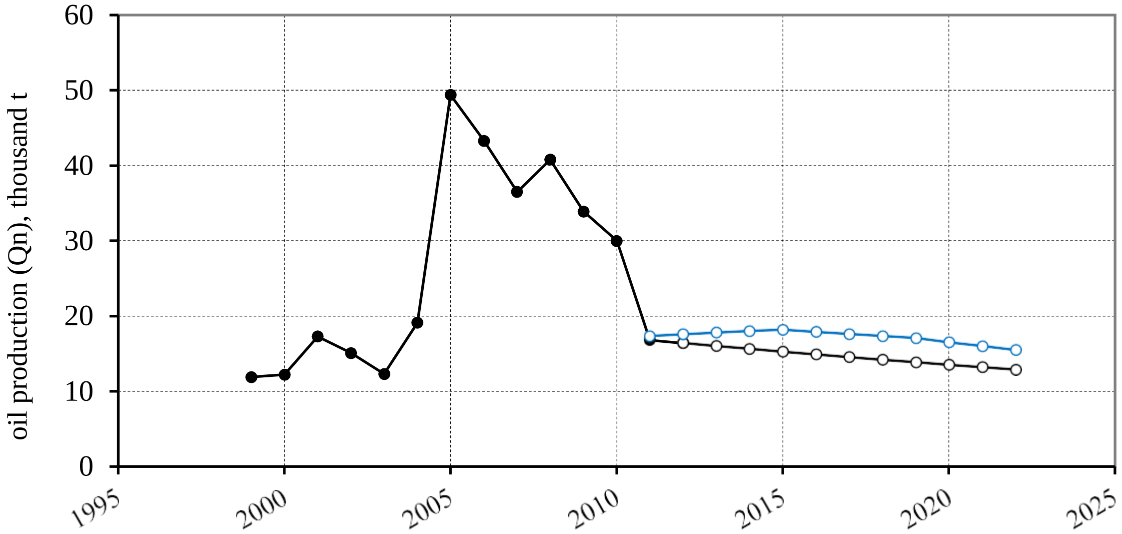
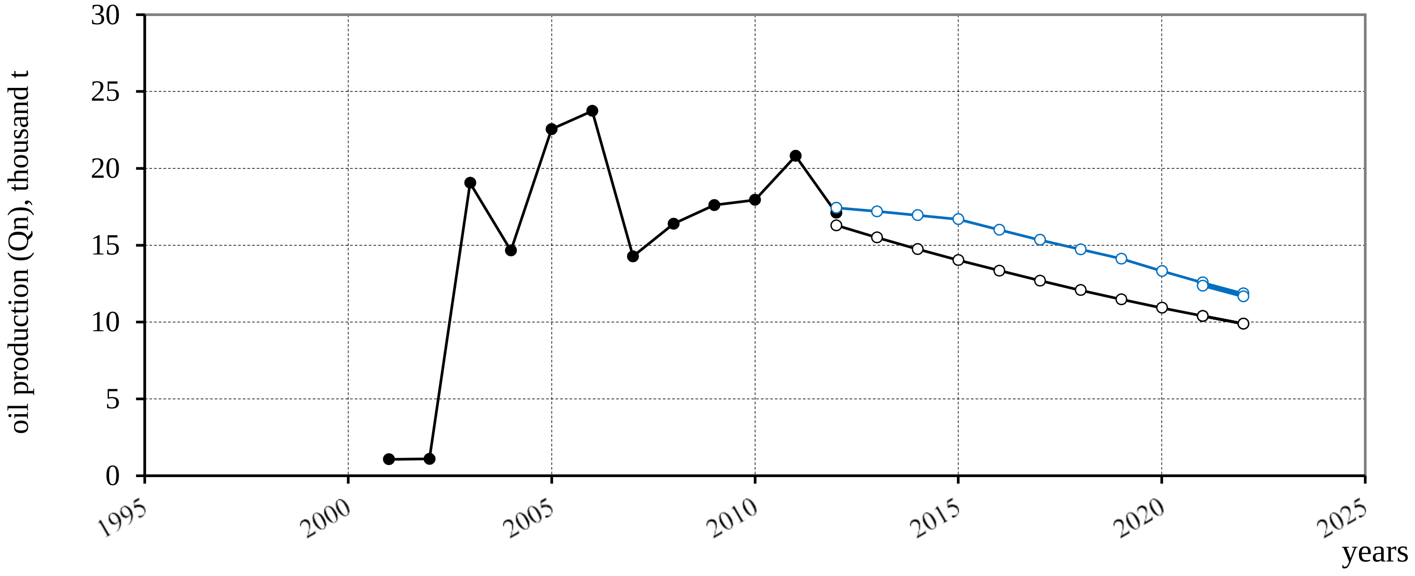



Table 4.39

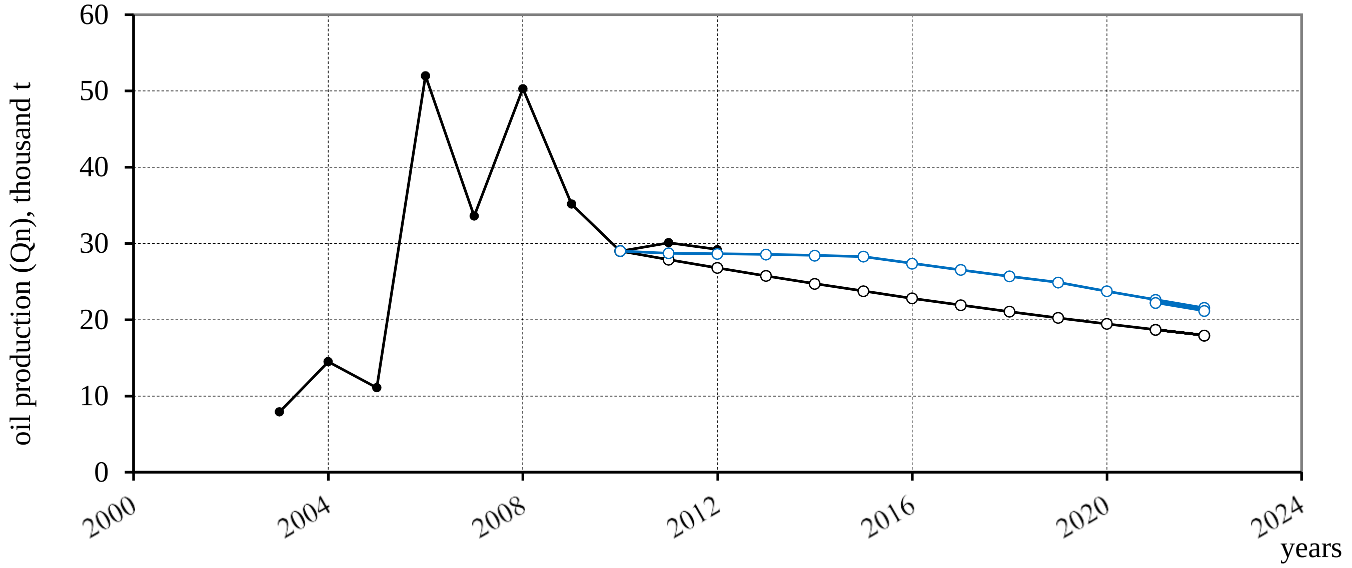
water injection well No. 278 operating on the IX horizon forecast indicators

| Years | Production wells covered by the active water injection well No. 278 - No. 281, 241,95,226 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without water injection | with water injection | the difference | the expense of water injection, % |
| 2012 | 16,29 | 17.43 | 1.14 | 7.0 |
| 2013 | 15.49 | 17,20 | 1.70 | 11.0 |
| 2014 | 14.74 | 16.95 | 2.21 | 15.0 |
| 2015 | 14.02 | 16.68 | 2.66 | 19.0 |
| 2016 | 13,33 | 16.00 | 2.67 | 20.0 |
| 2017 | 12.68 | 15.35 | 2.66 | 21.0 |
| 2018 | 12.07 | 14.72 | 2.65 | 22.0 |
| 2019 | 11.48 | 14,12 | 2.64 | 23.0 |
| 2020 | 10.92 | 13,32 | 2.40 | 22.0 |
| 2021 | 10.39 | 12.57 | 2.18 | 21.0 |
| 2022 | 9.88 | 11.85 | 1.98 | 20.0 |
| Total | 124.99 | 148.75 | 23.76 | 19.0 |



Prognostic indicators of water injection well No. 157 operating on the IX horizon

| Years | Production wells covered by the operating water well No. 157 - No. 147, 148, 149, 120, 126, 114, 158 | | | |
|---|---|---|---|---|
| | Oil production, thousand tons | | | |
| | without water injection | with water injection | the difference | due to water injection, % |
| 2012 | 26.77 | 28.64 | 1.87 | 7.0 |
| 2013 | 25.72 | 28.55 | 2.83 | 11.0 |
| 2014 | 24.71 | 28,42 | 3.71 | 15.0 |
| 2015 | 23.74 | 28,25 | 4.51 | 19.0 |
| 2016 | 22.81 | 27,37 | 4.56 | 20.0 |
| 2017 | 21.92 | 26.52 | 4.60 | 21.0 |
| 2018 | 21.06 | 25.69 | 4.63 | 22.0 |
| 2019 | 20,23 | 24.89 | 4.65 | 23.0 |
| 2020 | 19,44 | 23.72 | 4.28 | 22.0 |
| 2021 | 18.68 | 22.60 | 3.92 | 21.0 |
| 2022 | 17.94 | 21.53 | 3.59 | 20.0 |
| Total | 216.26 | 257.54 | 41,29 | 19.1 |




As can be seen from the table, the oil obtained without water injection was 216.26 thousand tons, and the oil production obtained with water injection was 257.54 thousand tons. Additional oil obtained due to injection was 41.29 thousand tons, which is 19.1% of oil production obtained without water injection.

Operating wells No. 293, 138, 144 are affected by water well No. 214. The forecast of oil production from production wells covered by this well during the years 2013-2022 is given in two variants: without the water injection process and with the water injection process (Table 4.16 and Figure 4.14).

As can be seen from the table, oil obtained without water injection was 100.59 thousand t, and oil production obtained with injection was 118.85 thousand t. Additional oil obtained due to water injection was
18.26 thousand tons, which is 18.1% of the oil production obtained without water injection.

Operational wells No. 125, 255, 267 are affected by water well No. 127. The forecast of oil production from production wells covered by this well during 2013-2022 is given in two variants: without the water injection process and with the injection process (Table 4.17 and Figure 4.15).

As can be seen from the table, the oil obtained without water injection was 302.92 thousand tons, and the oil production obtained with injection was 361.46 thousand tons. Additional oil obtained due to water injection was 58.54 thousand tons, which is 19.3% of oil production obtained without water injection.

Taking into account the low production of exploitation well No. 110, which is in the active exploitation fund on the IX horizon, it is proposed to use this well as a water injection well. The exploitation wells No. 3, 212, 161, 212, 94 are affected by the proposed injection well. The forecast of oil production from the production wells covered by this well during 2013-2022 is given in two variants: without the injection process and with the water injection process.
(Table 4.18 and Figure 4.16).

## 3.5 Appraisal and evaluation of water injection for Gunashli Field (total).

The Gunashli field has been under development since 1980. As of 01.04.2013, 14 deep sea cores have been built in the field. Mass drilling of wells was carried out in 1983-1991. As of 01.04.2013, 243 oil, 41 gas and 26 water wells were drilled in the field (Figure 5.1). 516 wells/objects participated in the operation of facilities (Figure 5.2).

There were 249 wells in the total operational production fund of the field, of which 233 wells are operational (173 oil, 60 gas) and 16 wells (13 oil, 3 gas) are inactive. Of the oil wells, 149 wells work by gas lift, and 24 wells work by the fountain method (Figure 5.3). There are 20 wells in the general injection fund, of which 15 wells are active and 5 wells are inactive. Due to certain geological and technical reasons, 20 wells are producing, 11 wells have been canceled from the injection fund, and 8 wells (7 oil, 1 injection well) are awaiting cancellation. The wells drilled for 2006-01.04.2013, their initial production and the distribution of wells by horizons are given (Table 5.1-5.2).

As of 01.01.2013, the nature of changes in the main horizons (IX, X, FLD) by wells is as follows:

There are 46 wells in the operational fund of the IX horizon, 40 of which are in operation, and 6 wells are in the inactive fund. 3 of these wells in the working fund are operated by fountain, and 37 by gas lift method. Thus, there are 8 wells in the facility's injection fund, of which 7 are active and 1 is inactive. 66 wells/facilities participated in the exploitation of Horizon. Due to certain geological and technical reasons, 9 wells were canceled from the production fund.

47 producing (45-oil, 2-gas) and 7 injection wells were drilled in the X horizon. Currently, there are 49 wells in the operating fund, of which 47 wells are in operation, and 2 wells are in the inactive fund. 2 of these wells in the working fund work with a fountain, and 45 with a gas lift method. There are 6 wells in the facility's injection fund, of which 5 wells are in operation, and 1 well is in the inactive fund. Due to certain geological and technical reasons, 4 wells from the production fund, 8 wells from the injection fund were canceled, and 4 wells.

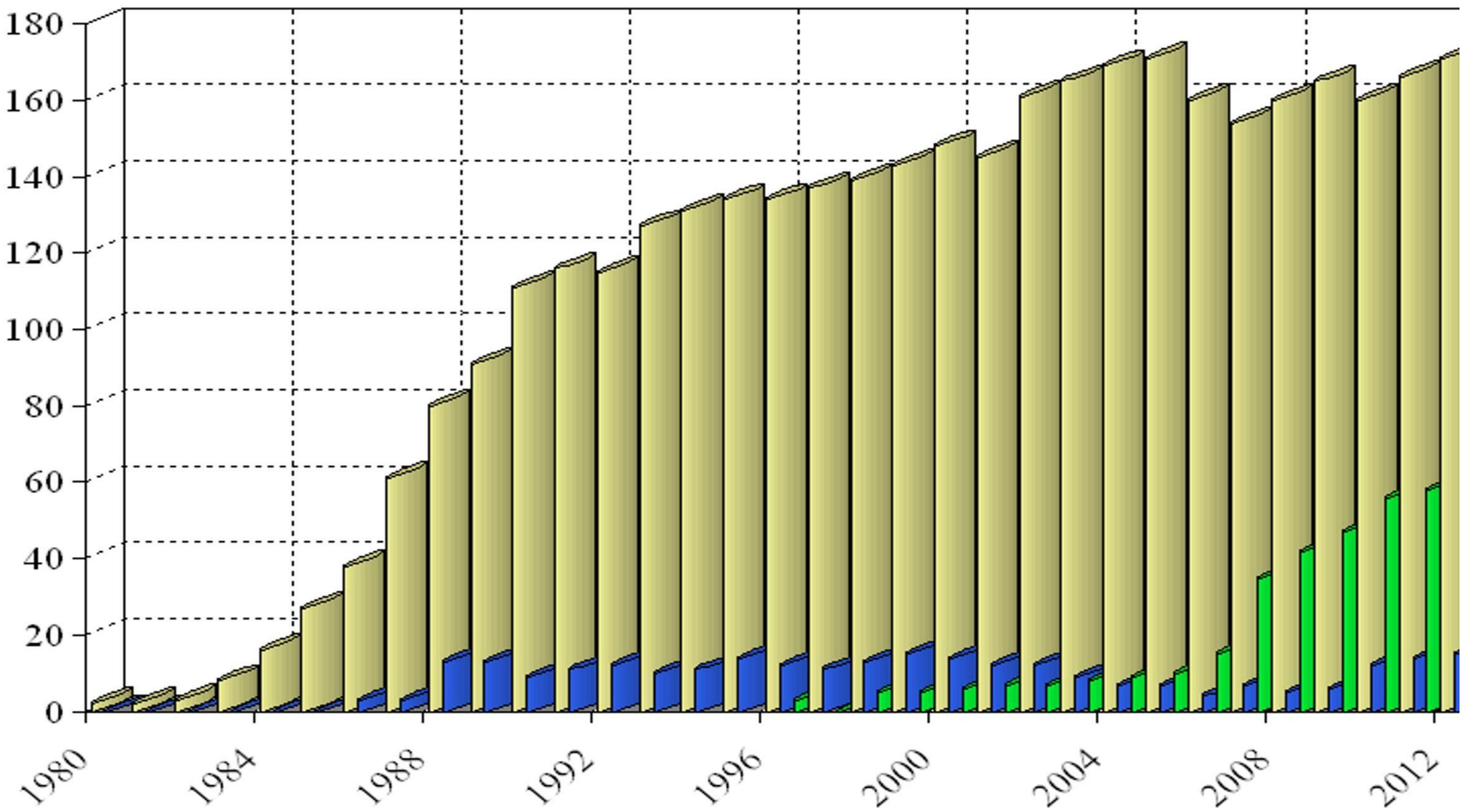



Fig. 5.1 Gunashli bed. The number of wells (well/facility) that participated in the operation of facilities by year

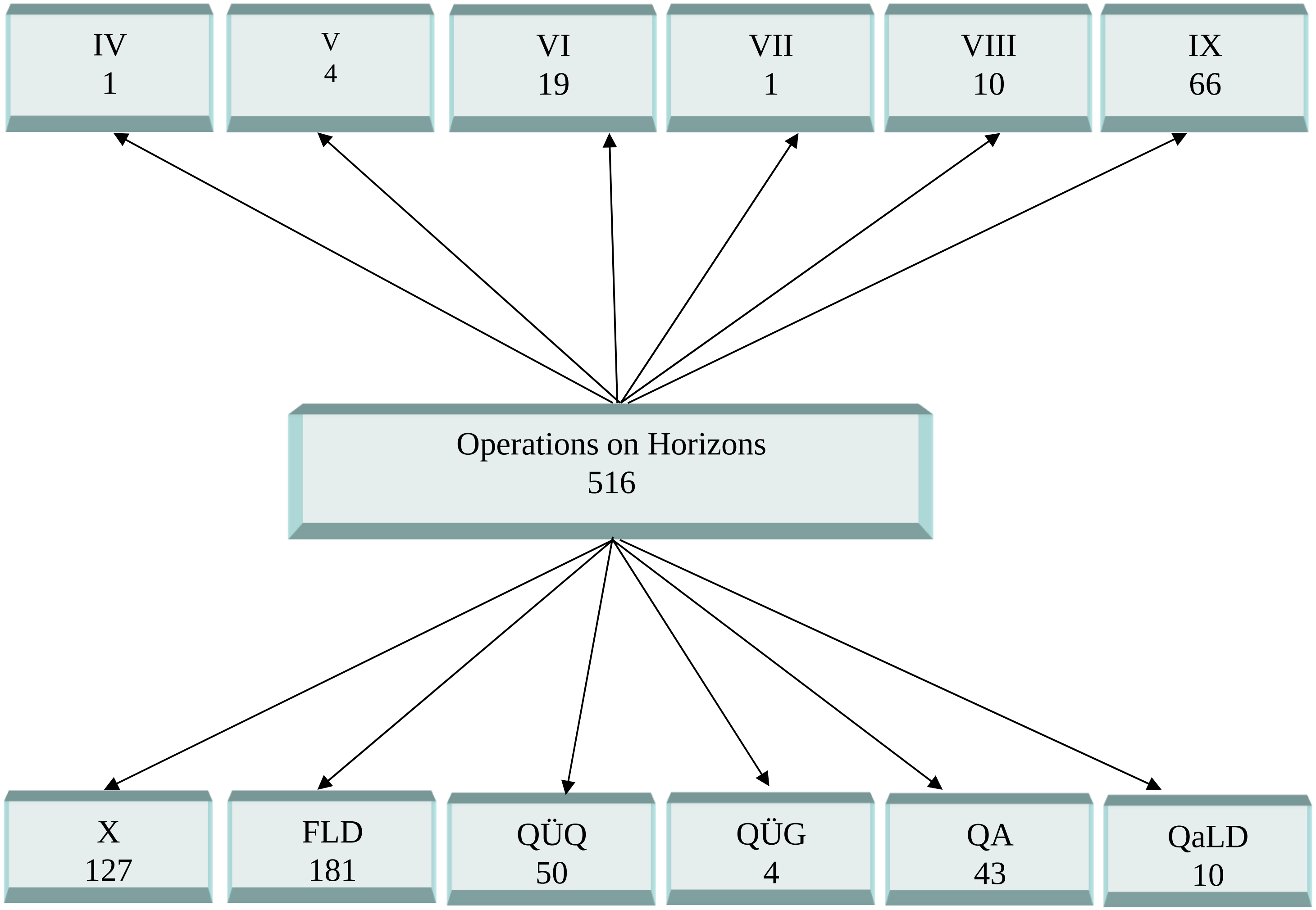



Fig. 5.2 Gunashli bed. Scheme of well stock (well/facility) in operation on horizons

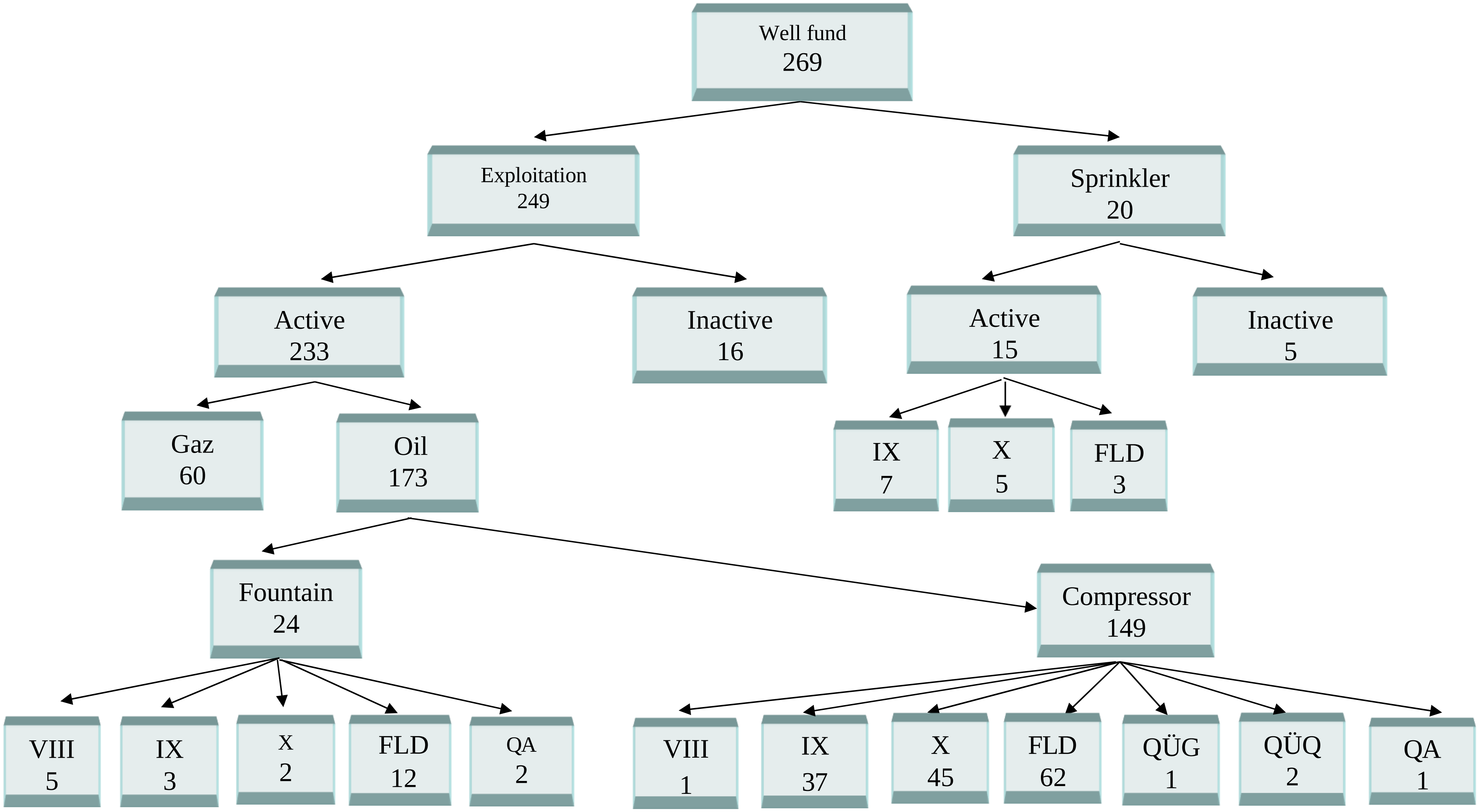



Fig. 5.3 Scheme of the active well fund on the Gunashli field

Table 5.1

Information on wells drilled in 2006-01.04.2013

| No No | WHO | Well No _ | depth, m | Exploitation Enter date | Horizon | Primary production | | | Total production as of 01.01.2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | oil / condensate, t/day | water, t/day | Dissolved gas/free gas, thousand $m^3$ /day | horizon | oil / condensate, thousand tons | water, thousand tons | Dissolved gas/free gas, mln.$m^3$ |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 2006 year | | | | | | | | | | | | |
| 1 | 14 | 417 g | 3571 | 01.05 | QQ | -/ 25 | - | -/490 | QQ | -/83.1 | 204.5 | -/361.7 |
| 2 | 13 | 427 | 3125 | 11.04 | FLD | 130/- | - | 28 | FLD | 466.6/- | 0.5 | 222.4/- |
| 3 | 8 | 232 | 2975 | 07.06 | FLD | 180/- | - | 51.1 | FLD | 430.9/- | 0.1 | 113.8/- |
| 4 | 19 | 73 | 3860 | 11.06 | FLD | 218 /- | - | 54 | FLD | 451.1/- | 71.0 | 89.8/- |
| 5 | 13 | 432 g | 3605 | 12.10 | QQ | -/ 30 | - | -/350 | QQ | -/127.7 | 0.13 | -/901.6 |
| 2007 year | | | | | | | | | | | | |
| 6 | 8 | 228 | 2925 | 12.01 | FLD | 229/- | - | 122.5/- | FLD | 566.5/- | 0.2 | 146.5/- |
| 7 | 13 | 428 g | 3157 | 21.02 | QQ | -/50 | - | -/280 | QQ | -/132.8 | 0.74 | -/987.5 |
| 8 | 19 | 75g | 3705 | 23.04 | QLD | - | 30 | | QQ | -/145.1 | 9.8 | -/1089.7 |
| 9 | 14 | 74 g | 3645 | 27.04 | QA | - /7 | - | -/125 | QQ | -/68.7 | 2.1 | -/813.3 |
| 10 | 8 | 162 g | 2610 | 29.05 | VI | -/7 | - | -/350 | VI | -/33.5 | 2.8 | -/1026.6 |
| 11 | 13 | 243 | 2695 | 18.06 | VII | 4 | 149 | 15.5 | VI | 1,2 | 14 | 1.8/ |
| 12 | 14 | 222 | 2517 | 21.07 | VIII | 100 / | - | 20.4 | VIII | 165.5/- | 9.3 | 52.9/- |
| 13 | 19 | 91g | 2532 | 23.10 | VIII | -/32 | - | -/250 | VIII | 105.8/44.9 | 38.9/2.1 | 70.2/121.9 |
| 14 | 15 | 294 | 2976 | 01.12 | X | 15 / | - | 75.0 | X | 50.4/- | 0.2 | 47.5/- |
| 15 | 8 | 300 | 2960 | 23.10 | FLD | 90 / | - | 187.0 | FLD | 404.1/- | - | 130.7/- |
| 16 | 13 | 420 | 2963 | 05.11 | FLD | 216 / | - | 154.9 | FLD | 280.8/- | - | 51.5/- |
| 17 | 14 | 225 | 2664 | 28.11 | VIII | 112 / | - | 180.3 | VIII | 144.9/- | 5.5 | 34.0/- |
| 2008 year | | | | | | | | | | | | |
| 18 | 14 | 247 | 2665 | 16.03.08 | VIII | 110/- | - | 20.0 | VIII | 112.6/- | 72.7/- | 42.9/- |
| 19 | 13 | 244 | 3101 | 25.03.08 | FLD | 140/- | - | 13.1 | FLD | 173.7/- | 11.6/- | 51.1/- |
| 20 | 8 | 165 | 2740 | 28.05.08 | X | 30/- | - | - | X | 179.9/- | - | 92.6/- |

Table 5.1

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 13 | 245 | 2725 | 18.07.08 | IX | 48/- | - | - | VIII | 58.5/- | 0.9 | 37.6/- |
| 22 | 13 | 246 | 2855.5 | 26.08.08 | FLD | 100/- | - | - | FLD | 213.5/- | 0.5 | 61.3/- |
| 23 | 13 | 250 | 3042 | 28.08.2008 | QA | 38/- | - | 125.0 | FLD | 232/- | - | 63.1/- |
| 24 | 15 | 431 | 4190 | 19.11.2008 | QQ | 130/- | - | 40.0 | QQ | 149.3/- | 130.3 | 39.3/- |
| 2009 year | | | | | | | | | | | | |
| 25 | 13 | 435 g | 3358 | 12.01.2009 | QQ | -/28 | - | -/192.0 | QQ | -/28.3 | - | -/289.4 |
| 26 | 13 | 249 g | 3222 | 09.02.2009 | QQ | -/19 | 120 | -/9.0 | QQ | -/48.1 | - | -/495.9 |
| 27 | 14 | 76 g | 3763.5 | 04.02.2009 | QQ | -/50 | - | -/250.0 | QA | -/70.0 | - | -/521.8 |
| 28 | 14 | 412 g | 3472 | 27.08.2009 | QQ | -/105 | - | -/150.0 | QQ | -/63.1 | -/29.4 | -/272.1 |
| 2010 year | | | | | | | | | | | | |
| 29 | 19 | 90g | 3666 | 06.01.2010 | QLD | -/30 | - | -/120.0 | QLD | 1.3-/1.6 | 0.1/1.8 | 0.2/6.4 |
| | | | | | | | | | QA | -/10.6 | 0.56 | -/118.6 |
| 30 | 10 | 61 g | 3442 | 21.01.2010 | QQ | -/40 | - | -/200.0 | QQ | 12.1/6.0 | 1.1/0.53 | 13.9/85.0 |
| 31 | 13 | 311q | 3777 | 16.03.2010 | QA | -/27 | - | -/250.0 | QA | -/14.5 | 0.03 | -/208.4 |
| 32 | 14 | 77 g | 3747 | 30.04.2010 | QQ | -/30 | - | -/170.0 | QQ | -/27 | - | -/287.5 |
| 33 | 11 | 59q | 3904 | 21.04.2010 | QQ | -/30 | - | -/200.0 | QA | -/22.5 | 0.07 | -/245.2 |
| 34 | 13 | 313 g | 3576 | 21.04.2010 | QA | -/31 | - | -/225.0 | QA | -/27.1 | - | -/198.0 |
| 35 | 13 | 80g | 3654 | 19.09.2010 | QQ | -/10 | - | -/100.0 | QA | -/5,6 | 0.61 | -/101.4 |
| 36 | 11 | 56 g | 4090 | 21.09.2010 | QQ | -/28 | - | -/150.0 | QA | -/18.6 | 0.57 | -/193.4 |
| 37 | 13 | 312 g | 3720 | 20.10.2010 | QQ | -/20 | - | -/120.0 | QQ | -/12.8 | 0.13 | -/182.0 |
| 38 | 6 | 70g | 3627 | 11.10.2010 | QA | -/25 | - | -/170.0 | QA | -/7.1 | - | -/83.2 |
| 2011 year | | | | | | | | | | | | |
| 39 | 11 | 209 | 3374 | 03.05.2011 | FLD | 123 | - | - | FLD | 47/- | 18.5/- | 9.3/- |
| 40 | 11 | 57 g | 3920 | 03.02.2011 | QA | -/20 | - | -/150 | QA | -/20.4 | 0.05 | -/170.8 |
| 41 | 13 | 79q | 3621 | 21.02.2011 | QA | -/20 | - | -/160 | QA | -/5.5 | | -/104.7 |
| 42 | 6 | 421 g | 3709 | 09.05.2011 | QA | -/15 | - | -/145 | QA | -/3,3 | | -/72.2 |
| 43 | 13 | 240 | 2940 | 17.05.2011 | FLD | 102 | - | - | FLD | 102.9/- | - | 14.6/- |
| 44 | 13 | 314 | 3975 | 02.07.2011 | QA | 110 | - | - | QA | 50.4 | 6.0 | 30.6/- |

Continuation of Table 5.1

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | 11 | 52 g | 3505 | 10.08.2011 | QA | -/18 | - | -/170 | QA | -/6.9 | 0.13 | -/93.5 |
| 46 | 14 | 305 | 3010 | 19.08.2011 | FLD | 108 | - | | FLD | 64.1/- | 11.1 | 9.9/- |
| 47 | 11 | 54 g | 3722 | 27.11.2011 | QA | -/15 | - | -/150 | QA | -/2.4 | - | -/54.9 |
| 48 | 13 | 218 | 2951 | 27.12.2011 | FLD | 74 | - | | FLD | 61.9/- | - | 13.7/- |
| 2012 year | | | | | | | | | | | | |
| 49 | 6 | 49q | 3821 | 01.01.2012 | QA | -/41 | /6 | -/278.4 | QA | -/14.9 | 2.2 | -/101.9 |
| 50 | 13 | 46 | 4117 | 24.01.2012 | QA | 219 | - | 57.3 | QA | 75.1/- | - | 19.6/- |
| 51 | 14 | 301 | 3012 | 23.04.2012 | FLD | 144 | - | 19.2 | FLD | 36.5/- | - | 4.9/- |
| 52 | 11 | 48 g | 3655 | 24.04.2012 | QA | -/12 | - | -/164.5 | QA | -/3.1 | 0.123 | -/41.4 |
| 53 | 13 | 217 | 2916 | 23.05.2012 | FLD | 175 | - | 18.9 | FLD | 39.1/- | - | 4.2/- |
| 54 | 10 | 160 | 2990 | 03.06.2012 | FLD | 124 | - | 17.0 | FLD | 26.3/- | - | 3.6/- |
| 55 | 11 | 44 g | 3800 | 04.10.2012 | QA | -/14 | - | -/124.3 | QA | -/1,2 | - | -/11.1 |
| 56 | 10 | 43 g | 3458 | 10.12.2012 | QA | -/9 | - | -/100.0 | QA | -/0.2 | - | -/2.2 |
| 57 | 13 | 308 | 3009 | 10.09.2012 | FLD | 92 | - | 19.0 | FLD | 8.9/- | - | 1.8/- |
| 58 | 14 | 306 | 3152 | 15.12.2012 | FLD | 106 | - | 12.5 | FLD | 1.8/- | - | 0.2/- |
| 59 | 13 | 315 | 3071 | 11.12.2012 | FLD | 112.0 | - | 78.4 | FLD | 2.3/- | - | 1.6/- |
| 01.04.2013 | | | | | | | | | | | | |
| 60 | 6 | 42 g | 3760 | 14.01.2013 | QA | -/15.0 | - | -/160.0 | QA | -/2,3 | -/0.03 | -/12.6 |
| 61 | 11 | 210 | 3420 | 11.02.2013 | FLD | 90/- | - | 13/- | FLD | 3.9/- | - | 0.6/- |

Table 5.2

Sunny bed

Analysis of well stock on horizons

| | | H horizons | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | IV | V | VI | VII | VIII | IX | X | FLD | KÜG | QQ | QA | QLD | On the bed |
| General dug up | | | 1 | 1 | 1 | 5 | | 54 | 175 | | 29 | 33 | 11 | **310** |
| Operating well fund | Excavated in the operating fund | | 1 | | | 5 | | 45 | 149 | | 18 | 19 | 6 | 243 |
| Operating well fund | General operating fund | 1 | 4 | 18 | | 6 | 46 | 49 | 79 | 1 | 18 | 27 | | 249 |
| Operating well fund | working | | | | | 6 | 40 | 47 | 74 | 1 | 2 | 3 | | 173 |
| Operating well fund | From them: fountain | | | | | 5 | 3 | 2 | 12 | | | 2 | | 24 |
| Operating well fund | From them: gas lift | | | | | 1 | 37 | 45 | 62 | 1 | 2 | 1 | | 149 |
| Operating well fund | inactive | | | | | | 6 | 2 | 5 | | | | | 13 |
| Operating well fund | pending cancellation | | | | | | | 4 | 2 | | 1 | | | 7 |
| Operating well fund | Total canceled | | | | | | 9 | 4 | 4 | | 1 | | 2 | 20 |
| Gas wells | dug up | | | 1 | 1 | | | 2 | 7 | | 11 | 14 | 5 | 41 |
| Gas wells | working | 1 | 3 | 16 | | | | | | | 16 | 24 | | 60 |
| Gas wells | inactive | | 1 | 2 | | | | | | | | | | 3 |
| Gas wells | observation wells | | | 1 | | | | | | | | | | 1 |
| Injection well fund | dug into the injection fund | | | | | | | 7 | 19 | | | | | 26 |
| Injection well fund | common sinking fund | | | | | | 8 | 6 | 6 | | | | | 20 |
| Injection well fund | working | | | | | | 7 | 5 | 3 | | | | | 15 |
| Injection well fund | inactive | | | | | | 1 | 1 | 3 | | | | | 5 |
| Injection well fund | pending cancellation | | | | | | | 1 | | | | | | 1 |
| Injection well fund | Total canceled | | | | | | | 8 | 3 | | | | | 11 |

pending cancellation. 127 wells/facilities participated in the exploitation of Horizon.
156 producing (149 oil, 7 gas) and 19 injection wells were drilled in FLD. As of 01.04.2013, there are 79 wells in the operating fund, of which 74 wells are in operation, and 5 wells are in the inactive fund.
12 of these wells in the working fund are sunny bed operated by fountain, and 62 by gas lift method.
There are 6 wells in the facility's injection fund, of which 3 wells are active and 3 wells are inactive. Due to certain geological and technical reasons, 4 wells from the production fund and 3 wells from the injection fund were canceled. 181 wells/facilities participated in the exploitation of Horizon.

The bed is divided into 3 zones: north, center, and south by longitudinal fractures. Wells in operation by zones and horizons are given below,

| | | IV | V | VI | VII | VIII | IX | X | FLD | QUG | QQ | QA | On the bed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North | n | | | | | | 12 | 5 | 3 | 1 | 2 | 3 | 26 |
| | q | 1 | | | | | | | | | | | 1 |
| Center | n | | | | | 6 | 11 | 32 | 64 | | | | 113 |
| | q | | 3 | 6 | | | | | | | 13 | 17 | 39 |
| South | n | | | | | | 17 | 10 | 7 | | | | 34 |
| | q | | | 10 | | | | | | | 3 | 7 | 20 |
| Bed on | n | | | | | 6 | 40 | 47 | 74 | 1 | 2 | 3 | 173 |
| | q | 1 | 3 | 16 | | | | | | | 16 | 24 | 60 |

Table 5.3 Wells in operation by zones and horizons

As a result of the analysis carried out on the Guneshli field, it was found that the implementation of measures to improve the II impact method intended to produce residual extractable oil can give more effective results on the IX, X horizons and FLD in the IX and X blocks. Taking this into account, the remaining recoverable oil reserves were calculated for the objects indicated in blocks IX and X of the field as of 01.01.2013 (See tables 5.1 and 5.2).

It should be noted that the implementation of the improvement of the II impact method in the Guneshli field is mainly planned for the IX, X horizons and FLD in the IX and X blocks. The first recoverable oil reserves on the indicated horizons were 50758 thousand t, and vary in the range of 1182-28249 thousand t.
As of 01.01.2013, if it is taken into account that the amount of oil produced in the specified block (IX, X blocks) and horizons (IX, X and FLD) is 39326 thousand t, then the remaining recoverable oil reserve will be 19432 thousand t.

## 4. Increase of efficiency of water flooding in Gunashli field

In the world experience, the development of oil fields using the injection method is very widespread. Currently, more than 90% of all oil fields are processed using secondary impact methods.Summarizing the experience of the development of deposits shows that, despite the fact that mostly positive results were obtained during the application of the injection process, the results of the application of this method should be widely studied even today. Non- homogeneous formations are not completely covered by the application of the injection process, the increase in the volume of hard-to-extract reserves, the change in the properties of the oil-saturated porous medium, the change in the physical-chemical properties of the formation oil at the final stage of development, and the increase in man-made manifestations in the fields create difficulties for the efficient development process.

In order to create efficient development systems in the fields, in many cases, the recovery of formation energy, the close connection of the injected working agent with the compression of oil in the porous environment of the reservoirs is related to the optimization of injection systems in the development process.

In the early stages of the development of the oil industry in Azerbaijan (until the 1940s), the fields were exploited in the depletion mode, which ensured that the oil yield ratio was up to 36% even in the best case. From the end of the 40s, injection methods were applied in the fields. Currently, three types of injection (behind the contour, along the contour, inside the contour) and their various modifications are used. Injection, being a highly effective method of impacting the formations, keeps the formation pressure stable and increases the rate of development. On the other hand, injection has the effect of reducing the duration of field development, and the evaluation of the effectiveness of the injection process applied in order to ensure the efficient development of oil fields is of great importance.

Azerbaijan, USA, Canada, Russia, Saudi Arabia, etc. In countries, the injection process is intensively applied in the development of oil fields.

Relative simplicity of injection technology, high efficiency, availability of water source and economic efficiency of the working agent have encouraged the wide spread of this method.

The application of injection for a long time in different geological conditions has led to the creation of its various modifications. They are the following;

Contour back waterflooding: With this method, water is injected behind the water-oil contour of the reservoir. The water injected into the formation by this method has a positive effect on the hydrodynamic conditions of the field when the degree of geological diversity in the formation is low, the permeability of the formation rocks is high, and the viscosity of the oils is low. The width of the bed should be up to about 5 km, and if it is larger, its central parts are not affected by the injected water.

Non-water contour waterflooding: The conditions required for the application of this method are similar to the conditions for the application of contour injection. A distinguishing feature here is that the permeability of the layers is relatively low only in the water-oil contour zone. Therefore, placing injection wells far from the water-oil contour and injecting water into the reservoir through them reduces the efficiency of the process. In such cases, placement of injection wells on water-oil contours (internal and external) eliminates this complexity.

Contour internal (field) waterflooding: This method is sometimes called a modification of "field injection". As the name suggests, this method involves the placement of impact wells in the oil field of the field. For the effective application of field injection modification, the oil field of the field should be large, the geological diversity of the formation should be high, the permeability of the rocks should be relatively low, and the viscosity of the oils should be high.

The above methods of injection are given in general. Against the background of this division, injection is carried out in various forms depending on the geological structure: injection in the arch part of the field, injection cutting the oil field, injection in the direction of the axis of the structure for example.

Taking into account the fact that there are enough residual extractable oil reserves (54582 thousand t) in the Gunashli field, it is possible to restore the pressure injection process and achieve high efficiency by rebuilding the injection system. In the Gunashli field, the contour and back contour injection systems are used. Injection, being a highly effective method of impacting the formations, keeps the formation pressure stable, increases the development rate, which ultimately creates conditions for increasing the oil yield coefficient. On the other hand, the injection process helps to reduce the working time of deposits, which is an important factor for marine deposits. Therefore, it is of great importance to evaluate the effectiveness of the applied injection process in order to ensure the efficient working of the deposits in the future.

It is known that the amount of water injected into the formations should be 20% more than the extracted liquid to ensure the effective processing of deposits. Previously, if 2-3 $m^3$ of water were required to extract each 1 ton of oil, now it is necessary to inject 32.3 m 3 of water for this.

In order to evaluate the efficiency of the injection process, a graph of the dependence of oil production on the areas under the influence of injection wells was established. Decline curves obtained and their approximation (Decline curve) [1; 2], a quantitative evaluation of the efficiency of the injection process was carried out.

$$Q(t) = Q_o \cdot e^{-Dt}$$

Here: Q(t) – annual oil production

Q(t) – oil production at time t = 0

D - rate of decline in oil production

A comparison of the actual technological performance indicators of the water-injected object obtained without injection with the calculated indicators characteristic of the operation of the object without injection was made. Also, the calculation results for the water injection period (2013-2022) were extrapolated. The regularity revealed because of the analysis of the actual data on the objects injected with water by analogy method injection has been transferred to the projected objects.

Detailed information about the efficiency of the II impact method on the IX, X horizons and FLD of the Gunashli field is given below.

Sunny Currently, the injection process is carried out through 7 wells on the IX horizon of the field. Considering, the lack of influence of injection wells No. 123 and 125 on the surrounding wells, it was recommended to remove these wells from the injection fund, and to keep 5 wells (Nos. 280, 278, 214, 157,
127) in the injection fund. It is considered appropriate to use the II impact (injection) method to absorb residual extractable oil reserves on the IX horizon.

Operational wells No. 98, 275, 282 are affected by the operating well No. 280. The forecast of oil production from production wells covered by this well during the years 2013-2022 is given in two variants: without the injection process and with the injection process (Table 4.13 and Figure 4.11).

As can be seen from the table, the oil obtained without injection was 143.99 thousand tons, and the oil production obtained with injection was 171.6 thousand tons. Additional oil obtained due to injection was 27.6 thousand tons, which is 19.2% of oil production obtained without injection.

Operational wells No. 281, 241,95, 226 are affected by the operating water well No. 278. The forecast of oil production from production wells covered by this well during 2013-2022 is given in two variants: without injection process and with injection process (Table 4.14 and Figure 4.12).
As can be seen from the table, oil obtained without injection was 124.99 thousand t, and oil production obtained with injection was 148.75 thousand t. Additional oil obtained due to injection was 23.76 thousand tons, which is 19.0% of oil production obtained without injection.

Operational wells No. 148, 149, 147, 120, 126, 114, 158 are affected by the operating water well No.

157. The forecast of oil production from the production wells covered by this well during 2013-2022 is given in two variants: without the injection process and with the injection process.
(Table 4.15 and Figure 4.13).

Various geological and mining factors affect the effective operation of the injection system. Without taking into account these factors, it is difficult to determine the measures that will ensure the effectiveness of the injection process.

It should be taken into account that when applying the injection process, the effect of layer parameters should be studied in a complex way, not separately. Multivariate statistical models are used to study the joint effect of geological-mining factors on injection.

## 4.1 Hydrodynamic model of Water injection and Drlling process in Shallow water Gunashli Field.

4.1.2 FLD and X horizon of the Guneshli deposit, a single geological and update of hydrodynamic models.

During the preparation of oil and gas field development projects, it is necessary to carry out numerous calculations taking into account the influence of various factors in the selection and justification of optimal development systems, various geological-technical measures, methods of influencing the layer. Hydrodynamic modeling of deposits is a very important tool in making all these calculations more accurate and efficient. Reservoir modeling plays an important role not only in saving accuracy and time, but also in gaining a deeper understanding of reservoir structure, seepage-capacity parameters, and fluid seepage properties, and how they change over time and during development.

To build a hydrodynamic model, it is necessary to have the following initial input data:

1. Three-dimensional geological model;
2. Information on the depths and dates of perforations on all wells;
3. production data on all wells in operation from the beginning of operation to the current period ( oil , gas , water ).
4. Information on the entire striking ( water , gas ) wells from the beginning of operation to the current period.
5. Initial and measured current lay pressures and temperature.
6. Physical, chemical and thermodynamic features of oil.
7. Information on phase conductivities.

The modeling process is one such as geophysics, geology, petrophysics and development, it includes several important areas. The hydrodynamic model of the bed is its three-dimensional it is built on the basis of the geological model, and its accuracy is highly dependent on the accuracy of the geological model.

The pumping process of the Guneshli field FLD and X horizon and the gas injection process through the hydrodynamic model, first of all, the existing three-dimensional geological and hydrodynamic models of these horizons should be updated. For this, the database was updated until June 2013. In order to update the database created on the Guneshli field, new information was collected during this period. The new wells No. 160, 209, 210, 211, 240, 301, 304, 305, 306 drilled in the Guneshli field in the last two years have been added to the database, the platforms, coordinates, and inclinometry of these wells have been uploaded to the database. The logging diagrams of those wells were digitized, the ceiling and bottom depths of the X horizon and Fasila formation were recorded and uploaded to the Open Works database.

The newly drilled wells were drilled into the Fasila formation, and the logging diagrams of these wells are a valuable source of information in terms of determining the structure and formation parameters. of sandy-clay thicknesses in X horizon and FLD, three-dimensional distribution of sand and clay facies along the area and depth using the values obtained as a result of the interpretation of logging diagrams; two- dimensional of oil-gas thicknesses ; two -dimensional, three-dimensional distribution of porosity along area and depth ; two-dimensional, three-dimensional distribution of conductivity along the area and depth; Two -dimensional, area and depth distribution maps of water (oil ) saturation have been constructed .

In addition, production, irrigation, and pressure data for wells exploiting the X horizon and Fasila formation until June 2013, as well as information on perforation and cement bridges of wells returned to these horizons from other horizons, were collected and systematized for use in updating the hydrodynamic model. specially formatted.

After that, the restoration of the development date, i.e. the adaptation of the parameters included in the model to the actual values (adaptation process) began. Usually, in the process of adaptation, attention is paid to the overlap of more precisely measured parameters. For our case, since the prices of oil, gas, water production and pressure are considered more accurate and informative, adaptation of these parameters was taken as a basis. The overlap of the initial balance reserves indicates the accuracy of the geological model, that is, the collection properties of the layers used in this model are very true. However, these parameters are not enough for the adaptation of the hydrodynamic model. The most important parameter for the complete adaptation of the hydrodynamic model is the values of the relative phase conductivities. The correct values of this parameter mean that the percolation equations and hydropermeabilities of the formations describe the ongoing processes more accurately and the process of predicting the performance indicators is accurate. Values of relative phase conductivities for FLD were obtained by processing based on core data.

The history of development in the hydrodynamic model of the X horizon and the Interval Formation was restored, and the model was fully prepared for the calculation of the efficiency of the injection and gas injection processes in these horizons.

Wells No. 17, 67, 111, 121 (FLD) and 99, 124, 136, 153, 223, 291 (X horizon) were selected in order to intensify the process of pumping the Guneshli field into FLD and X horizon . In the break formation, water injection is planned in A, B, C and D formations throughout the formation. These wells were placed as irrigation wells in the hydrodynamic model and their relationship with operational wells in the area of influence was analyzed, the logging diagrams of these wells were correlated by indicating the existing perforation intervals. Correlation schemes are shown (Figures 5.1-5.4).

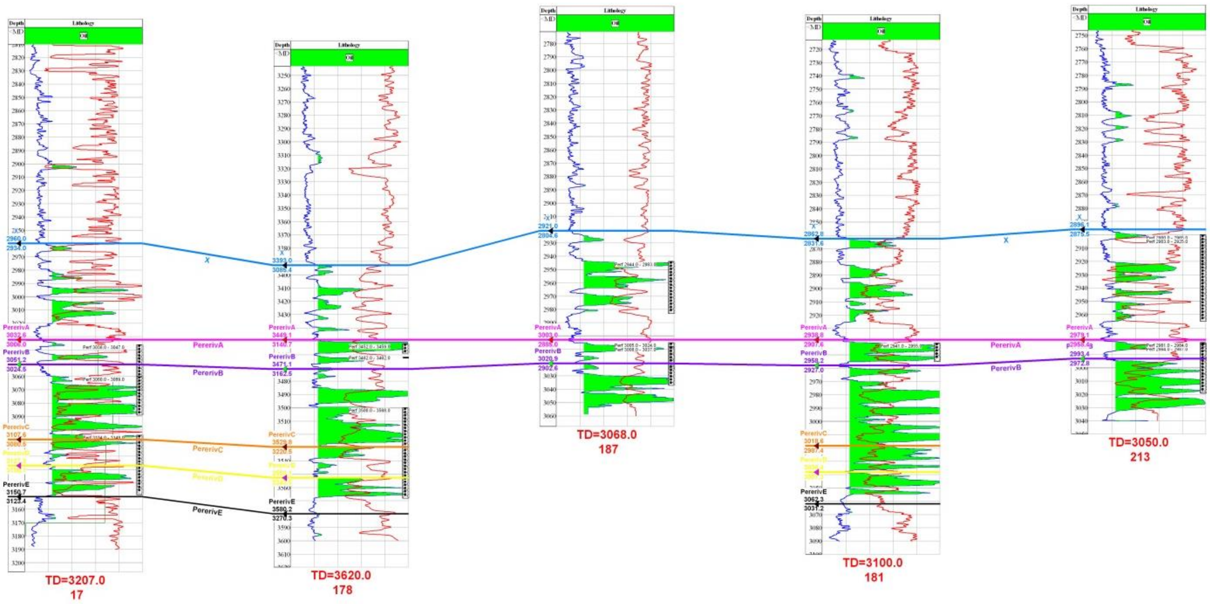


Fig. 5.4 Correlation of well No. 17 with surrounding wells under influence

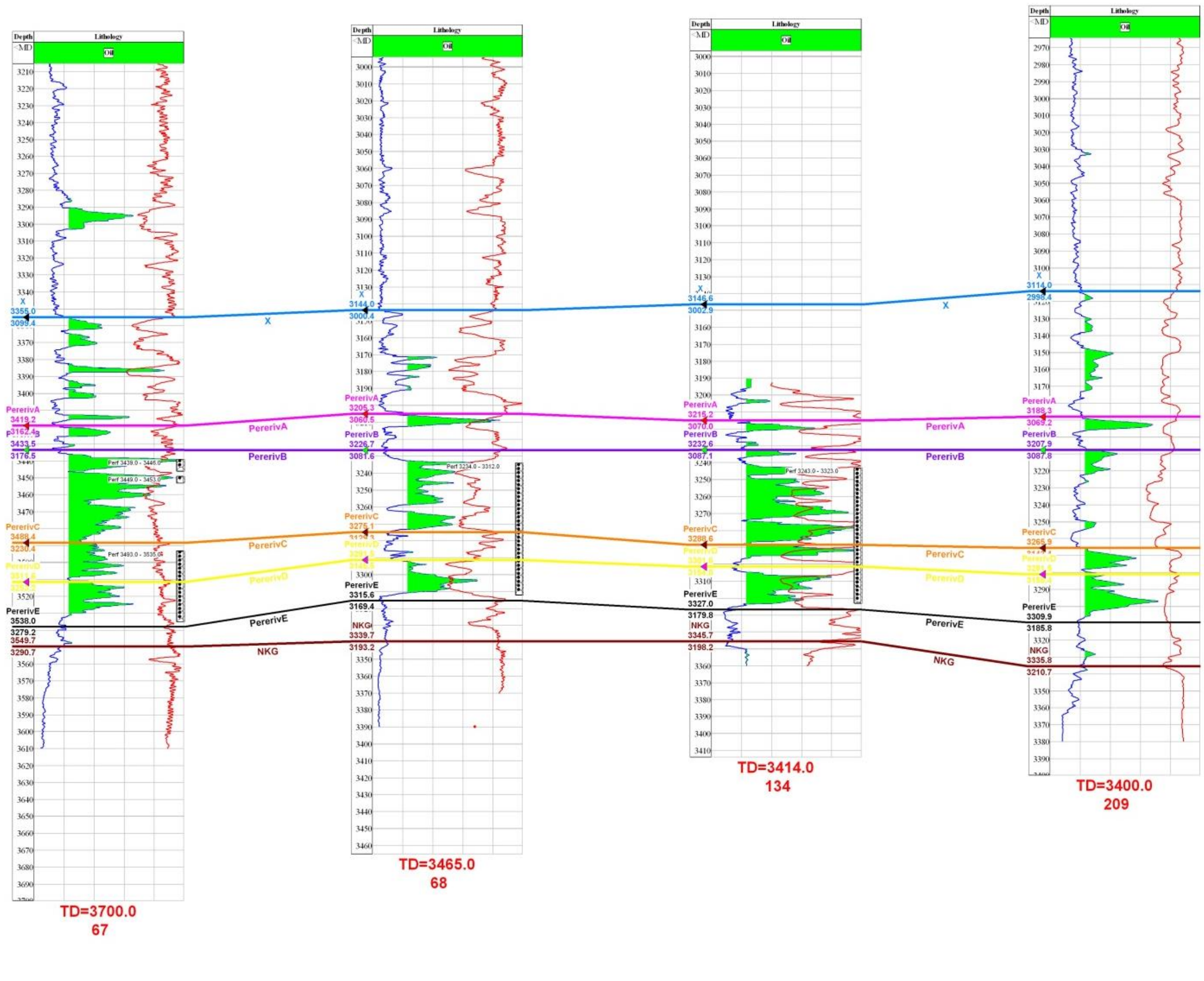


Fig. 5.5 Correlation of well No. 67 with surrounding wells under influence

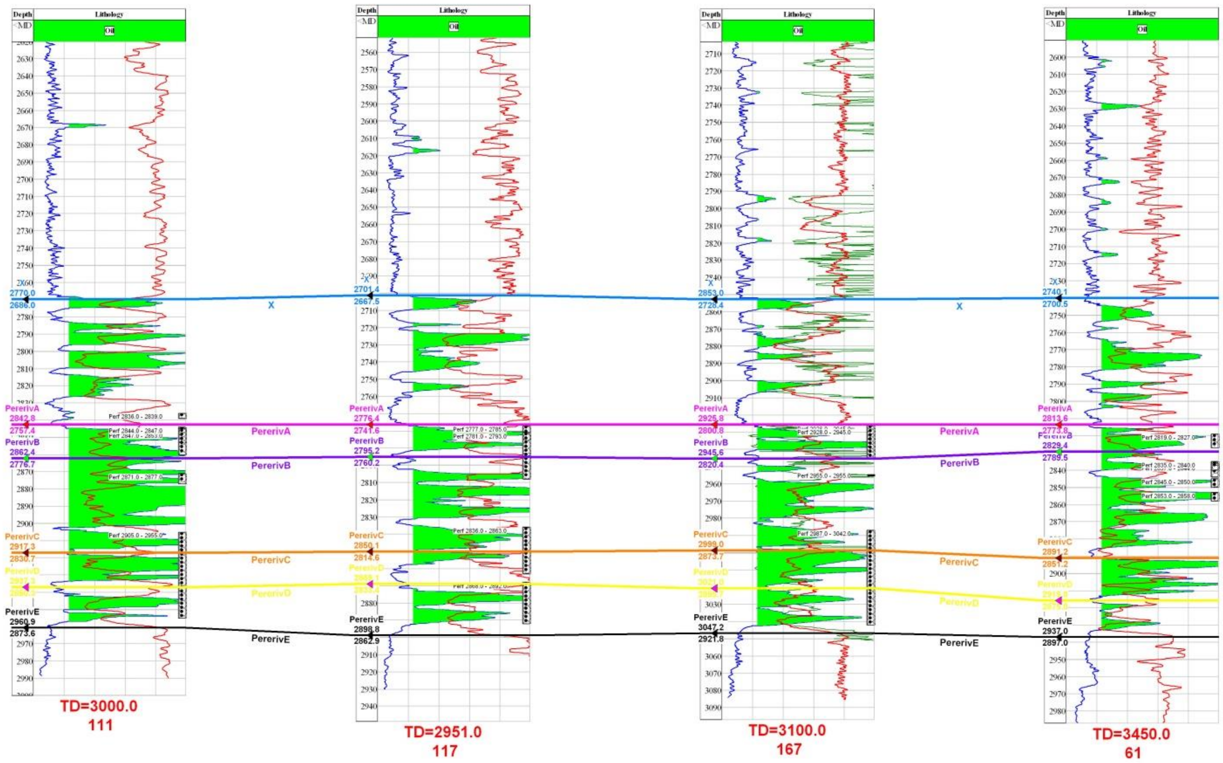



Fig. 5.6 Correlation of well No. 111 with surrounding wells under influence

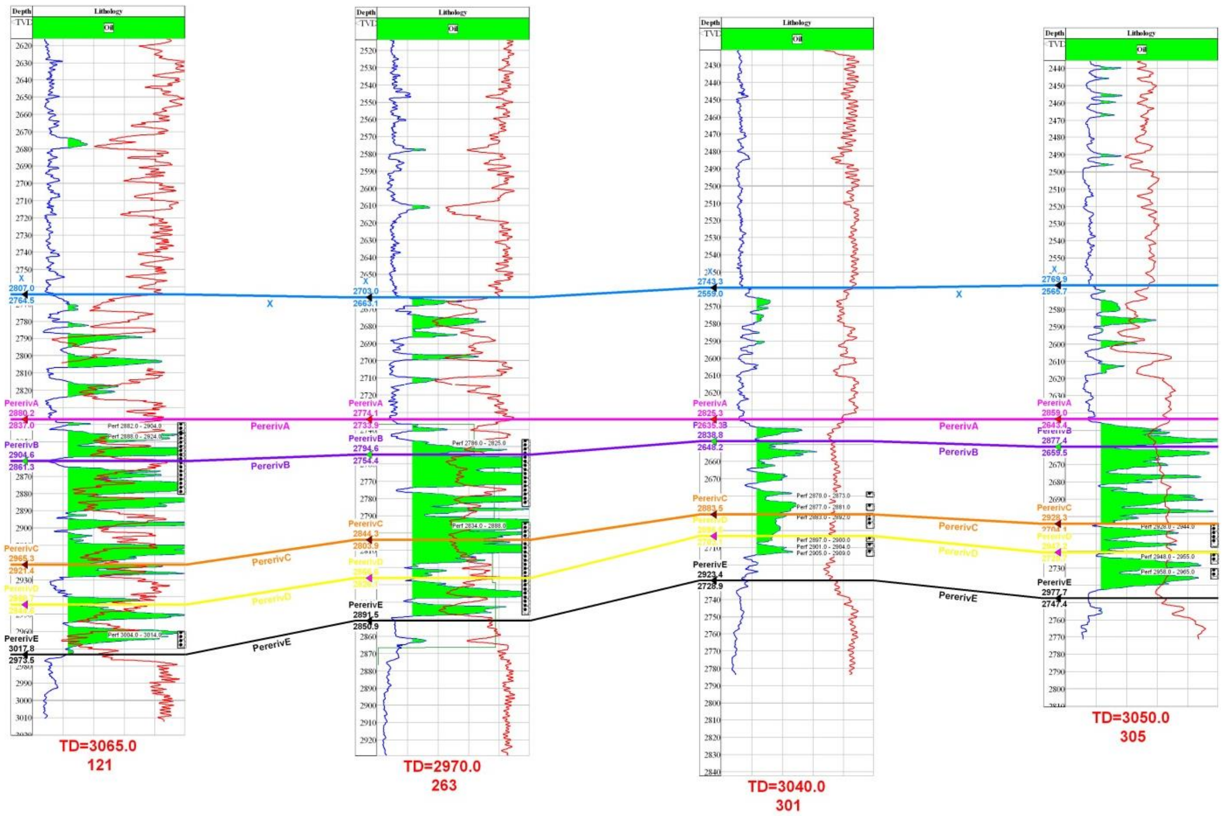



Fig. 5.7 Correlation of well No. 121 with surrounding wells under influence

## 5. Geological and Technical Problems of Gunashli field

To effectively carry out the process of artificial influence in the beds, the following problems must be solved:

1. Time to start injection. It is known from the world oil extraction experience that it is appropriate to start the injection process after some time after starting the development of fields - when a small amount of degassing occurs in the formation, when the formation pressure is 10-20% lower than the gas dissolution pressure in oil. After this period, the movement of water in the formation can be effectively controlled. However, the subsequent degassing of the reservoir has a negative effect on the full exploitation of the reserves of the reservoir. In this case, the oil's viscosity increases, and accelerating its movement through water injected into the formation creates great difficulties and this problem can be solved as a result of the application of the third type of influence methods.

Injection in some beds started at the time of commissioning, which creates positive conditions for obtaining a high oil yield coefficient.

In other cases, the application of injection is started after a long time has passed after the working of the beds, and the application of injection is relatively effective. Long-term development processes until the application of the injection process led to the uneven absorption of the initial resources of the formation, and the decrease of the energy of the formation at different rates on the site. In such cases, the water injected into the layer moves unevenly and can lead to the formation of "water tongues" of different scales.

2. Location system of wells. It is known that the efficient development of oil and gas fields depends on the density of the well network and the placement system. This dependence is more pronounced when the development process is carried out by injection. When the area of the bed is small, the method of contour injection or contour injection is applied in its development system. The number and density of drilling and production wells depends on the geological-hydrodynamic properties of the reservoir.

In the conditions of highly permeable and geologically homogeneous layer, the back-contour modification of injection is applied, and it is assumed that the injected water will move freely in the layer. Otherwise, the impact wells should be placed close to the water-oil contour, and the distance between them is determined as a result of geological-hydrodynamic studies.

If the field is characterized by high geological inhomogeneity, if the viscosity of oil is high, if the rocks have poor permeability, the series of injection wells should be alternated with the series of production wells, which is called a single-row system of injection. If the geological-hydrodynamic environment of the reservoir is considered satisfactory, two-, three- and five-row systems can be applied. The latter system can be applied only when the bed is characterized by an ideal property for development, which means that the water injected into the bed will penetrate all its parts.

3. Injection rate. The volume of water injected into the fields in the process of injection should be 10-20% more than the volume of the total fluid produced from the field (oil and water) in formation conditions. When the volume of injected water is less than the volume of fluid produced from the formation, it does not fully compress the oil accumulations in the rock pores, which leads to uneven distribution of residual resources in the developed formation.

4. Stopping the injection process. When the percentage of water in the fluid produced from working wells located around the contour of the field reaches a very high level (80-90% and more) in the process of injection of the contour or the contour, the striking wells should be gradually maintained.

In the field injection process, in cases where production in the field increases sharply, in order to prevent the formation of "water tongues", some injection wells should be stopped. In all cases, the direction of movement of water injected into the formation should be determined by geological-mining methods (on the basis of production, formation pressure, etc. data).

5. Prediction of the effectiveness of the injection process. The effectiveness of the injection process should be predicted, as well as all geological-technical measures applied in the development of deposits. To solve this problem, the specific layer parameters that affect the effectiveness of the process should be determined.

The generalizations show that the following parameters have the most influence on the injection process: permeability of formation rocks, sandiness, hydro permeability of formation, viscosity of oil, ratio of viscosity of water and oil, density of the well network, injection system and development rate. Based on the indicated data, the efficiency of injection can be determined by applying statistical and dynamic models.

The conducted studies show that the optimal volume of water injected into the FLD should be calculated on the injection wells (in the VIP program) to efficiently absorb the remaining recoverable oil reserves of the field in the DaySG area. In addition, a proper network of circular injection wells should be selected, considering the areas of influence of the injection wells. During the selection of wells, geological and technical conditions, optimal amounts of water consumption for wells should be calculated. To look at these issues in a comprehensive way, the optimal injection well network was selected using geological-mathematical models (Figure 5.8) and its efficiency was calculated (Table 5.4).

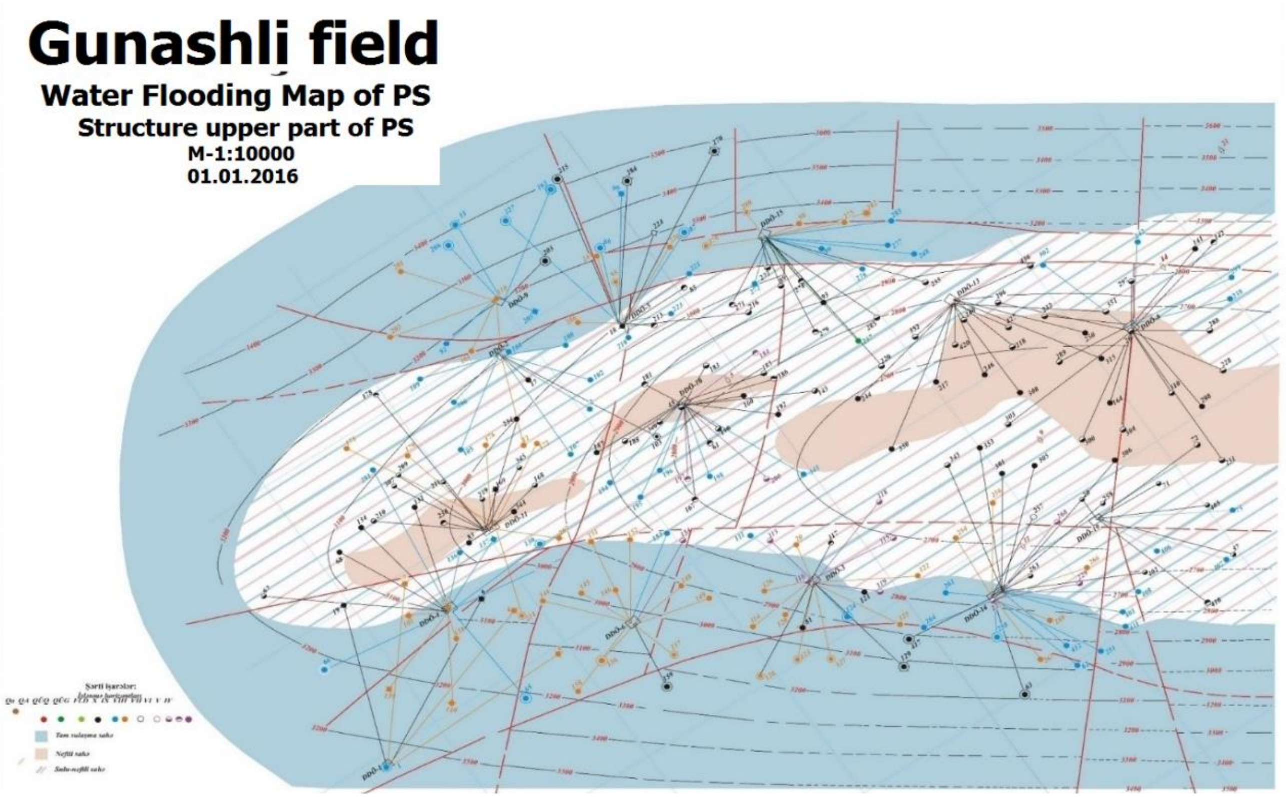



Fig. 5.8 Flooding map of Gunashli field FLD.

The Pereriva Suite development started in 1980. In the first-time installation of production platforms were carried out comparatively shallow water area. In that area sea depth was 80-150meter.And the installation of production platforms takes a long time. Therefore, drilling of production wells has taken more down-tempo, mainly in the north-east and south-western areas of the fold. The number of the completed drilling wells was around4 or 5 wells per year at the build-up period of development. Oil production rate of this wells was in the range 350 - 450 tons per day. Gradually, oil and gas production of PS was intensified. The annual oil production rate and initial recoverable reserve of PS increased up to 5-7%.

From beginning of field development 169960 thousand tons of oil, 189357 thousand tons of liquid, 46664 MMSCM dissolved gas, 45659 MMSCM natural gas, 3691 thousand tons of condensate produced from the field.

Table 5.4

Schedule of incremental oil production from affected wells based on the volume of water to be injected per FLD.

| Intended injection wells | Volume of injected water, $m^3$ /Day | Affected production wells | Oil production, thousand t (during 2014-2024) | | the difference |
|---|---|---|---|---|---|
| | | | Without injection | with injection | |
| 67 | 1200 | 134 | 87.74 | 144.59 | 56.85 |
| | | 209 | 49.92 | 111.65 | 61,73 |
| 17 | 1200 | 178 | 91.63 | 105.13 | 13.50 |
| | | 181 | 104.50 | 195.41 | 90,91 |
| | | 213 | 71.39 | 110.56 | 39,17 |
| 111 | 700 | 61 | 239.58 | 322.25 | 82.67 |
| | | 117 | 86.15 | 142.91 | 56,76 |
| 121 | 1200 | 263 | 14.91 | 15,32 | 0.41 |
| | | 305 | 171.11 | 182.74 | 11.63 |
| Total | 4300 | 12 | 1944 | 2297 | 352 |

FLD is currently being injected through 3 wells (417, 122, 159). Considering, the lack of influence of these injection wells on the surrounding wells, it was recommended to remove these wells from the injection fund. The current condition of operational wells 67, 117, 111 and inactive fund 67, 117, 111 and 17 in the non-active fund under FLD was examined, considering that they have low production, it was proposed to use them as injection wells. Oil production obtained without injection on FLD is 36502.9 thousand tons. With injection (that is, when the volume of injected water is 1200 $m^3$/day), 38925.7 thousand tons of oil are obtained, which is 2422.8 thousand tons more than the oil production obtained without injection, that is, 7%. Therefore, it is reasonable to increase the volume of water pumped in the existing injection wells to 1200$m^{3.}$

After 2010, production exceeds forecast prices. This gives us reason to think that the water injected into the layer in the DSG area has an effect on the FLD. So, according to the forecast prices, the oil production collected during the last 5 years will be 17423 thousand tons, but 17957 thousand tons have been produced (picture 5.8).

However, 11,399 thousand tons of oil were extracted from those operational wells as a result of the water injected in the DSG area. As a result of the water injected in the DSG field, 1741.3 thousand tons of additional oil was produced from the wells of the Gunashli field located on the border and under control. This, in turn, means an additional daily oil production of 1,755 tons.

In 2013, due to the reduction in the rate of drilling in the DSG field, oil production decreased. Studies conducted in several wells in that area show that due to the start of injection, the reservoir pressure has increased in this area. In order to improve the injection system on the field, research was conducted in the IX and X horizons and a new network of injection wells was selected. The optimal network of injection wells and the consumption of water injected into the formations for the entire Gunashli field were calculated and an action plan was prepared (tables 5.4). The current results of the injection process carried out in the Gunashli field since 1986 are listed in the table below (table5.4).

The current state of injection once again shows that there is a need for further improvement of the process in the Gunashli field. The bed compensation factor is only 0.23. Geological measures should be taken in some injection wells. Due to the geological measures carried out in the surrounding wells (returning to another horizon, opening a new filter, etc.), the number of operating wells in the impact area of the impact wells has decreased or there are no wells.

Table 5.5

The table of injection process carried out in Gunashli field.

| Horizon | Injection history | Number of production wells | Number of tapping wells | Liquid production since the beginning of development, thousand tons | Total volume of injected water, thousand m3 | T is the coefficient of drag from the beginning of the impact |
|---|---|---|---|---|---|---|
| IX | 2009 | 39 | 9 | 7089.2 | 4702.9 | 0.66 |
| X | 1986 | 49 | 5 | 38300.8 | 15171.8 | 0.40 |
| FLD | 1986 | 83 | 2 | 126083.3 | 19770.1 | 0.16 |
| Total | | 171 | 16 | 171473,3 | 39644.8 | 0.23 |

In the Neft Daslari field (Block V), the injection process has been applied since 1962 (table 5.5). In the V tectonic block, 199,000 $m^3$ of water is being injected into VII, VII, VIII, X and FLD in the current year. IX, QUQ, QD-2, QA-1 operating facilities, injection processes were stopped at various times due to technical problems. From the analysis of the development, it is clear that the reception of the layers and the effect of the injection process were satisfactory.

## 6. New approach for Increasing Water Injection

The specific importance of the Gunashli field in the oil industry of the Republic of Azerbaijan is very large. Implementation of technical and technological measures aimed at stable maintenance and increase of oil production in this field is of great importance. One of such measures is the application of the process of injecting water into the formation along the IX, X horizons and FLD of the field. Wells No. 280, 278, 214, 157 and 127 in the working injection fund in the IX horizon were accepted as injection wells. According to the water pumped from these wells, the following wells are covered: 98, 275, 282, 281, 241, 95, 226, 293, 138,144, 148, 149, 147, 120, 126, 114, 158, 125, 255, 267. On the other hand, the volume of water pumped from these wells is also different: 600 $m^3$ /day from pumping well No. 280, 900 $m^3$ /day from well No. 278, 550 $m^3$ /day from well No. 157, and 250 from each of wells No. 214 and 127. $m^3$ /day water is pumped. In this horizon, operational well No. 110, intended as a water well, includes wells No. 3, 202, 161, 212, and 94. The volume of water pumped from this well is 500 $m^3$ /day. Keeping wells 258, 124 in the operational injection fund on the X horizon as injection wells was accepted. According to the water pumped from these wells, the following wells are covered: 266, 251, 62 and 261. On the other hand, the volume of water pumped from these wells is also different: 500$m^3$ /day from water pumping well No.258, and 900 $m^3$ /day from well No. 124 water is injected.

The injection wells numbered 136, 291, 223, 99, 153, intended as injection in this horizon, include wells numbered 135, 292, 107, 166, 171, 106, 105, 170, 177, 219, 182, 272, 2,102, 108, 277, 248, 283, 194, 619, 1919, 1919. 500 $m^3$ /day of water is pumped from each of these wells. Wells No. 67, 17, 111 and 121 intended as injection from the operating fund under FLD68, 134, 209, 178, 187, 181, 213, 117, includes wells 167, 61, 263, 301 and 305. The amount of water pumped from wells No. 67, 17 and 121 is 1200 $m^3$ /day, and from well No. 111 is 700 $m^3$ /day.

## Basis of Comparison

The oil production before and after the introduction of water injection process from operational wells was taken as the basis of comparison.

## Factors Ensuring Economic Efficiency

Obtaining additional oil production by applying the water injection process to the wells in the IX, X and FLD horizons of the Gunashli field.

## Calculation of Expected Economic Efficiency

The following formula of the "Methodical Guide on determining the economic efficiency of projects in the oil and gas complex" developed by the "Oil and Gas Research Project" Institute was used to calculate the economic benefit from the application of new techniques and technology:

$DXM = [(1-0.20635) * \Delta MQ \pm TTX - \Delta MN] * \alpha$

Here: DXM – discounted net product, man

Q – price of 1 ton of oil (project, budget, world)
man

TTX – technology implementation costs, man
N – normative variable costs per 1 t of oil, man/t

$\Delta$MN – total conditional-variable costs, man

$\alpha$ – discount factor, part of the unit.

For the calculation of the economic efficiency, the following preliminary data were accepted: the cost of pumping 1m $^3$ of water -0.87man/m3 (taken from the actual material of the NQCI), the cost of oil processing -
89.64 man/t (decision of the Price Council of SOCAR); conditional-variable cost norm-1.98 man/t (from the actual materials of NQCI
taken). The price of 1 ton of oil in the calculation of economic efficiency: 289.32 manat/t (project price, decision of the Price Council of SOCAR); 337.0 man/t (formation of the revenue part of the budget of the

Republic 1 barrel = 60$), 635 man/t (the world price of oil as of 14.10.2013) were taken. The results of the report are given.

It should be noted that the DXM > 0 condition was met when water was injected in the IX, X, FLD horizons at all three price levels of oil, whether in working wells or planned wells, which indicates that the process of water injection in the Gunashli field is economically efficient.

## Conclusion and Suggestions

Summarizing the above, the following general conclusion can be reached.

As is known, the Gunashli field was exploited in the mode of reservoir energy depletion until 1986. In order to increase the efficiency of the operating facilities, the process of injection was applied on the layers. Starting from 04.04.1986, water has been pumped into the X horizon through well No. 1 located in the southwestern wing of the field with a daily injection volume of 259 $m^3$. Later, this process included FLD and IX horizon.

As of 01.04.2013, 26 water wells were drilled in the field in order to keep the formation pressure stable and increase the development rate. At present, the process of injection continues in the field, and during this period, a total of 34062.8 thousand $m^3$ of water was pumped into the objects of the field, in addition, 7199 thousand tons of oil were obtained.

In order to absorb residual extractable oil reserves on the Gunashli field, the goal is to select the optimal option for the restoration of the injection system on the IX, X horizons and FLD. That is, determining the location, number and volume of water to be pumped for new injection wells on these horizons is considered one of the main issues. For this purpose, it was recommended to maintain 5 wells in the operational injection fund on the IX horizon, and transfer 1 well in the operational fund to the injection fund, and the volume of water to be pumped from these wells should be 3550 $m^3$. Maintenance of 2 wells in the operational injection fund on the X horizon, transfer of 1 well in the inactive fund and 4 wells in the operating fund to the injection fund, and the water volume to be pumped from these wells daily is 3900 $m^3$ to be held in the injection fund and the daily volume of water to be pumped from these wells should be 4650 $m^3$. The efficiency of these selected injection wells has been evaluated and economically justified. It was recommended to maintain 7 wells in the working injection fund of the Gunashli field, and transfer 11 wells in the operating fund to the injection fund. Thus, as a result of the application of the II influence method, 250.97 thousand tons of additional oil is expected to be extracted according to the operational pumping fund, and 1019.85 thousand tons according to the intended pumping fund. The effectiveness of the II influence method is economically justified. That is, if the price of 1 ton of oil is: 289.32 manats/t (project price, decision of the Price Council of SOCAR), 118887.7 thousand manats; If it is 337.0 manat/t (formation of the revenue part of the budget of the Republic) 158628.4 thousand manat, 1 barrel=$60; If it is 635 manat/t (the world price of oil), it is expected to be 407008.2 thousand manat.

## References


1. Abdus Satter, Ghulam M. Iqbal, Reservoir Engineering, The Fundamental simulation management of conventional and unconventional Recoveries, 2016.
2. Abasov, M. T., Dzhafarov, I. S., and Dzhafarova, N. M., 1983. Application of the double Fourier series for geologic mapping: Baku, *Proceedings of the Azerbaijan Academy of Sciences,* Earth's Science Series.
3. Abramovich, M. V., 1948. *Exploration for Oil and Gas Accumulations:* Baku, Azgostoptekhizdat Publishing House.
4. Akhmedov, G. A., 1957. *Geology and Oil Content of Kobystan Region:* Baku, Aznefteizdat Publishing House.
5. A Holistic Review of the water injection process, B. Palssan, D.R.Davies, 2003
6. Aquifer Influx Versus Water Injection in GoM, Mohammad Reza Fassihi; J. P. Blangy 2022
7. Buryakovsky, L. A., Dzhevanshir, R. D., and Chilingarian, G. V., 1991b. Mathematical simulation of sediment compaction: Amsterdam, Elsevier Science Publishers, *Journal of Petroleum Science and Engineering*.
8. Christensen J.R., SPE, and Stenby E.H., SPE, IVC-SEP,DTU, and Skauge A., SPE, Norsk Hydro A/S. 2001 "Review of WAG Field Experience" Paper (SPE 71203) was revised for publication from paper SPE 39883, first presented in the 1998 SPE.
9. Experimental Investigation of Clay Minerals' Effects on the Permeability Reduction in Water Injection Process in the Oil Fields**,** Saeed Abbasi; Abbas Shahrabadi; Hassan Golghanddashti, 2011.

10. Farid Babayev, Estimation of water Alternating Gas (WAG) injection performance of an offshore field using a sector simulation model, 2008.

11. Fetchovich M.I. , Fetchovich E.I. , Fetchovich M.D. Useful concepts for decline curve forecasting, reserve estimation, and analysis. SPE 28. 628, February 1996.

12. Grachevskiy, M. M. et al., 1982. The reef margin of the South Caspian Basin and its petroleum prospects (southwestern Turkmenia): *International Geology Review,* Vol. 24, No. 7, 807–813.

13. Gurevich, A., Chilingar, G., and Aminzadeh., F., 1994. Origin of formation fluid pressure distribution and ways of improving pressure prediction methods: *Journal of Petroleum Science and Engineering,* Vol. 12.

14. Нариманов А.А. Дифференцированный подход к оценке углеводородного потенциала верхних горизонтов ПТ месторождения Гюнешли. Baku: SOCAR, 2010 г., Азербайджанское нефтяное хозяйство, стр.

15. ipra, I., Azkawi, A., Ibrahim, B. et al. 2009. Dump Water Flooding Trials in Petroleum Development - Oman.Presented at the Middle East Artificial Lift Forum, Paper MEALF 4768855

16. Interference Analysis in Reservoirs with Bottom-Water Drive During Water Injection Processes Through Subsurface Connectivity Vladimir Martinez; Erdal Ozkan; Heber Cinco Ley, 2022

17. Islamov Fuad F, khazar university water injection in Azeri Chirag-Gunashli oilfields, 2009.

18. İsmayılov Ş.Z. Günəşliyatağındanqazhasilatınıncarivəziyyətivə artırılması perspektivləri. Bakı: ARDNŞ, 2006, AzərbaycanNeftTəsərrüfatı.

19. James G. Speight, Heavy oil production processes, 2013.

20. James Sheng, Enhanced oil Recovery in shale and tight reservoirs, 2019.

21. Jensen, Marc Daniel, A study of waterflood sweep efficiency in a complex viscous oil reservoir, university of Alaska, 2014

22. Jeyhun Alipanakhov, Khazar University Analyzing and intensification field development of shallow water Gunashli ,2017.

23. Johne Alex Larsen and Arne Skauge, Norks Hydro ASA, 1999 “Simulation of the Immiscible WAG Process Using Cycle-Dependent Three-Phase Relative Permeabilities” (SPE 56475) SPE Annual Technical Conference and Exhibition, Houston, Texas, October 1999

24. Khain, V. Ye., 1954. *Geotectonic Bases for Oil Field Exploration:* Baku, Aznefteizdat Publishing House.

25. Larry W. Lake. 1989 “Enhanced Oil Recovery” University of Texas at Austin, Prentice-Hall, Inc

26. Lackland S.D., SPE-AIME, Hunt Oil Co., Hurford G.T., SPE-AIME, Hunt-Oil Co., “Advanced technology improves recovery at Fairway” (SPE 3773) SPE-AIME symposium on Improved Oil Recovery Tulsa, Okla., April 16-19, 1972

27. Landmark Graphics Corporation “Landmark VIP User’s Guide”, 2001, 2002

28. Leonid A. Buryakovsky, George V. Chilingar Fred Aminzadeh. Petroleum Geology of the South Caspian Basin. 2001.

29. L. Dake, The practice of Reservoir Engineering, 2004.

30. L. Buryakovsky, Fred Aminzadeh, G.V. Chilingarian, Petroleum Geology of the South Caspian Basin, 2001.

31. Linda S. Smith-Rouch, Gale A. Norton, P. Patrick Leahy.Oligocene–Miocene Maykop/Diatom Total Petroleum System of the South Caspian Basin Province, Azerbaijan, Iran, and Turkmenistan. Reston: Geological Survey, 2006.

32. Mirchink, M. F., 1939. *Oil Fields of Azerbaijan:* Baku, AzGONTI Publish- ing House.

33. Moffitt P.D. and Zornes D.R., Philips Petroleum Co. SPE Copyright 1992, “Postmortem Analysis: Lick Creek Meakin Sand Unit Immiscible CO2 Waterflood Project”. (SPE 24933) 87th Annual Technical conference and Exhibition of the SPE, Washington, DC, October 4-7, 1992.

34. Mustafa Cobanoglu, Turkish Petroleum Corp.,TPAO 2001 “A numerical study to evaluate the use of WAG as an EOR method for oil production improvement at Baty Kozluca field, Turkey” (SPE 72127) SPE Asia Pacific Improved Oil Recovery Conference, Kuala Lumpur, Malaysia October 2001.

35. New Approach to Integrate Reservoir and Geological Information in Complex Fluvial-Stratigraphic Environments to Determine Potential Areas for Water Injection Processes J. R. Sandoval; C. Soto; H. Pérez; J. Sandoval; M. Trujillo; R. Castro; V. Gomez; F. Cárdenas; E. Rodriguez, 2009.

36. Nidia A. Crogh, SPE; Karen Eide; Siv E. Morterud, SPE all with Statoil ASA 2002 “WAG injection at the Statfjord field, a success story” (SPE 78348) SPE 13th European Petroleum Conference, Aberdeen, Scotland, U.K., 29-31 October 2002

37. *Oil and Gas Journal*, 1990. Soviets’ Caspian Sea drilling activity falls. Apr. 30.

38. *Oil and Gas Journal*, 1992. C.I.S. petroleum ventures proceed at fast clip, Vol. 90.

39. Robelius, Feygin and Ryzhik and.Theoretical production profile of an oil field, describing various stages of development in an idealized case. 2001, 2007.

40. Samedov, F. I. and Buryakovsky, L. A., 1956. Chemical composition and origin of formation waters at Neftyanyye Kamni (Neft Dashlary Field): Baku, *Transactions of the Azerbaijan Academy of Sciences,* Vol. 12.

41. Samedov, F. I., 1959. *Neftyanyye Kamni (Neft Dashlary Field). Geology, Oil Potential and Field Development:* Baku, Azerneftneshr Publishing House.

42. Sheriff, R. E., 1984. *Encyclopedic Dictionary of Exploration Geophysics*, 2nd

43. edition: *Society of Exploration Geophysicists.*

44. SOCAR proceedings (proceedings.socar.az).

45. Stephane Lanchec, (University of London) Department of Earth Science and Engineering, Centre for Petroleum Studies, Thesis, September 2005 “Impact and Management of Rate Dependence in a Gas Flood (Azeri Field) (Azerbaijan)”.

46. SPE, EUROPEC Distribution of Clay Mineral Assemblages in Lower Pliocene Sediments, Western Flank of the South Caspian Sea. Copenhagen: s.n., 4-7 June 2012. p. Denmark.

47. Taheri A. And Sajjadian V.A., SPE, NIOC, SPE Copyright 2006, “WAG Performance in a Low Porocity and Low Permeability Reservoir, Sirri-A Field, Iran” (SPE 100212) 2006 SPE Asia Pacific Oil&Gas Conference and Exhibition Adelaide, Australia, 11-13 September 2006.

48. The state statistical committee of the Republic of Azerbaijan (stat.gov.az).

49. Transforming Water Injection Process With Real Time Automation, Muhammad Zakwan Mohd Sahak; Eugene Castillano; Tengku Amansyah Tuan Mat; Maung Maung Myo Thant, 2021

50. Vassoyevich, N. B., 1930. On classification of oil accumulations in Azerbaijan: Moscow, *Oil Economy*.

51. Vladimir Vishnyakov, Baghir Suleimanov, Ahmad Salmanov, Eldar Zeynalov, Primer on Enhanced oil Recovery, 2020.

52. William B. Wethington, Cris Reddick, and Bahram Husseynov, BP 2002, “Development of a Super Giant, ACG Field, Offshore Azerbaijan: An Overview” AAPG Annual Meeting, March 10-13, 2002, Houston, Texas.

53. Zhang Jinghcun, Xie Shangxian, Han Peihui, Chen Jiabao, Zhang Zhenghua, Guo Encang Daqing Petroleum Administrative Bureau, SPE Copyright 1995 “Field Test of Immiscible CO2 Drive in Daqing Oil Field” SPE 30847.