CHAPTER IV

RESULTS AND DISCUSSION

4.1 History Matching

There are 21 wells located on the C platform. In this work, 17 wells are selected for the history match. During the history matching process, since, the reservoir properties from the raw data are uncertain. They may be changed to get the calculated results match with the real one.

An example of a good match and poor match is well C-19 and C-12 respectively.

4.1.1 Example 1: well C-19

A schematic for well C-19 is shown in Figure 6.1. The well penetrates through 11 sands: two of which are gas sands and six are oil sands. Three sands have oil water contacts while two have gas water contacts. These three are full to base oil sands that have no water contact. The perforation is based on bottom up policy that is the unrisky oil bearing sands have been perforated in first batch while the risky sands with water contacts will be perforated at latest stages.

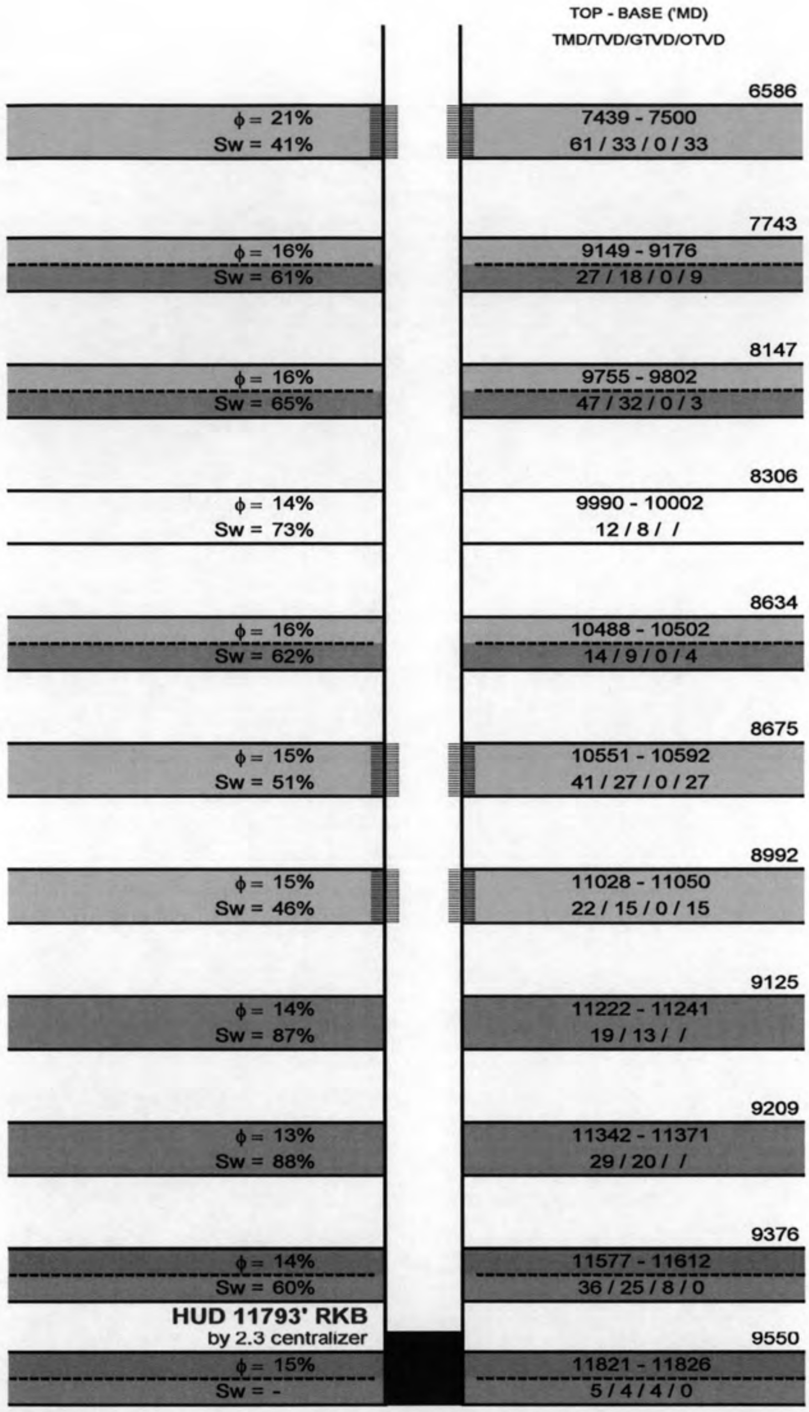


Figure 4.1: Schematic of well C-19 having multiple stacked sands.

Note: Green color	=	oil sand
Pink color	=	gas sand
Blue color	=	water sand
No color	=	not sure (not produce)

History matching for C-19

where Actual = Actual data

Simulation = Simulation Result

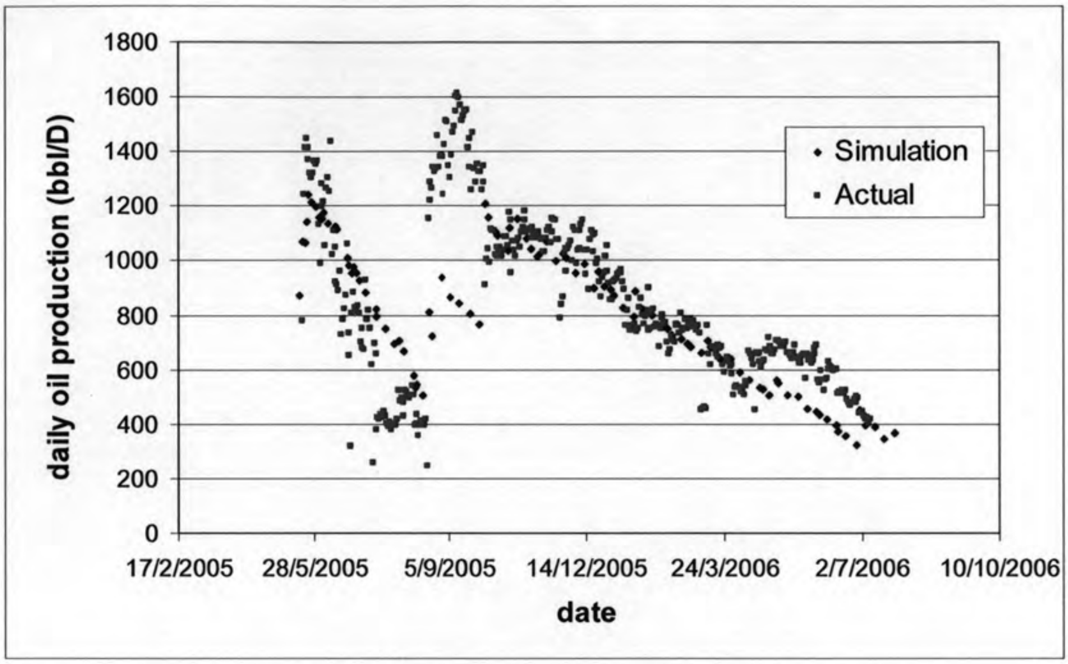


Figure 4.2: Daily oil production for C-19.

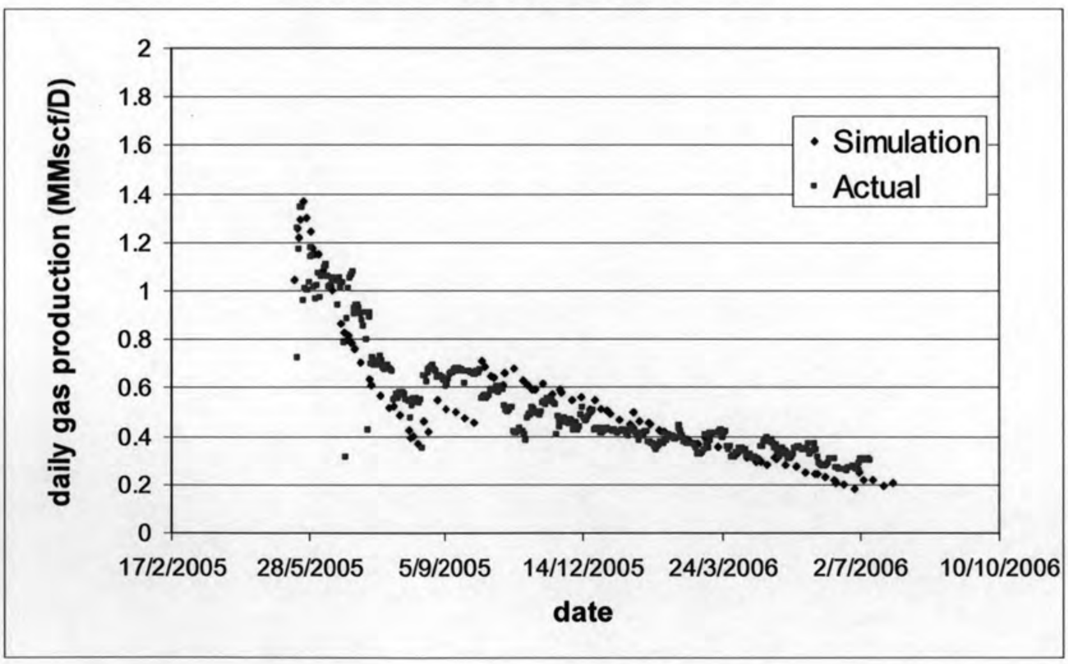


Figure 4.3: Daily gas production C-19.

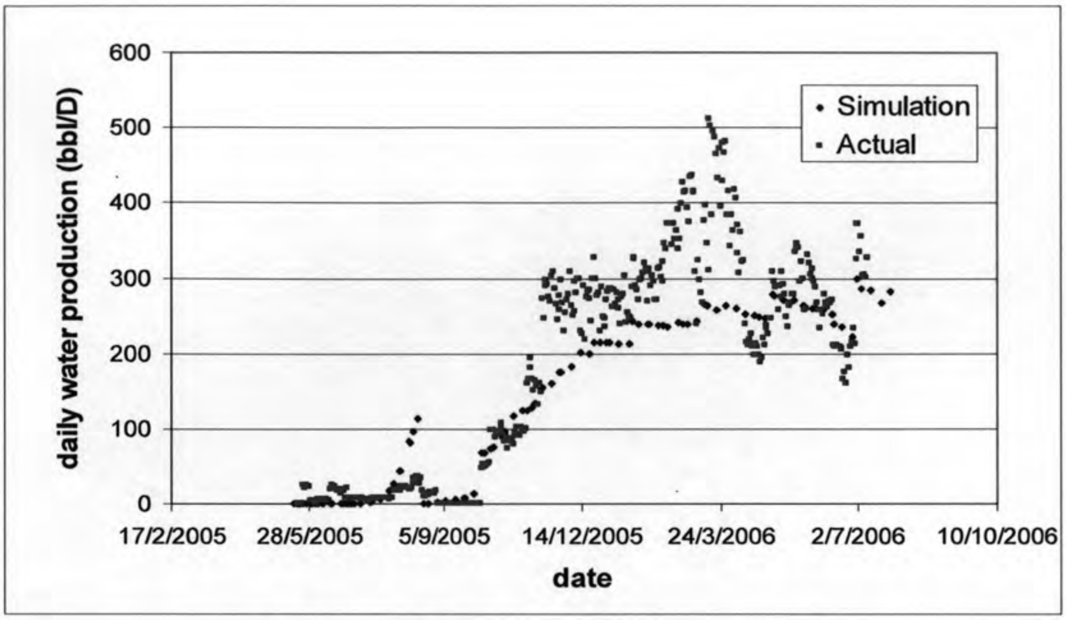


Figure 4.4: Daily water production for C-19.

The results of history matched of well C-19 are quite good. The daily production rates of oil, gas, and water obtained from this model are shown in Figures 4.2-4.4. The results from the simulation are very close to the actual production, and hence representing a good match. On a larger scale the cumulative productions also need to be compared for consistency. The cumulative production comparisons are shown in Figures 4.5 and 4.6.

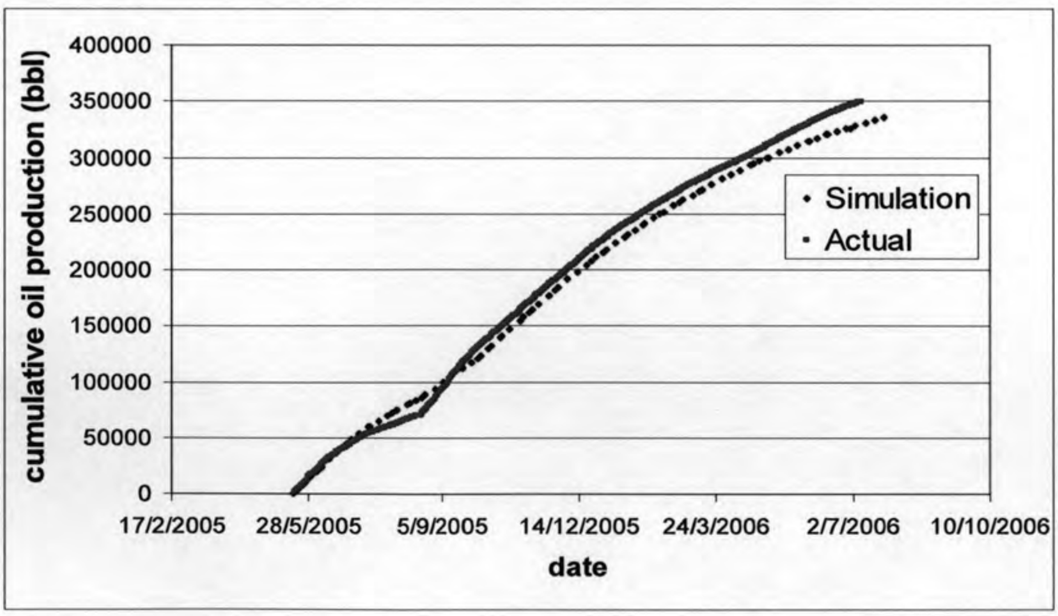


Figure 4.5: Cumulative oil production for C-19.

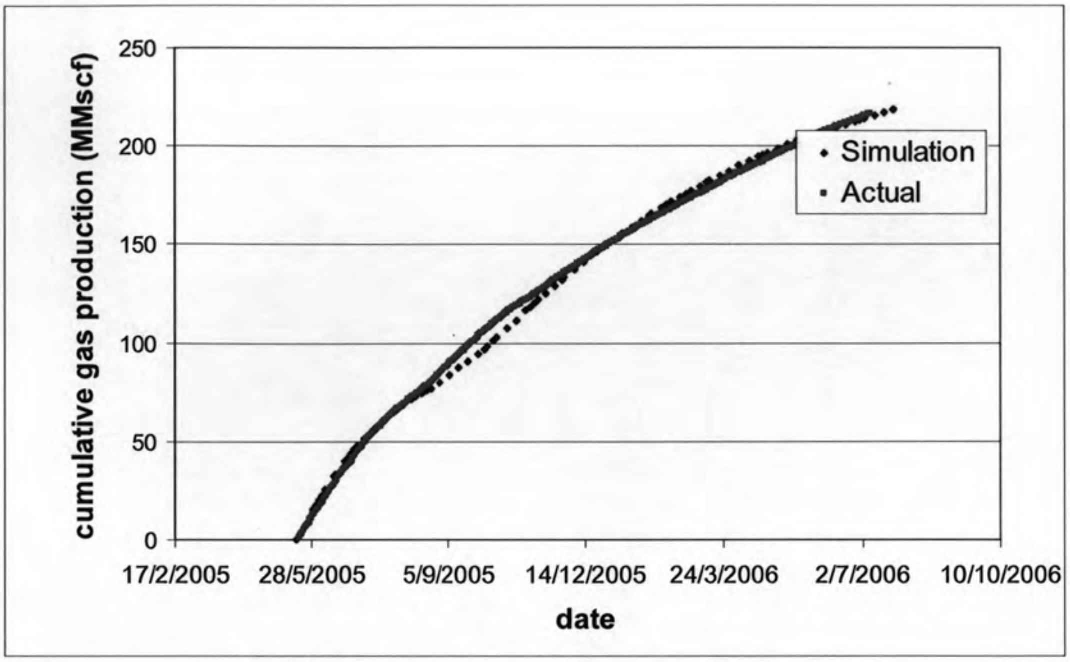


Figure 4.6: Cumulative gas production for C-19.

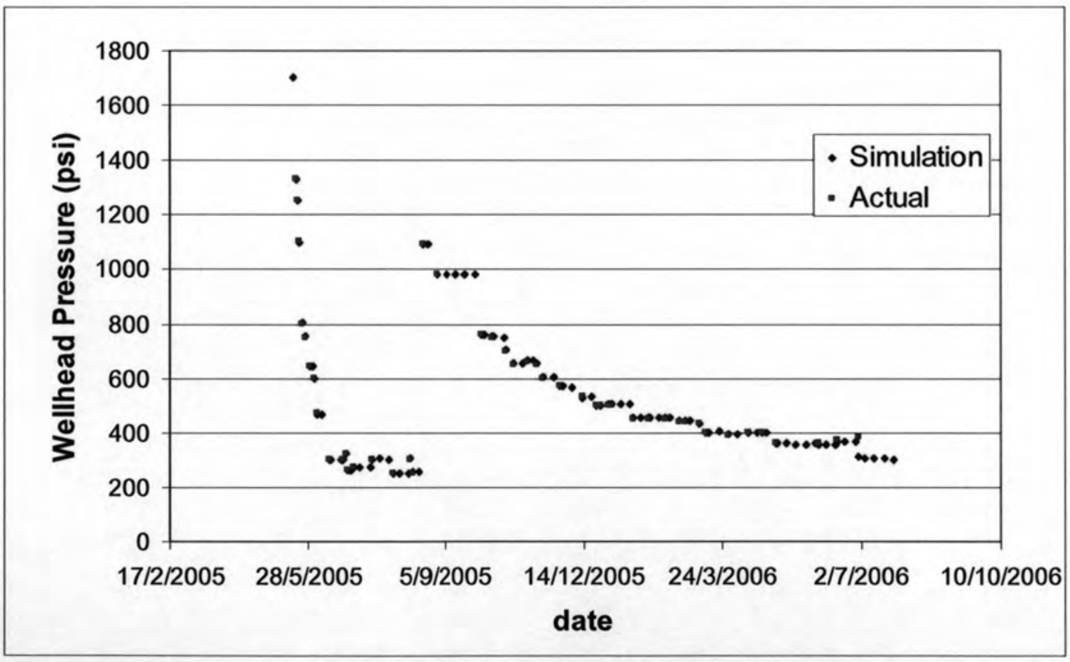


Figure 4.7: Wellhead pressure data matching for C-19.

There is also a good match on the well head pressure profile for well C-19 as shown in Figure 4.7.

4.1.2 Example 2: well C-12

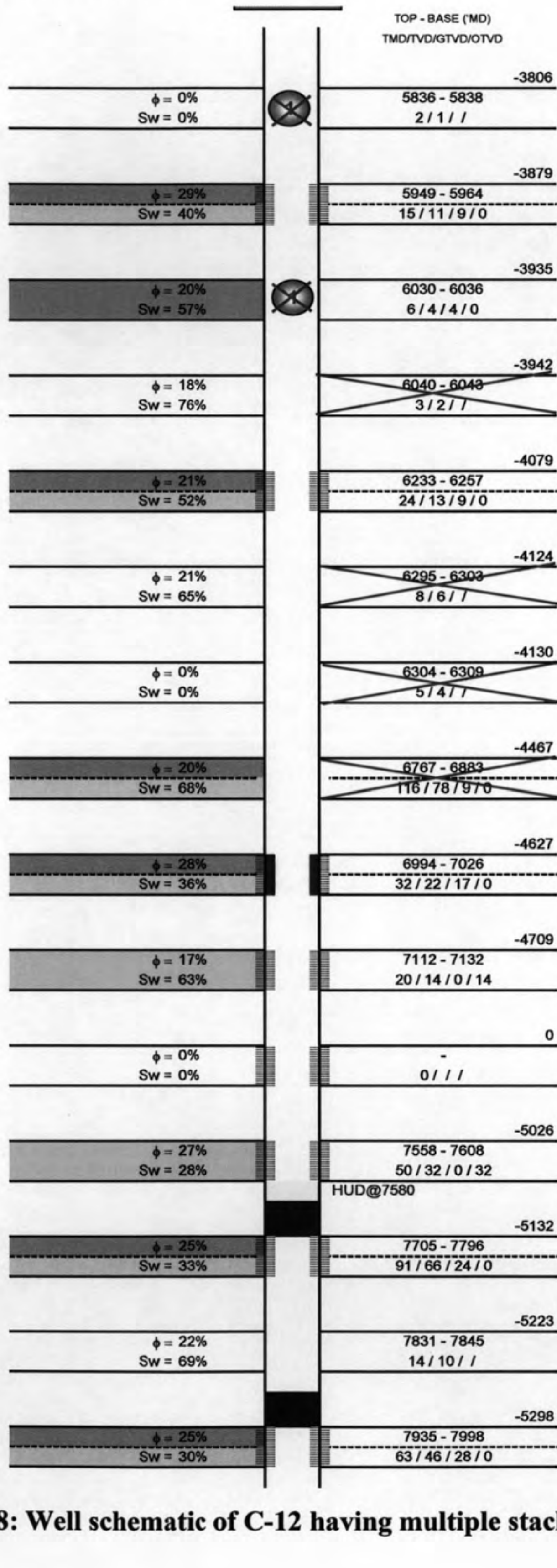


Figure 4.8: Well schematic of C-12 having multiple stacked sands.

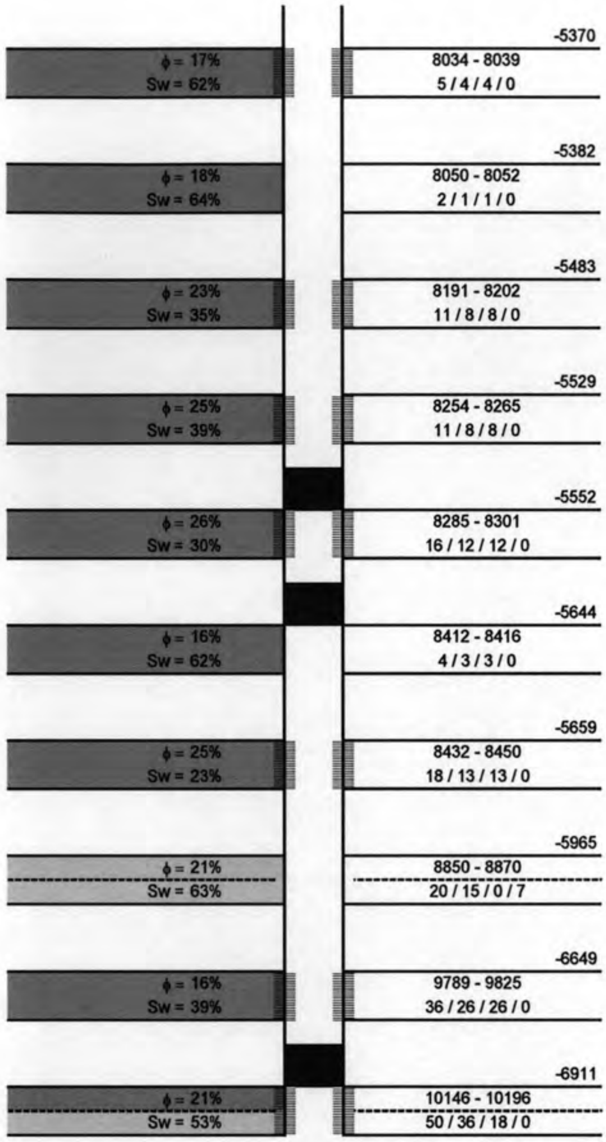


Figure 4.8: Well schematic of C-12 having multiple stacked sands (continued).

The complexity of the reservoir penetrated by well C-12 is shown in the schematic diagram in Figure 4.8. The reservoirs are more complex than those in the previously discussed case. There are layers of oil, gas and contact sands. In general, we know that the wells having more of gas sands will be difficult to match. In this case, we could not get a good match at all. The daily productions, cumulative production as well as the wellhead pressure profile obtained from the history match are compared with actual history in Figures 4.9-4.14.

History matching for C-12

where Actual = Actual data

Simulation = Simulation Result

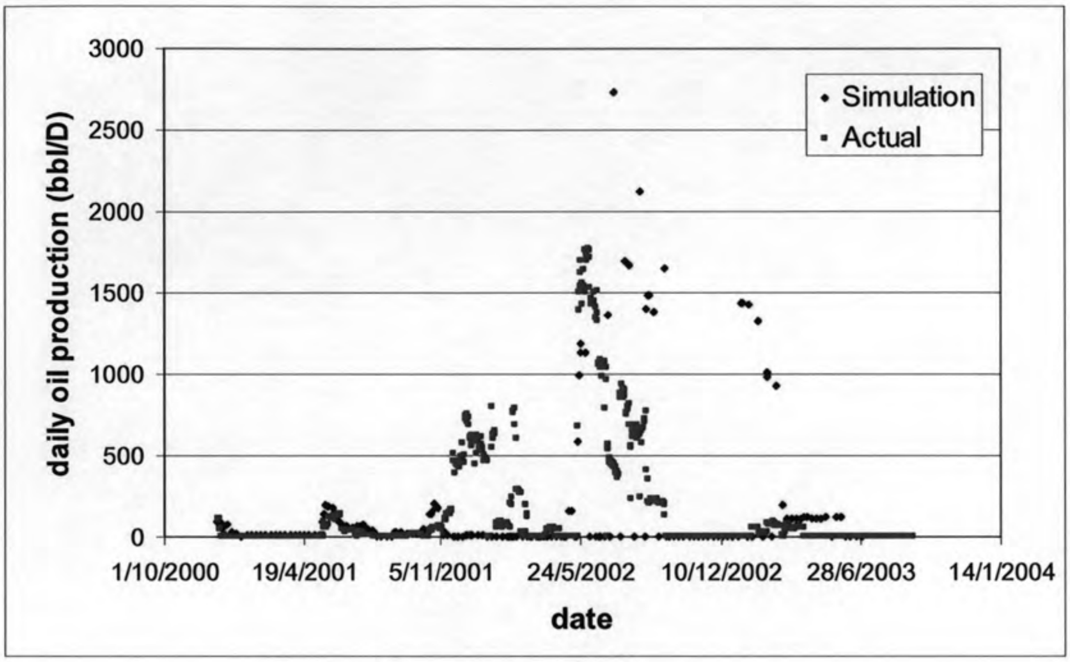


Figure 4.9: Daily oil production for C-12.

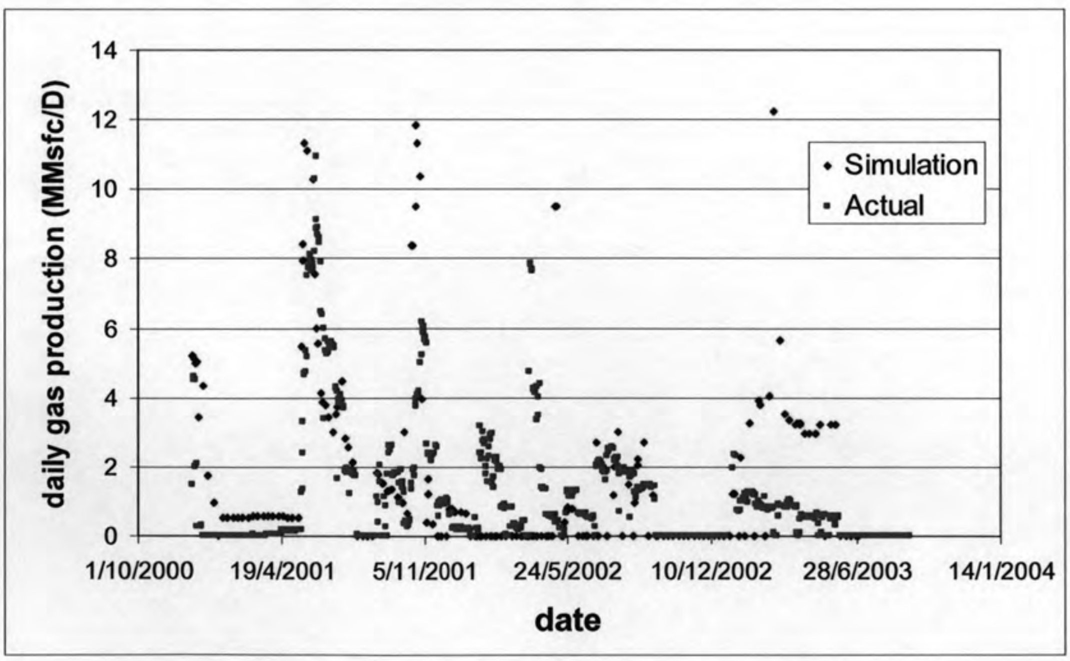


Figure 4.10: Daily gas production for C-12.

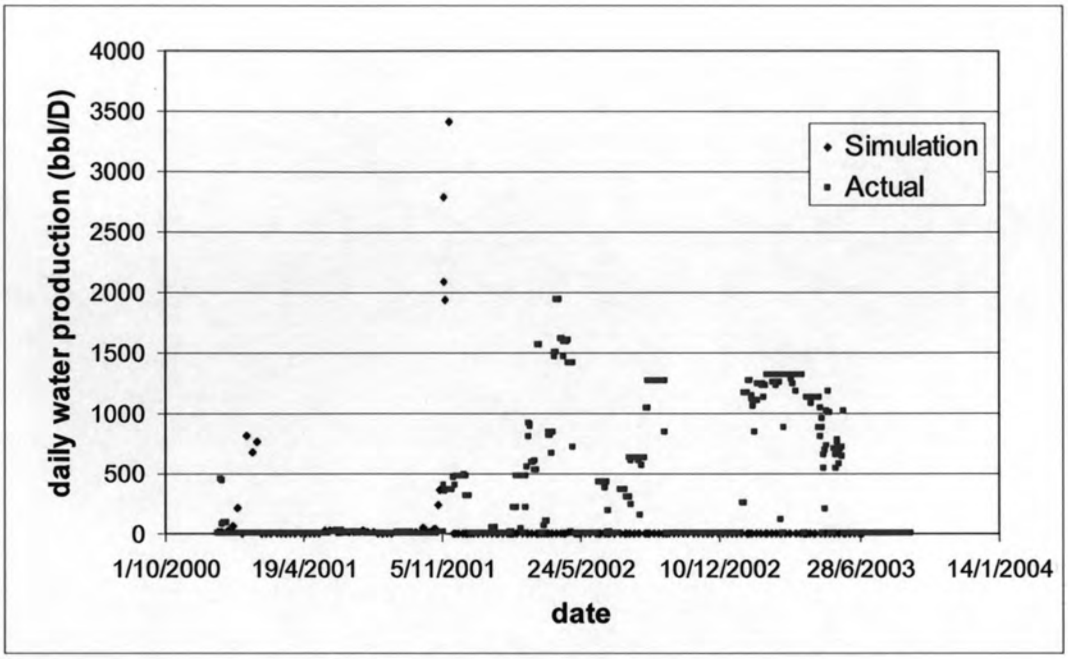


Figure 4.11: Daily water production for C-12.

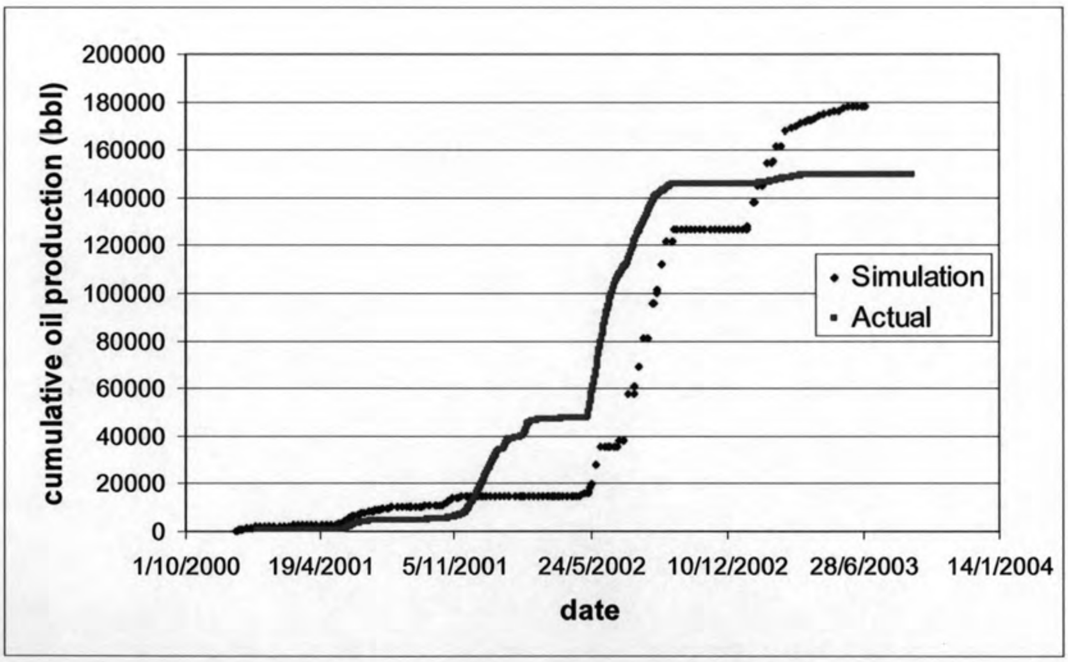


Figure 4.12: Cumulative oil production for C-12.

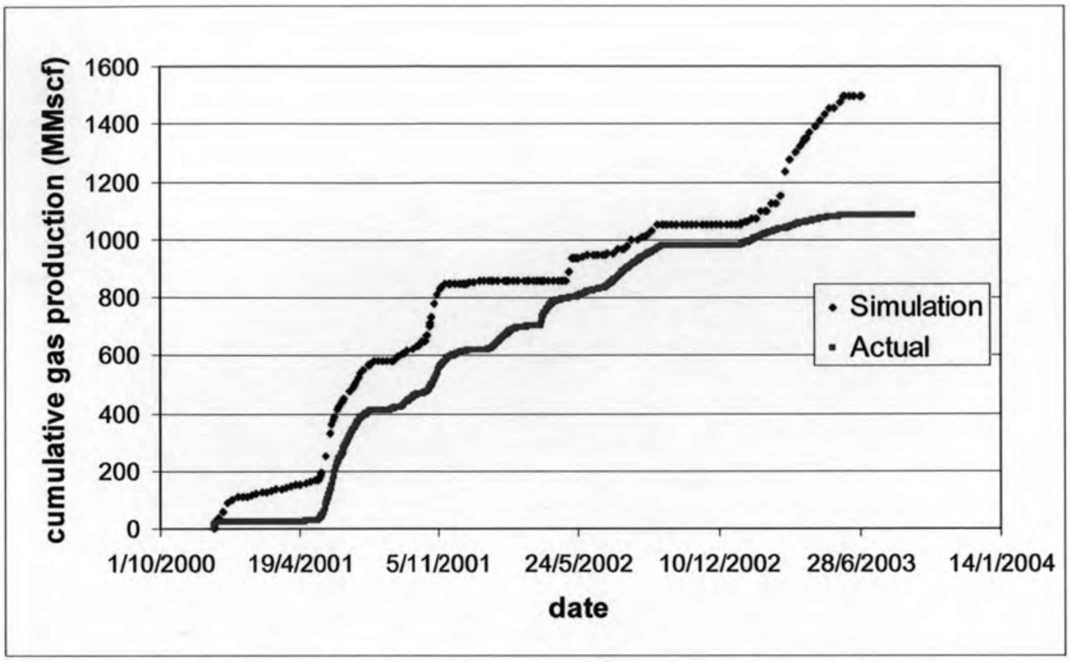


Figure 4.13: Cumulative gas production for C-12.

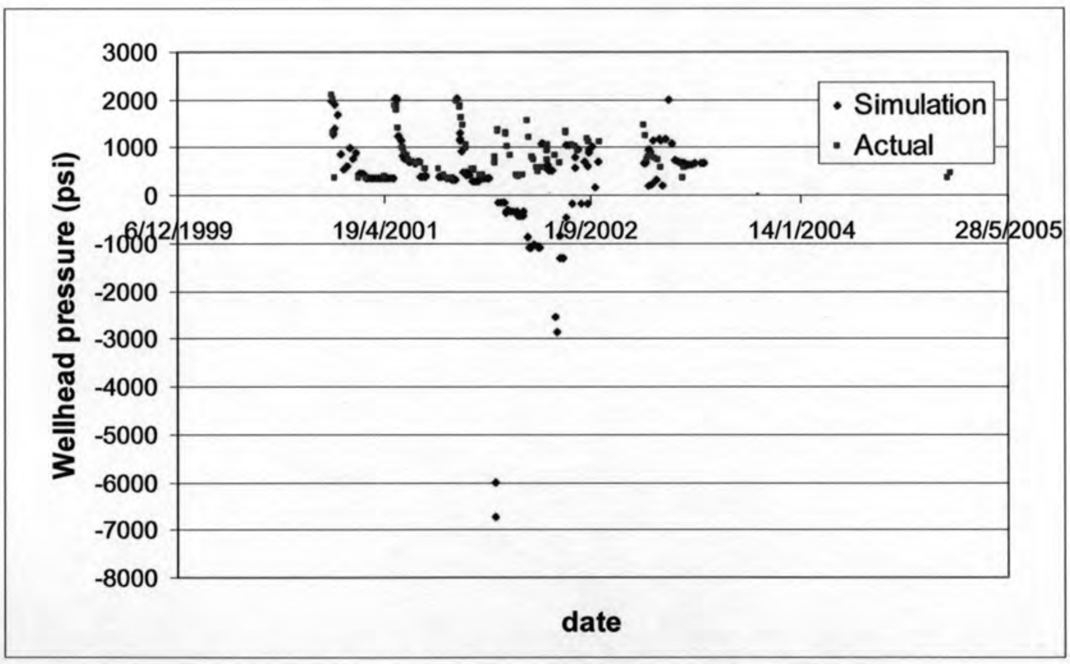


Figure 4.14: Wellhead pressure profile for C-12.

There is a substantial poor match in the simulated result and the actual data. This in turn will give inaccurate properties of the reservoir tank model used in material balance part of the software. In any case, these properties will be used to further evaluate different perforation strategies.

4.1.3 Summary

After matching the actual historical data, the matching results are categorized into two types: good match and poor match with the actual data. The matching results for 17 wells are shown in Table 4.1.

Table 4.1: Results for 17 wells history matched

Well name	History matched result
C-1	poor match
C-2	poor match
C-4	poor match
C-5	poor match
C-6	good match
C-8	poor match
C-9	good match
C-11	poor match
C-12	poor match
C-14	good match
C-15	good match
C-16	good match
C-17	poor match
C-18	poor match
C-19	good match
C-21	good match
C-22	good match

As depicted in Table 4.1, 8 wells have a good history match while 9 wells have a poor match. There are a lot of factors that affect history matching results such as the number of sands on each well and quality of raw data. Although some of the wells have poor match, the reservoir models constructed from all the match will be used in the evaluation of different perforation strategies in order to obtain the highest ultimate recovery. More focus will be given to the wells having a good match but the conclusion of this study will be drawn from both types of match.

4.2 Result & Analysis

There are several factors affecting he results obtained from different perforation strategies. We will analyze some of the wells and dig for possible reasons that support the strategy that outperforms in each case. From the history matched results, we will focus on the wells that have a good match. There are eight wells that have a good match: C-6, C-9, C-14, C-15, C-16, C-19, C-21, and C-22.

4.2.1 Example 1: Well C-6

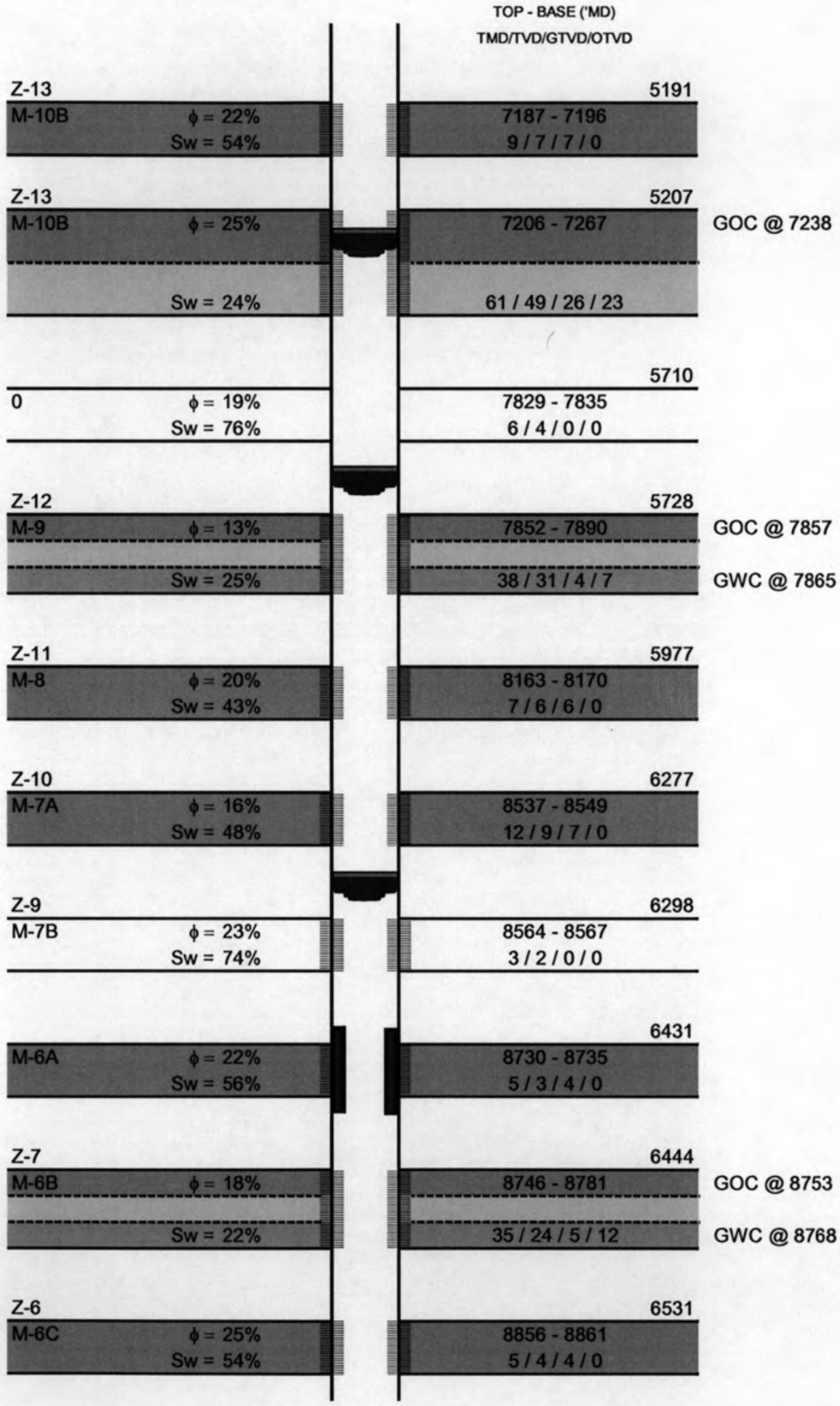


Figure 4.15: Well schematic for C-6.

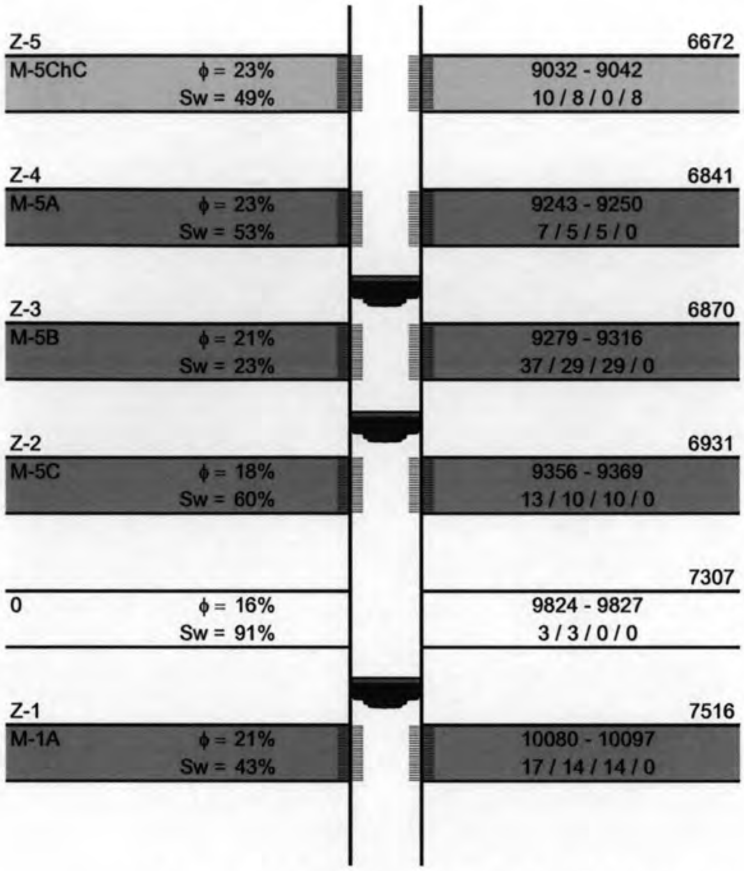


Figure 4.15: Well schematic for C-6 (continued).

A schematic of well C-6 is shown in Figure 4.15. This well penetrates through nine full to base gas sands, one full to base oil sand, one gas/oil contact sand and two gas/oil/water contact sands.

All of the sands in this well possess good oil production properties. The range of porosity is around 0.20 to 0.26. The overall average value of water saturation is 0.45. The cumulative productions of oil, water, and gas for six different perforation strategies are shown in table 4.2. The highlighted cells are the most favorable out of all the strategies. Lining up the results in a table format helps us identify the strategy that yields the highest oil, gas, and water perforation. The various strategies can be referred to in the beginning of this chapter.

From Table 4.2 shows that strategy 2 delivers the highest oil recovery whereas strategy 6 delivers maximum gas recovery and strategy 4 delivers minimum water recovery.

Table 4.2: Cumulative production for well C-6.

C-6	cum oil (STB)	cum water (MMSTB)	cum gas (MMscf)	BOE
Strategy 1	181,334	1.630	1,421	418,102
Strategy 2	354,080	3.211	1,814	656,417
Strategy 3	254,141	1.900	1,948	578,814
Strategy 4	230,706	0.573	1,167	425,150
Strategy 5	46,313	1.192	2,226	417,252
Strategy 6	232,217	0.660	2,549	657,050

The reason that strategy 2 delivers highest oil recovery is because the two biggest oil and gas bearing sands happen to be the GOWC sands at 5728'and 6444' TVD. So, perforating them first leads to maximum oil recovery and perforating these sands in a manner by keeping away from the water contact helps to delay the water influx into the wellbore and hence delaying the load-up. For other strategies, perforating these two big sands at the end will not help maximize recovery because there will be a lot of water influx coming into the wellbore and hence killing the well before producing from these sands.

If the gas sands are perforated in order to keep up with the production, it will help the well to deliver better results but not up to the production level obtained by strategy 2.

Strategy 5 gives the lowest oil production since gas reservoirs were depleted and water were loaded before the oil reservoir was produced.

If the interest lies in maximizing cumulative gas production, then strategy 6 gives the best result. The reason that strategy 6 delivers the highest gas recovery is because no cross-flow takes place between the sands. In terms of barrel of oil equivalent or BOE, strategy 6 still delivers the best result.

The production profiles for 6 perforation strategies are shown in Figures 4.16 to 4.21.

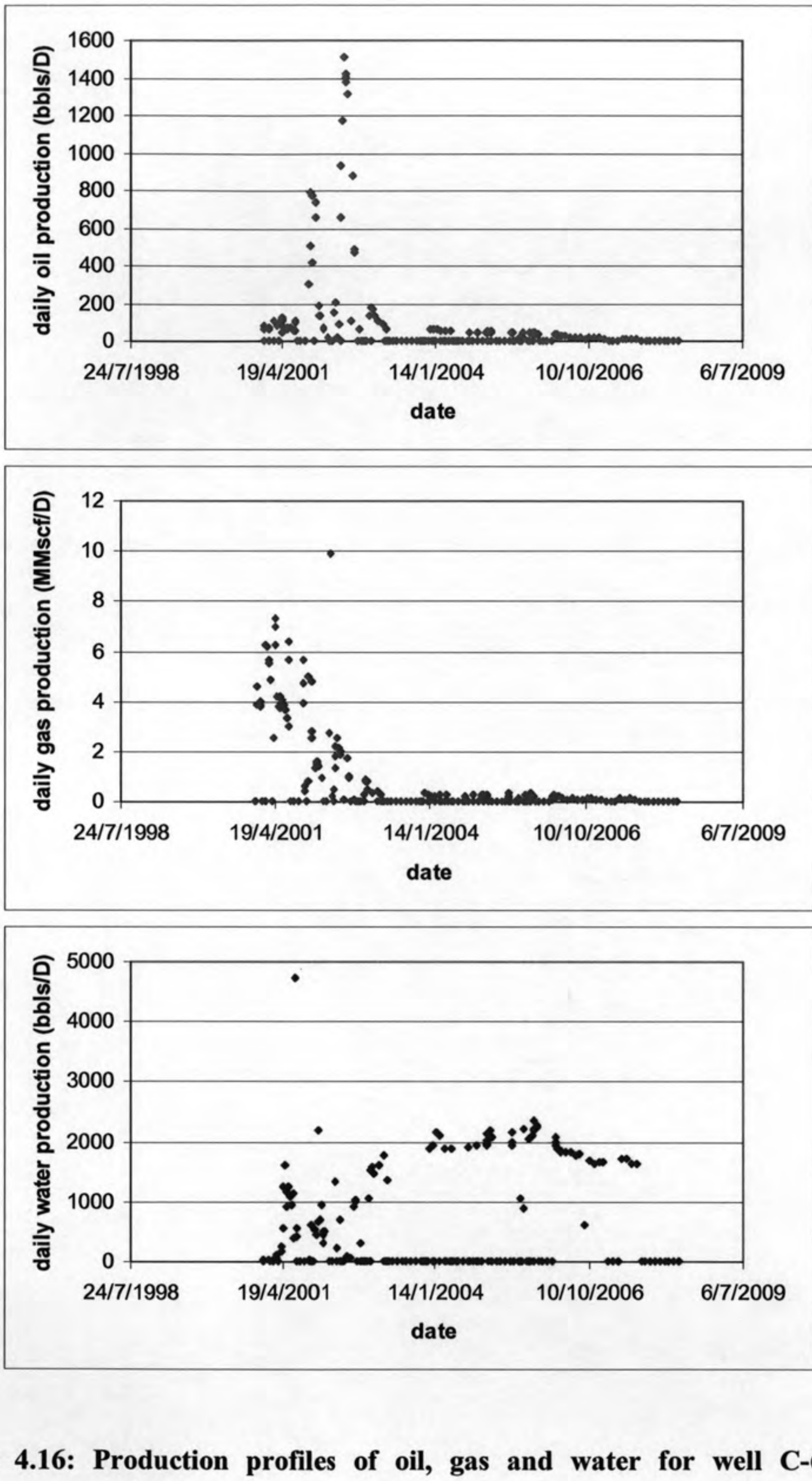


Figure 4.16: Production profiles of oil, gas and water for well C-6 using perforation strategy 1.

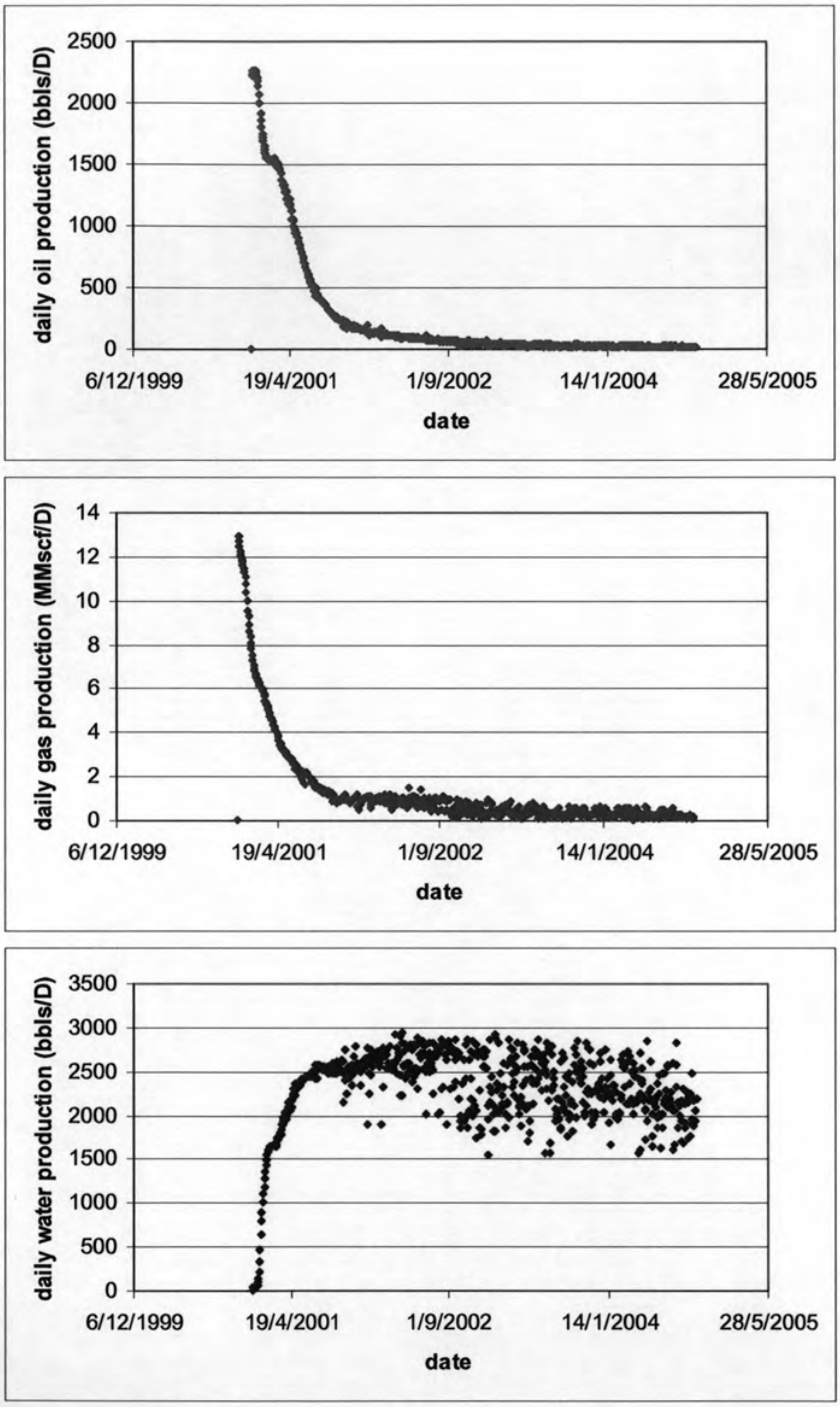


Figure 4.17: Production profiles of oil, gas and water for well C-6 using perforation strategy 2.

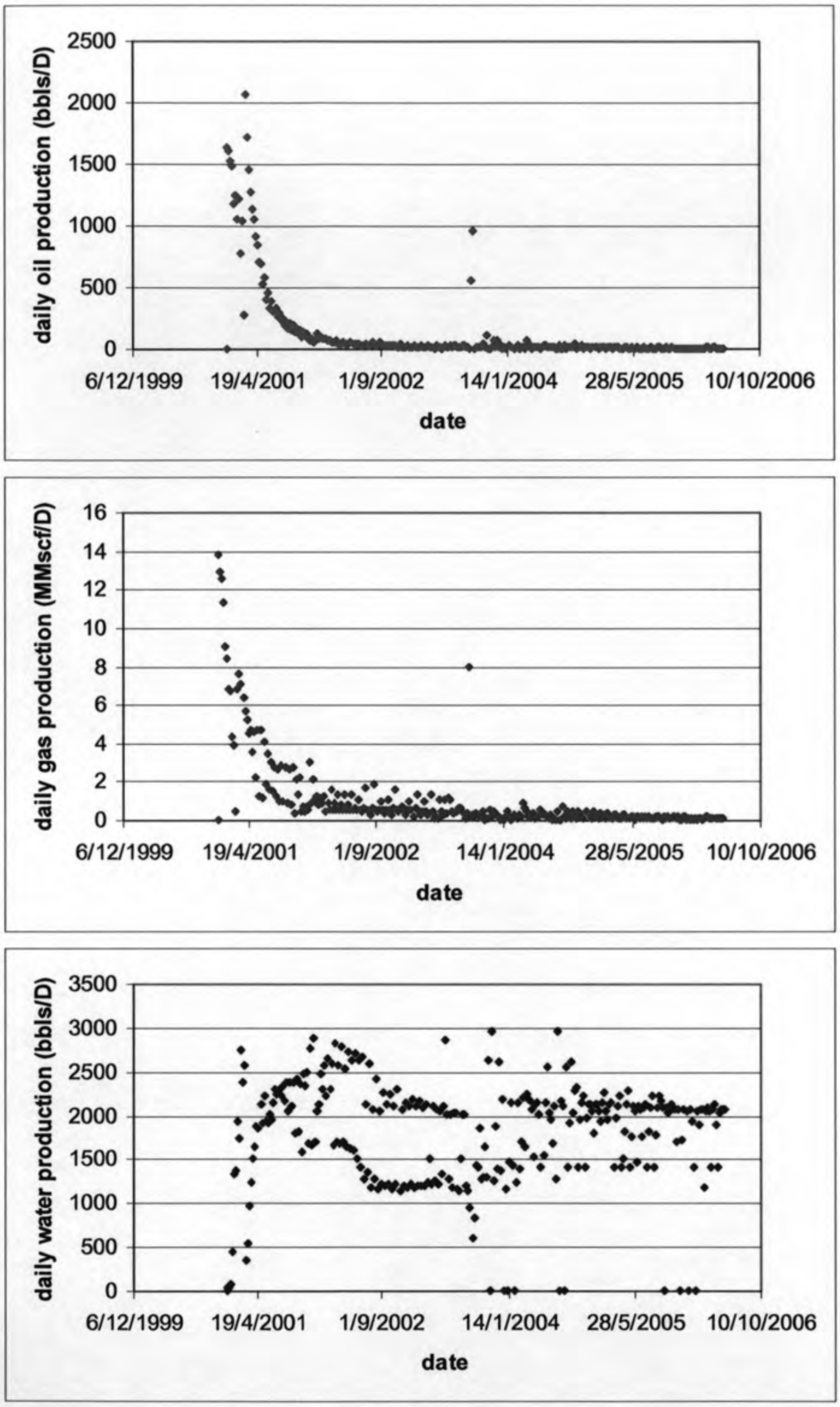


Figure 4.18: Production profiles of oil, gas and water for well C-6 using perforation strategy 3.

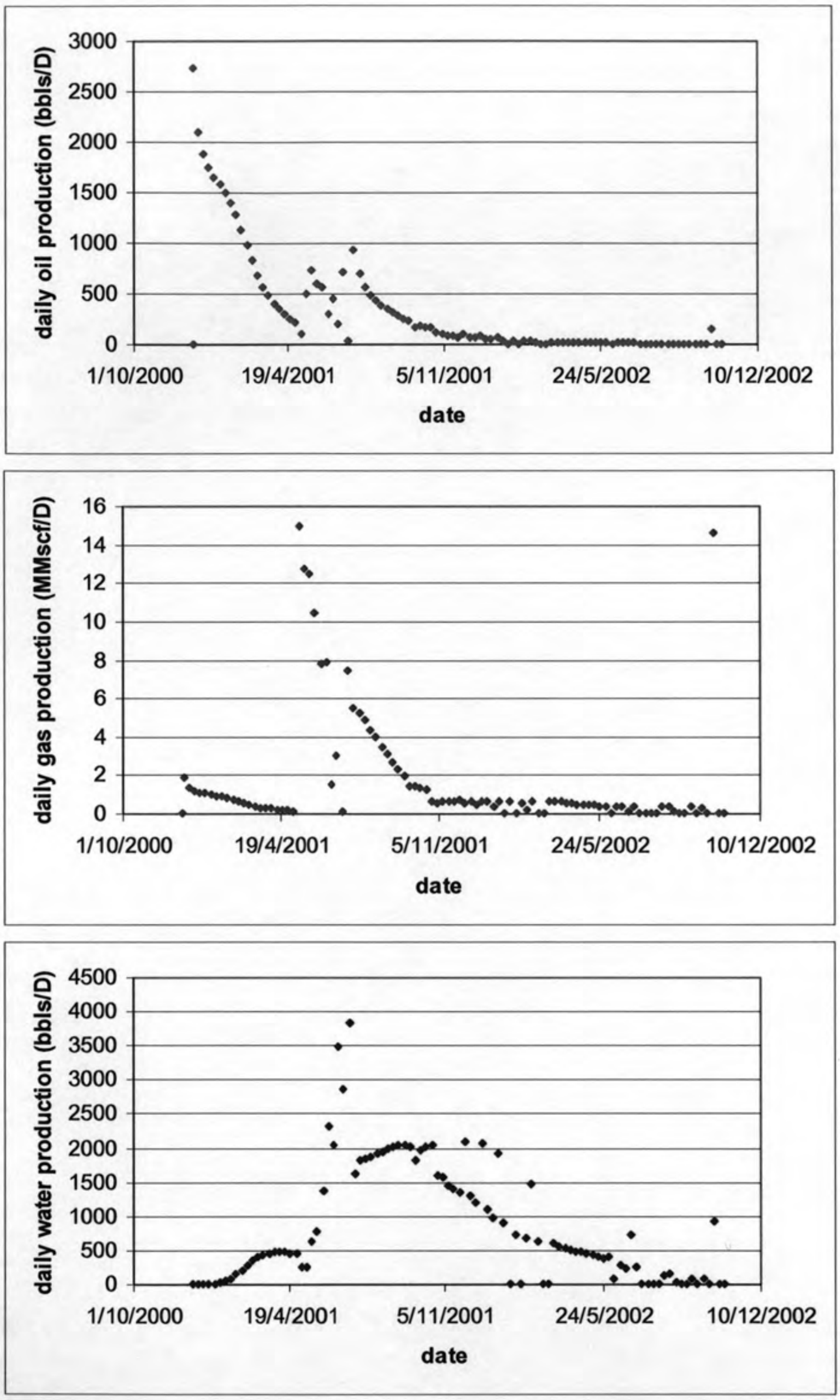


Figure 4.19: Production profiles of oil, gas and water for well C-6 using perforation strategy 4.

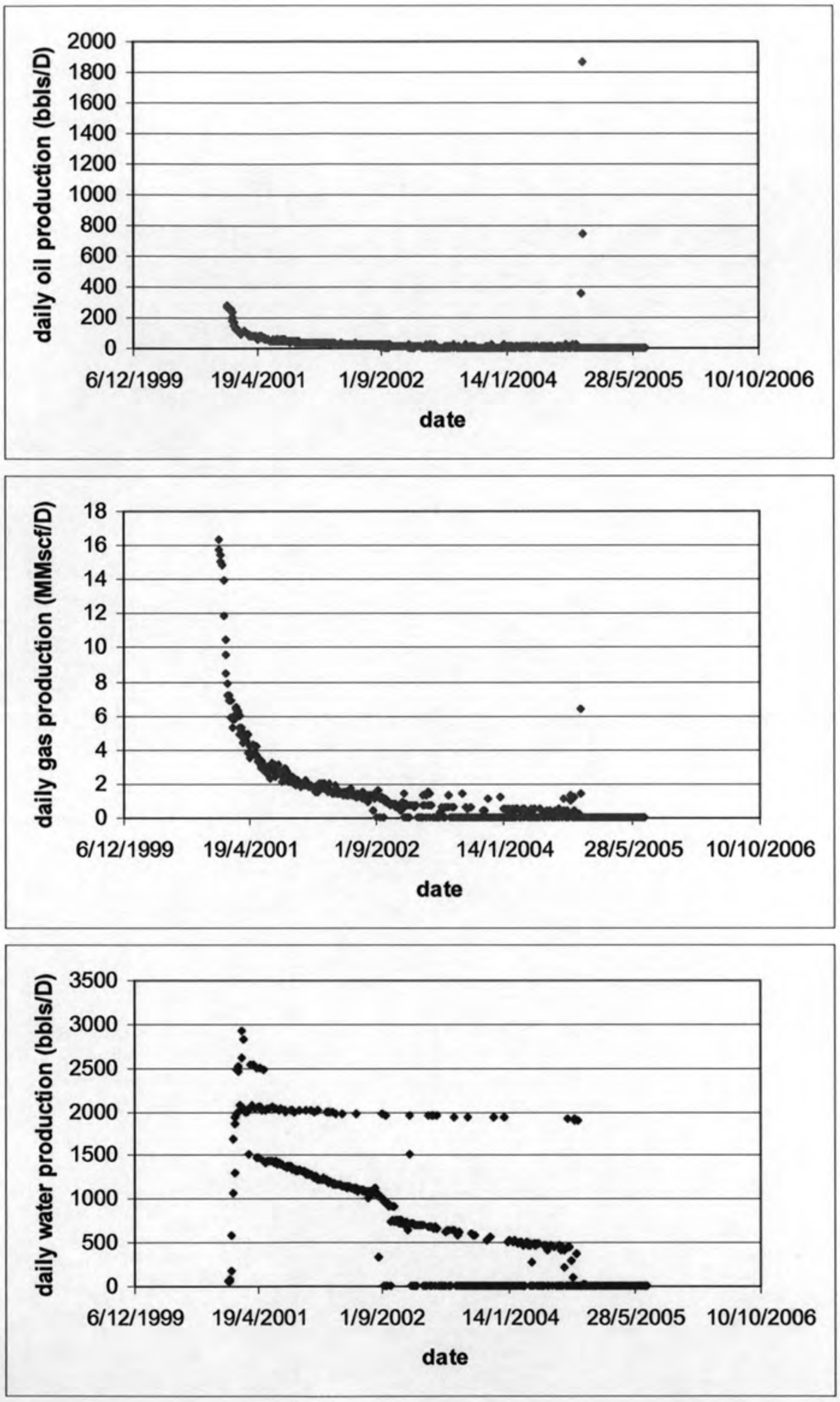
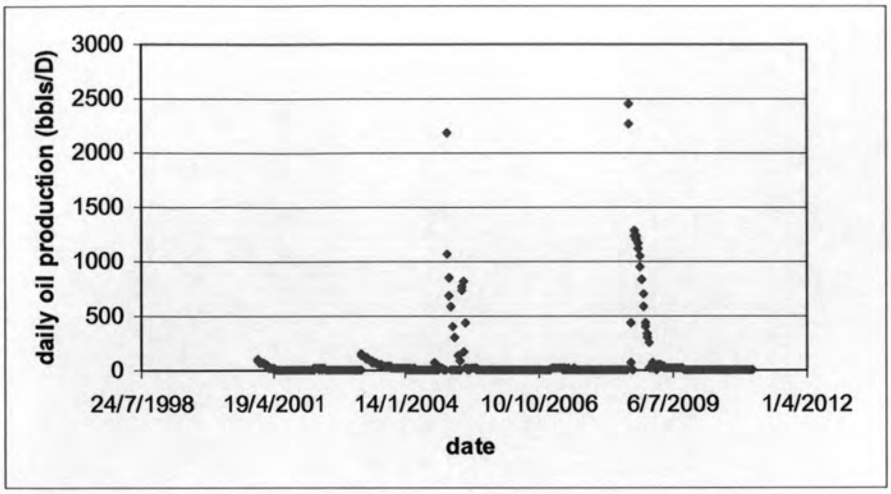
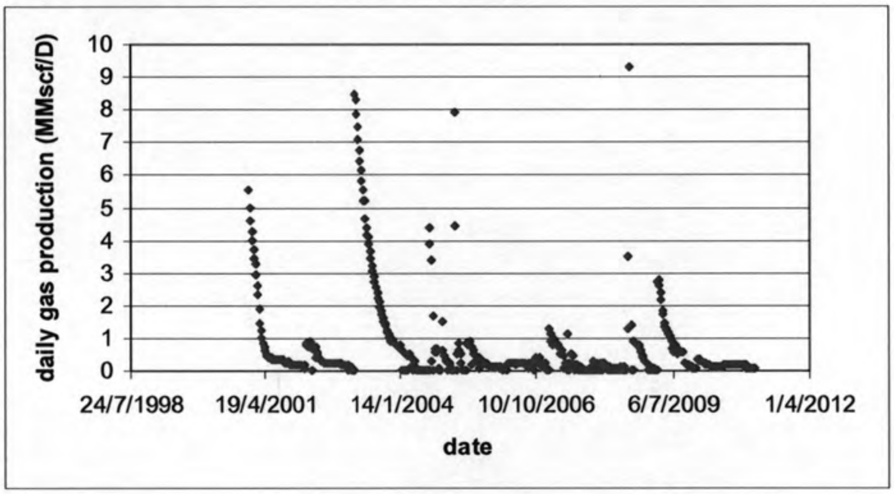


Figure 4.20: Production profiles of oil, gas and water for well C-6 using perforation strategy 5.





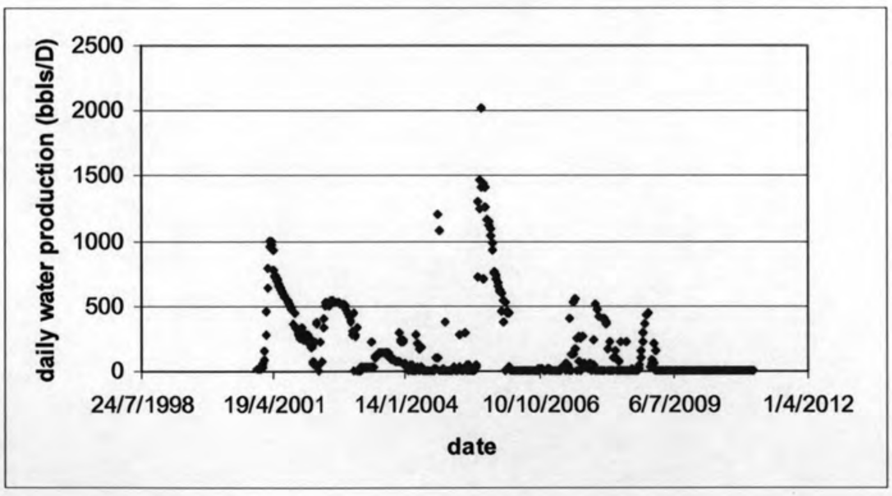


Figure 4.21: Production profiles of oil, gas and water for well C-6 using perforation strategy 6.

4.2.2 Example 2: Well C-9

The well has a lesser degree of complexity comparative to other wells and delivers results which are very close in terms of oil production. A schematic of well C-9 is shown in Figure 4.22

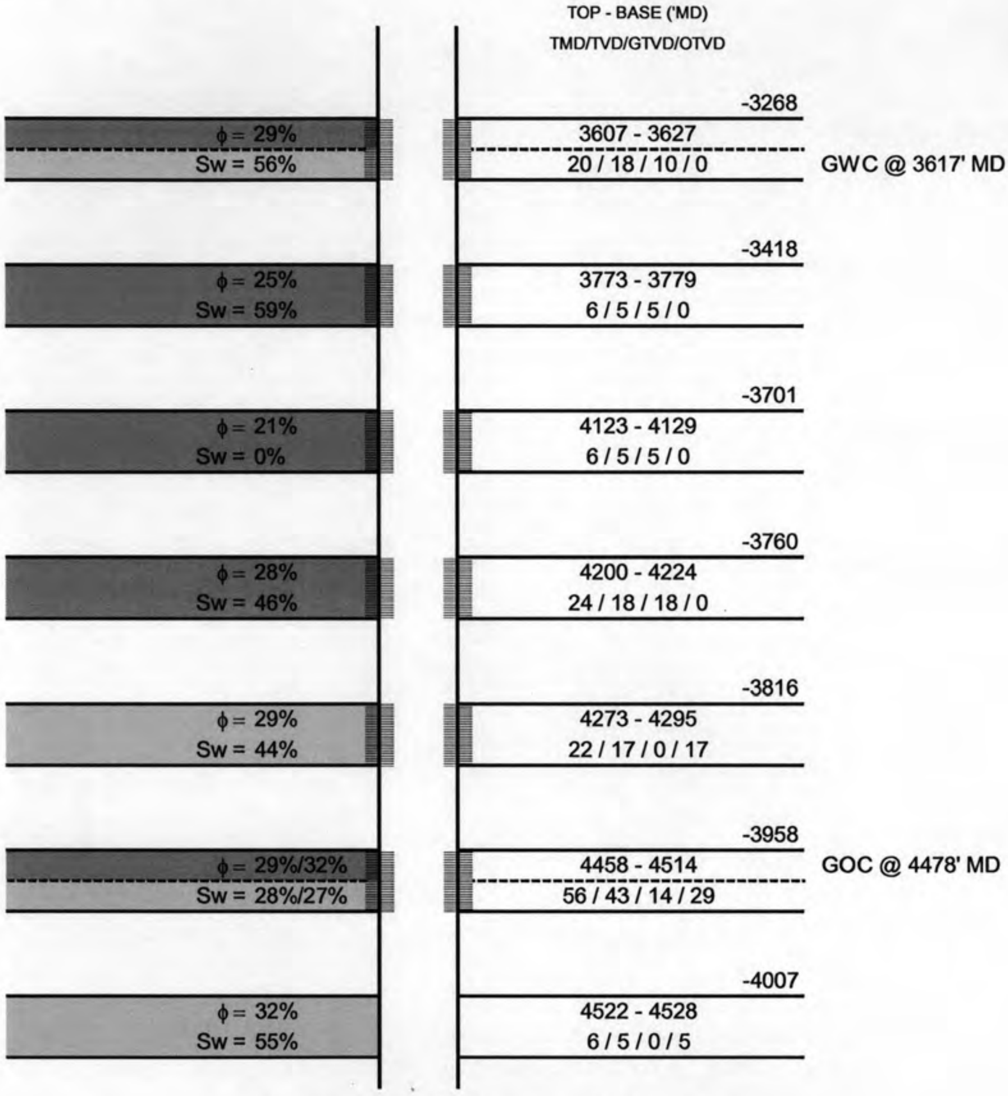


Figure 4.22: Well schematic for C-9.

This well penetrates through 7 sands: four of which are gas sands and three are oil sands. One sand has gas water contact while the other one has gas oil contact. For the actual production, the deepest oil sand is not perforated yet. So, we will not perforate this sand in the production profile in the six strategies.

All sands in this well possess good production properties. The average porosity is about 0.27, and the water saturation is around 0.49.

The results obtained from different strategies applied on this well are shown in Table 4.3

Table 4.3: Cumulative Production for well C-9

C-9	cum oil (STB)	cum water (MMSTB)	cum gas (MMscf)	BOE
Strategy 1	2,480,703	0.633	767	2,608,560
Strategy 2	3,034,595	1.629	3,852	3,676,570
Strategy 3	3,045,853	1.705	3,316	3,598,495
Strategy 4	3,050,849	1.515	1,013	3,219,737
Strategy 5	54,747	0.977	1,022	225,004
Strategy 6	2,629,706	0.672	775	2,758,882

The production profiles of well C-9 are shown in Figures 6.23 to 6.28. From Table 4.3, strategy 4 delivers results which is not very outstanding but can be taken in as the highest oil recovery strategy. The idea is to perforate oil sands first and let the well flow with the solution GOR and followed by perforating the gas sands when the energy of the solution GOR starts to deplete and in the end perforating contact sands for the remaining oil.

If the gas sands are perforated at the same time as the oil sands, the gas sand pressure will deplete a lot faster than that of the oil sand and hence oil will cross flow into the gas sands.

The differences between strategy 2, strategy 3 & 4 are in terms of a few thousand barrels of oil. Strategy 1 gives the lowest oil and water productions since some reservoirs were selectively shut off when water cut was too high to be handled by water disposal facilities.

Strategy 5 gives the lowest oil production because gas sands are depleted and then the well loads up due to high water cut before oil sands come into production.

For BOE comparison, strategy 2 gives the highest recovery because strategy 2 recovers high cumulative oil and gas. Looking at the reservoir properties, we find that gas oil contact sand at the bottom of this well is the main oil and gas producer.

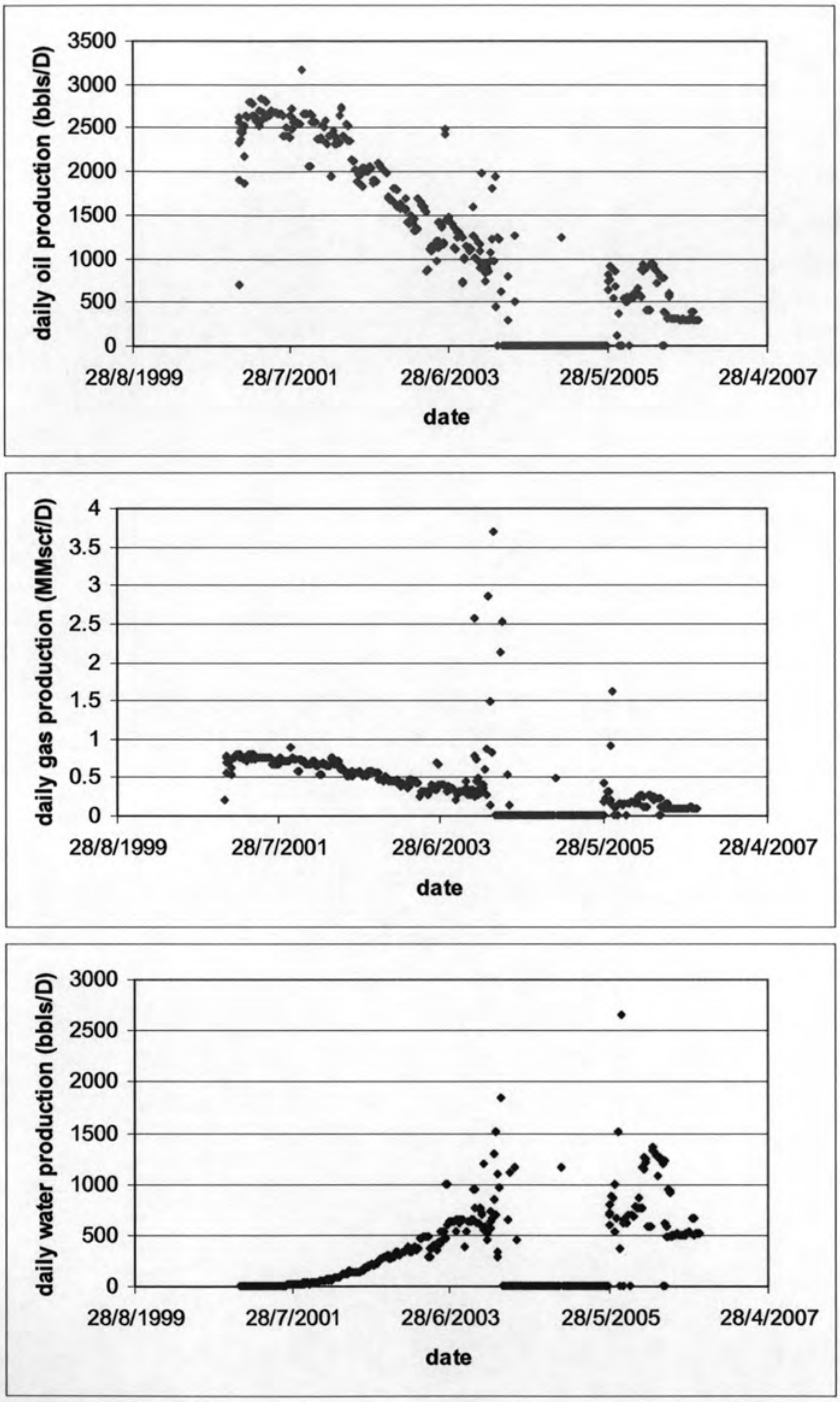


Figure 4.23: Production profiles of oil, gas and water for well C-9 using perforation strategy 1.

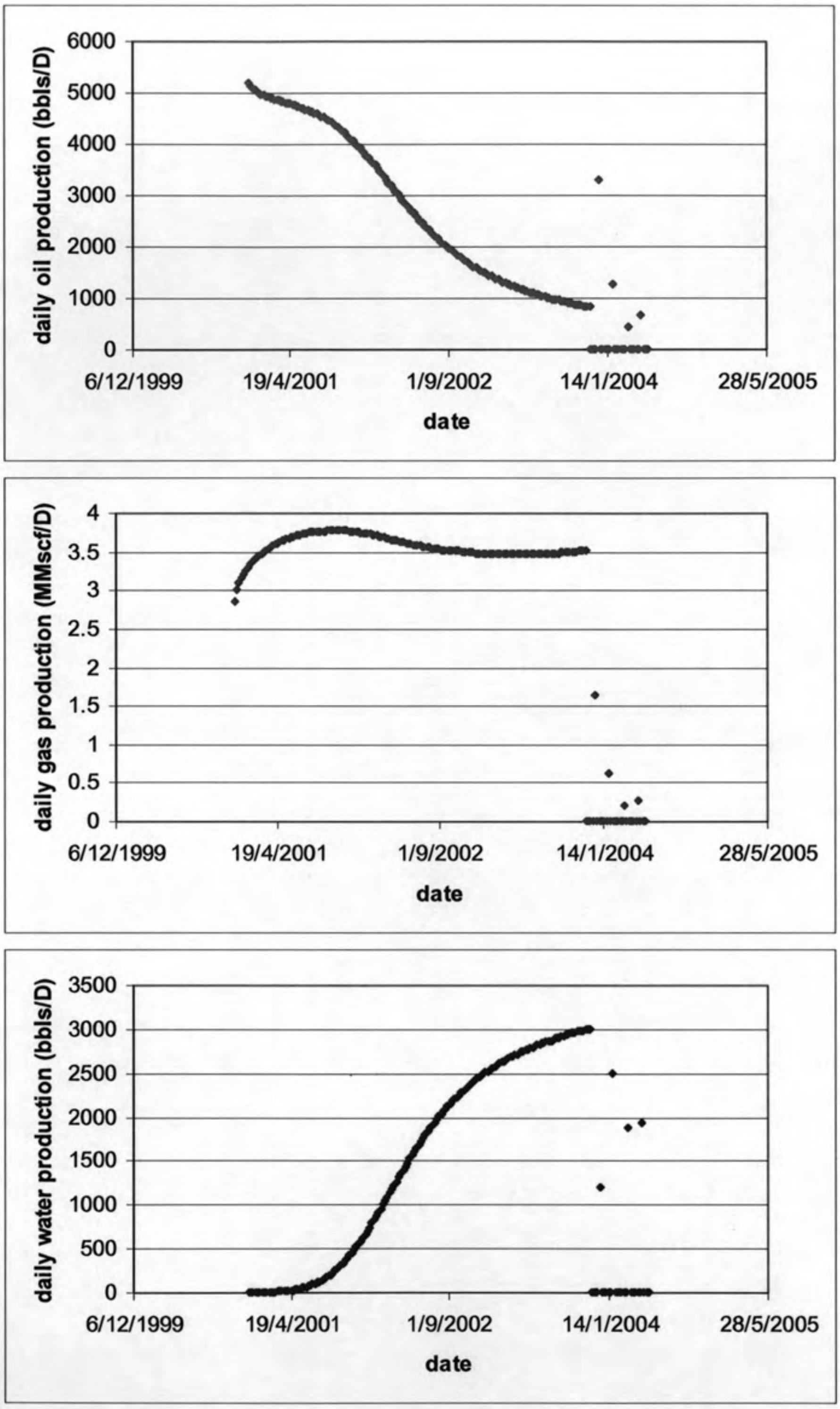


Figure 4.24: Production profiles of oil, gas and water for well C-9 using perforation strategy 2.

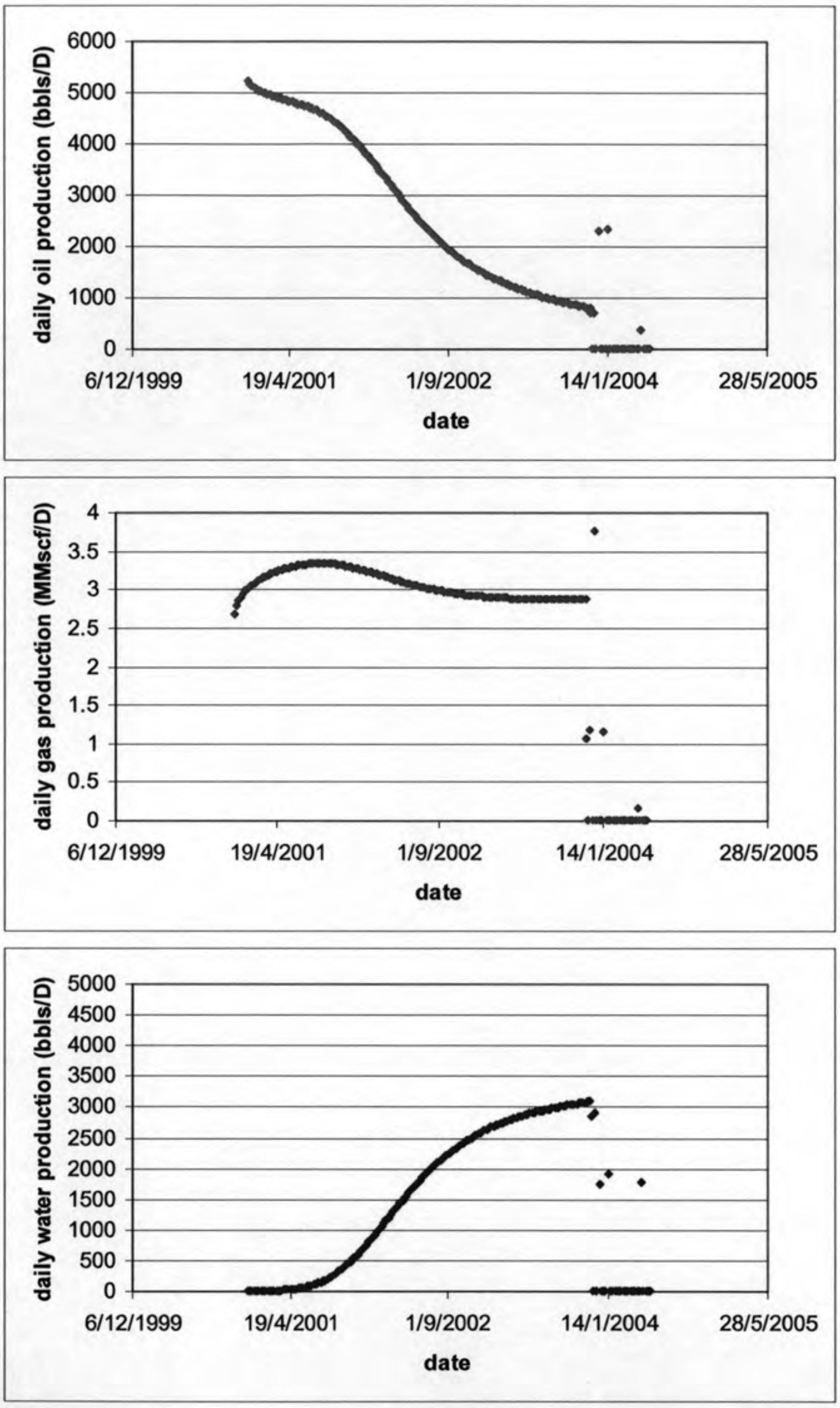


Figure 4.25: Production profiles of oil, gas and water for well C-9 using perforation strategy 3.

Comparing between Figure 4.24 and 4.25, production profiles are very similar because this well has only one gas water contact sand.

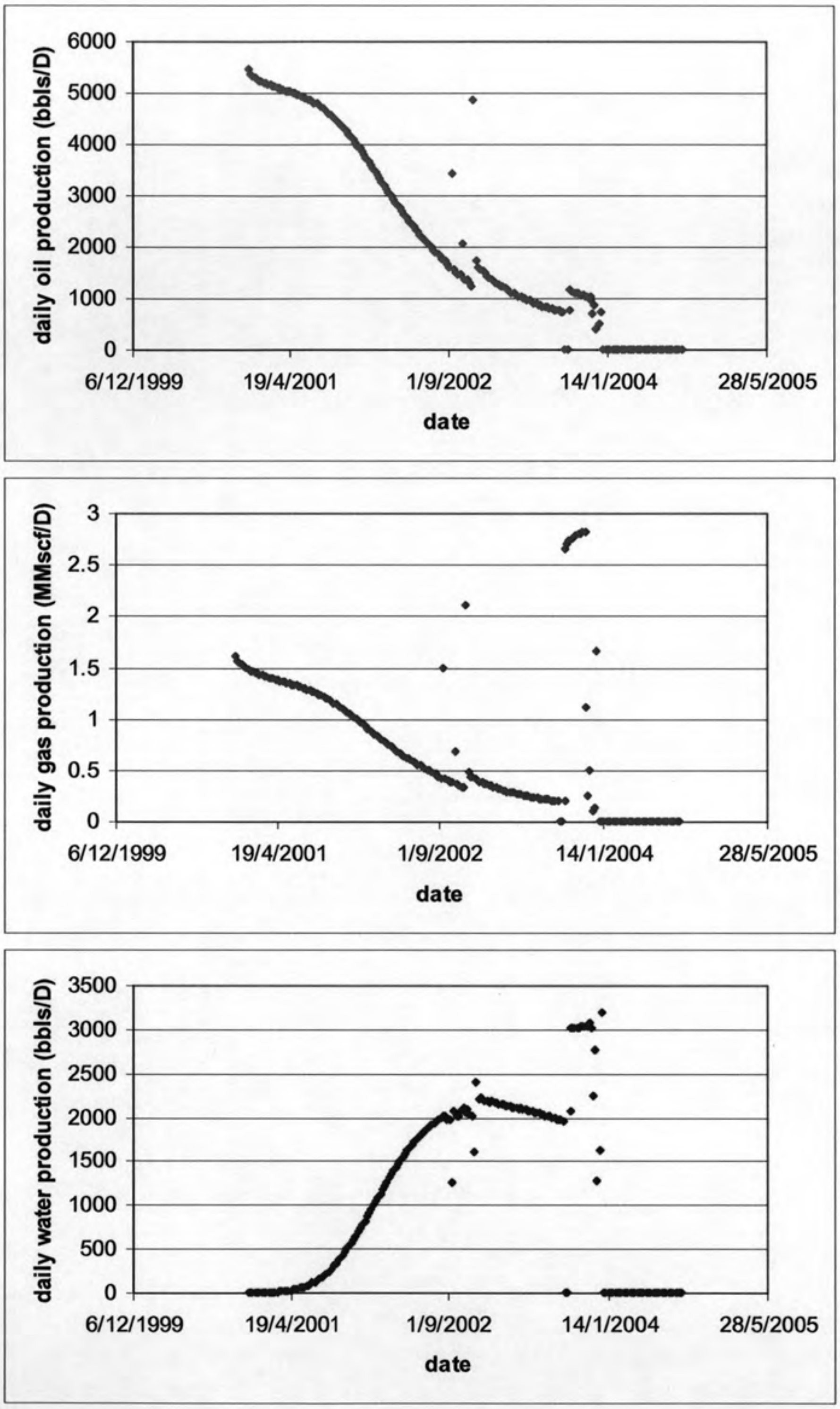


Figure 4.26: Production profiles of oil, gas and water for well C-9 using perforation strategy 4.

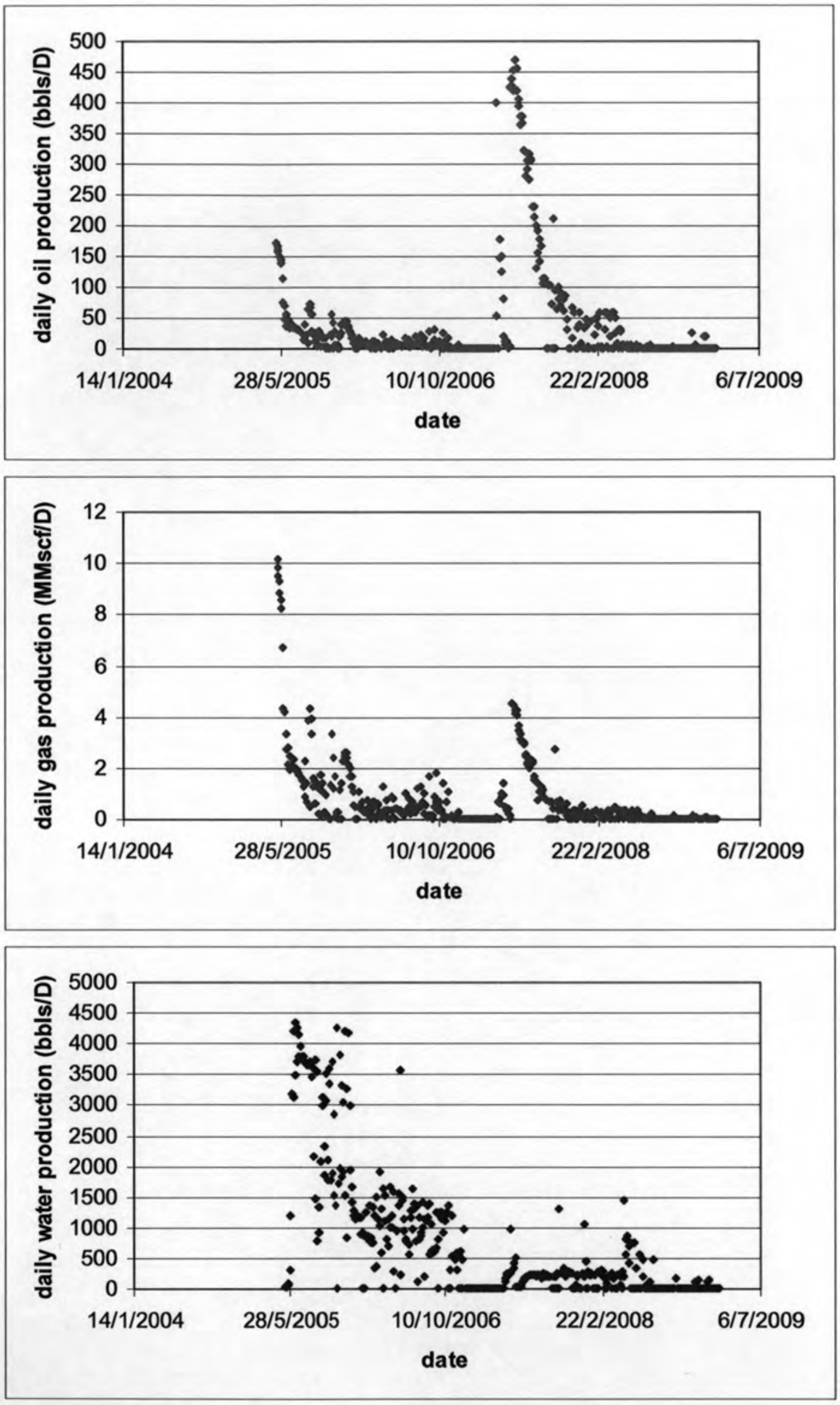


Figure 4.27: Production profiles of oil, gas and water for well C-9 using perforation strategy 5.

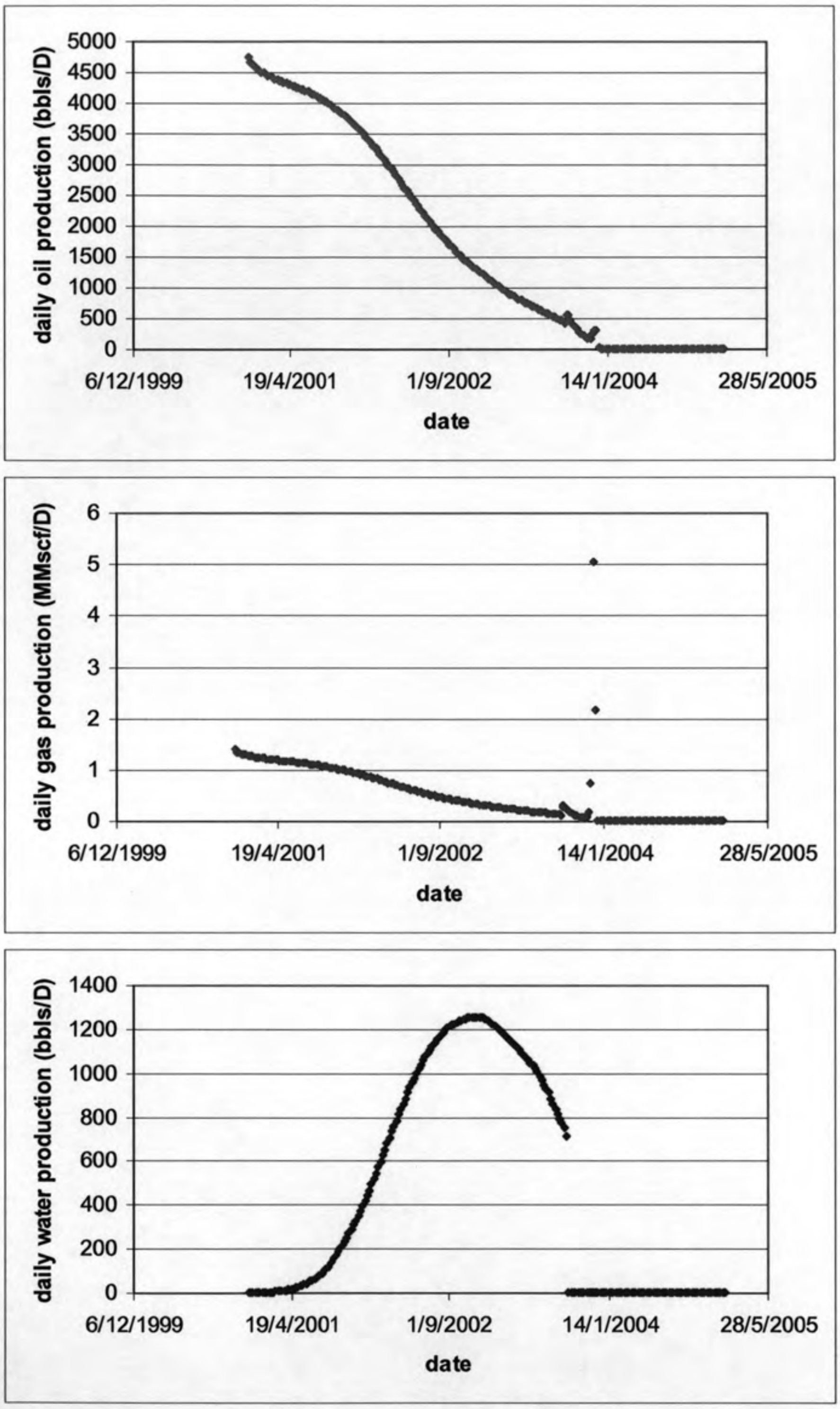


Figure 4.28: Production profiles of oil, gas and water for well C-9 using perforation strategy 6.

4.2.3 Example 3: Well C-14

Table 4.4: Cumulative production for C-14

C-14	cum oil (STB)	cum water (MMSTB)	cum gas (MMscf)	BOE
Strategy 1	689,290	0.317	7,965	2,016,757
Strategy 2	1,824,396	1.359	8,758	3,284,144
Strategy 3	1,414,086	1.319	8,853	2,889,571
Strategy 4	1,549,304	1.435	8,963	3,043,208
Strategy 5	375,030	1.454	9,158	1,901,349
Strategy 6	670,362	1.091	9,571	2,265,512

Well schematic of C-14 is shown in Figure 4.29. The well has multilayers of sands. The oil as well as the gas sands are commingled. The properties of shallow and middle sands are better than the bottom. The main source of oil production comes from the top oil sand, and the bottom sands are the main source of the gas.

Having gas sands at lower depth is beneficial because the gas helps lift fluid to the surface. However, this configuration is prone to cross-flow. The performances of the six strategies used in this study are summarized in Table 4.4. Strategy 2 delivers the maximum oil recovery for this well. By perforating all sands at the same time, the gas helps lift the oil from lower layers that are the ones having the most pressure loss as it flows up to the surface.

Strategy 5 gives the lowest oil production since gas sands are depleted and water loads the well before the oil sands are produced.

Strategy 6 gives the highest gas recovery because no crossflow takes place and this well have a lot of gas sands. When we compare BOE, results still favor strategy 2 because strategy 2 recovers a lot of oil and gas. The production profiles for 6 perforation strategies are shown in Figures 4.30 to 4.35.

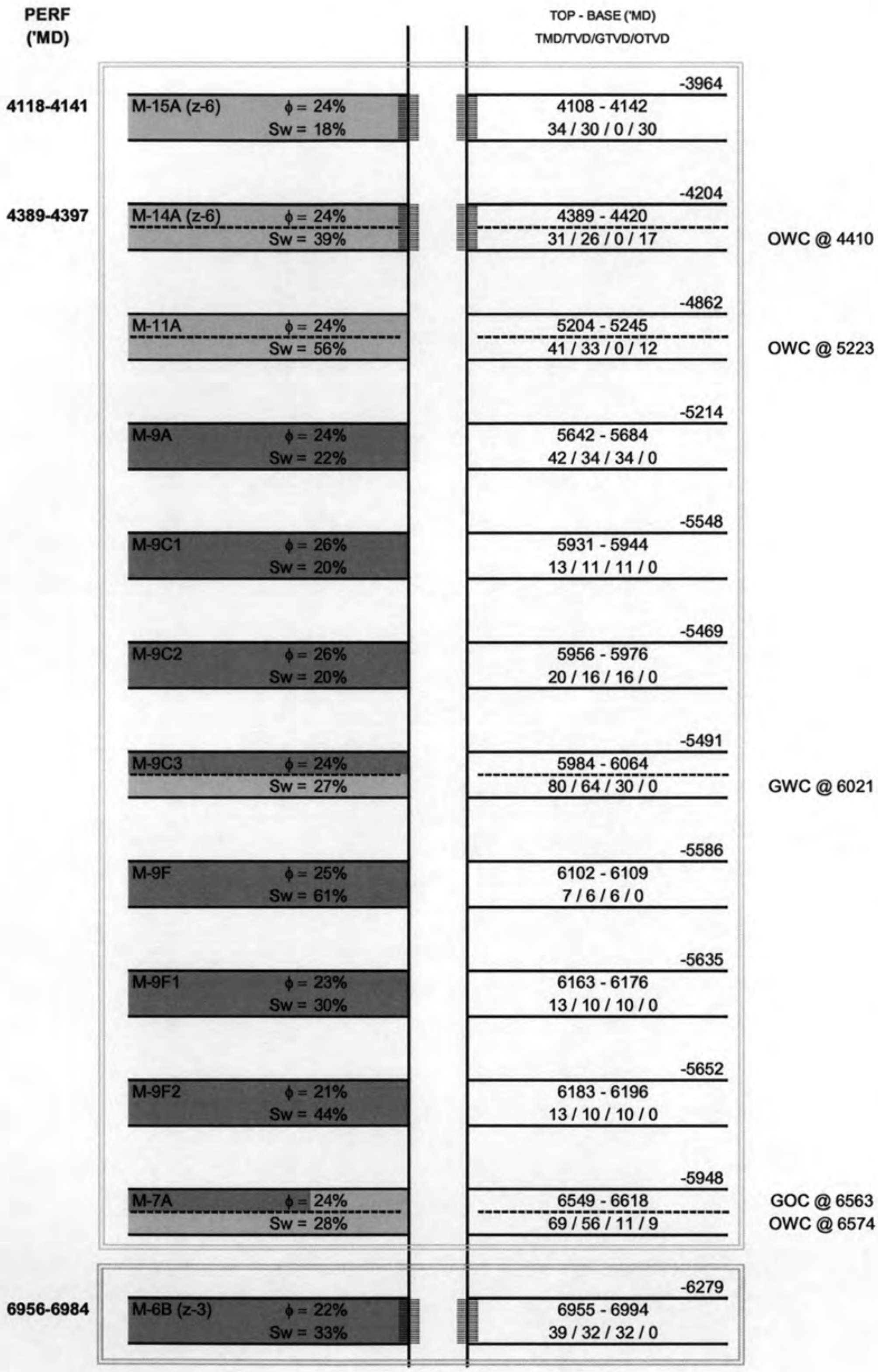


Figure 4.29: Well schematic for C-14.

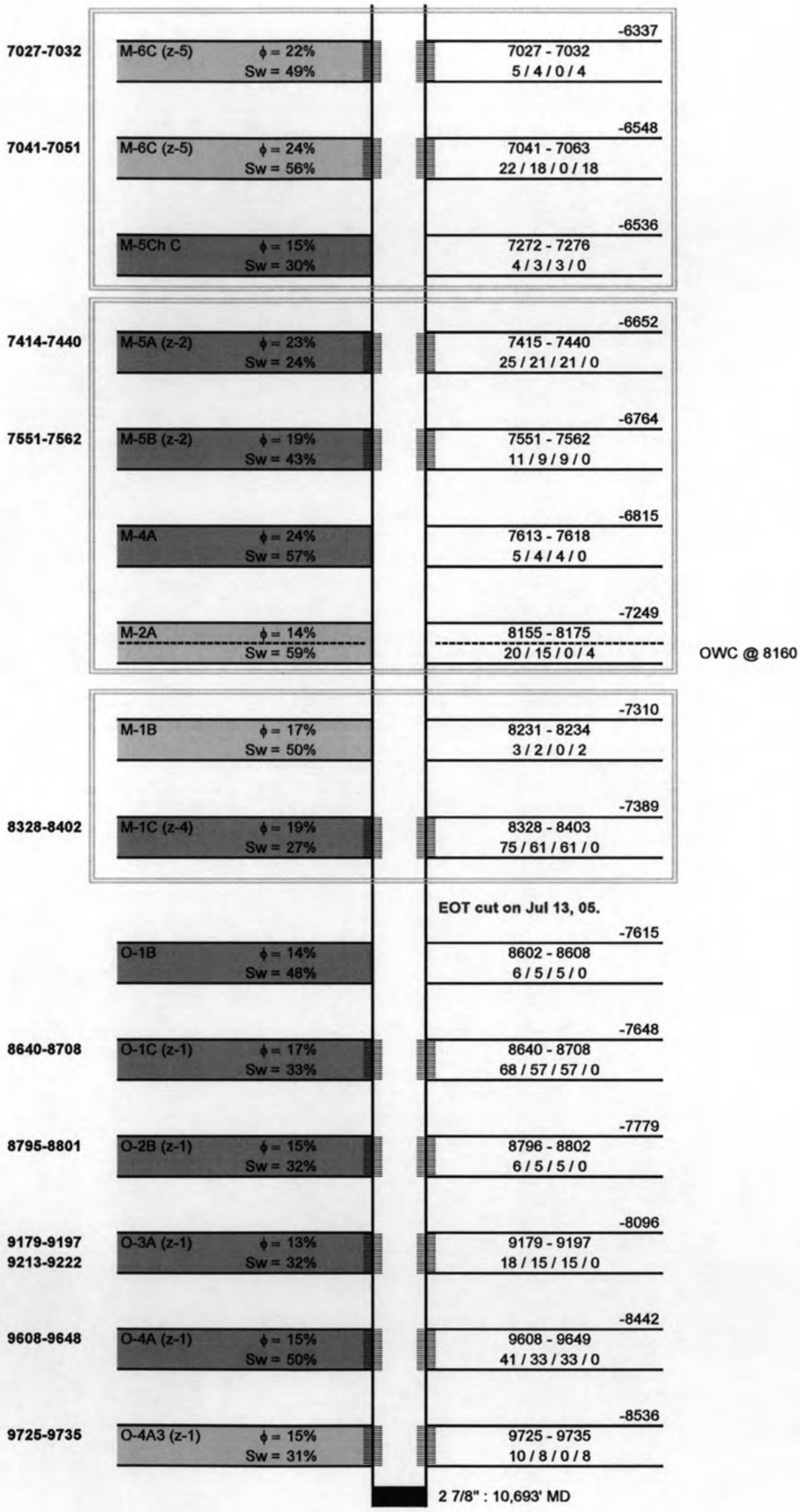


Figure 4.29: Well schematic for C-14 (Continued).

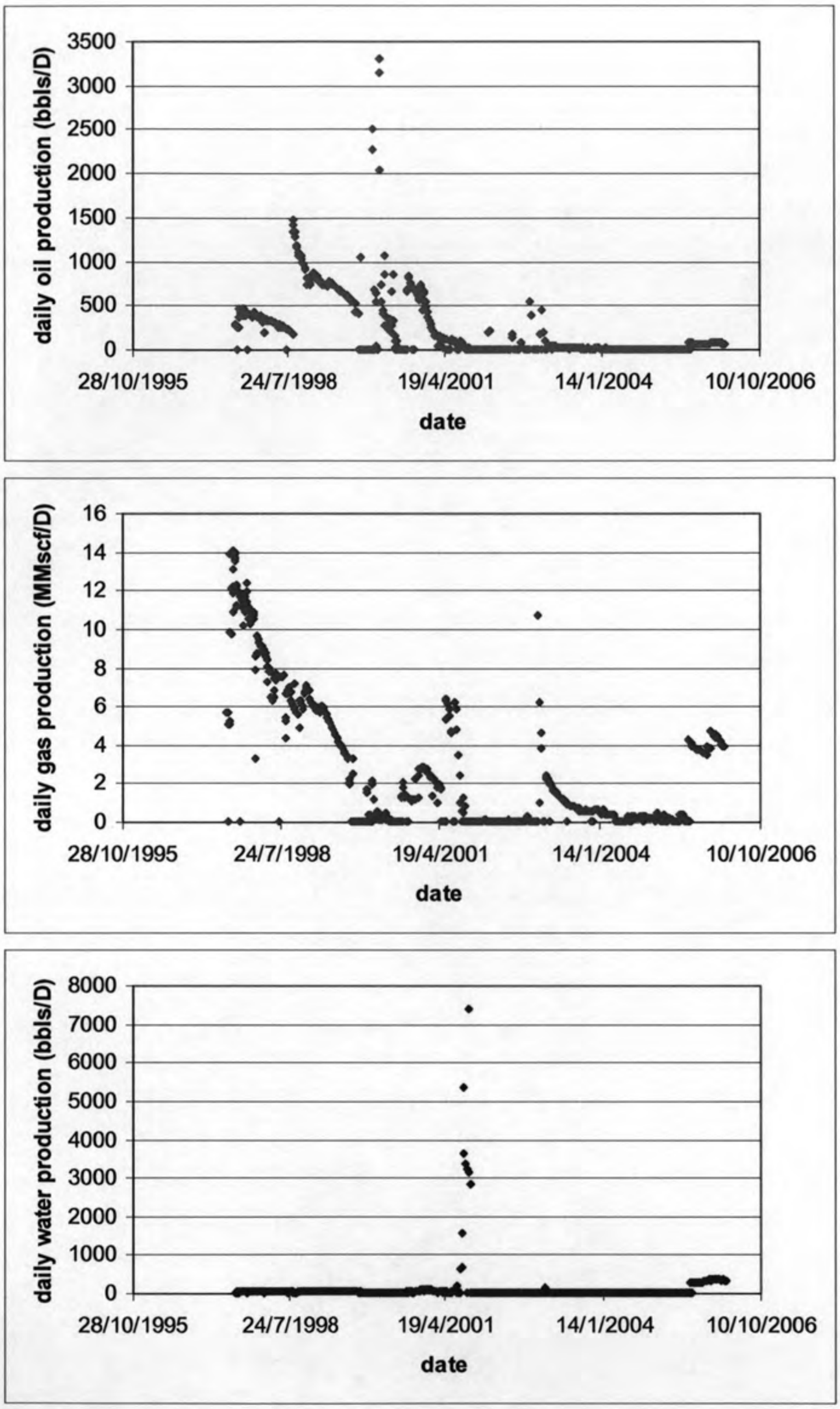


Figure 4.30: Production profiles of oil, gas and water for well C-14 using perforation strategy 1.

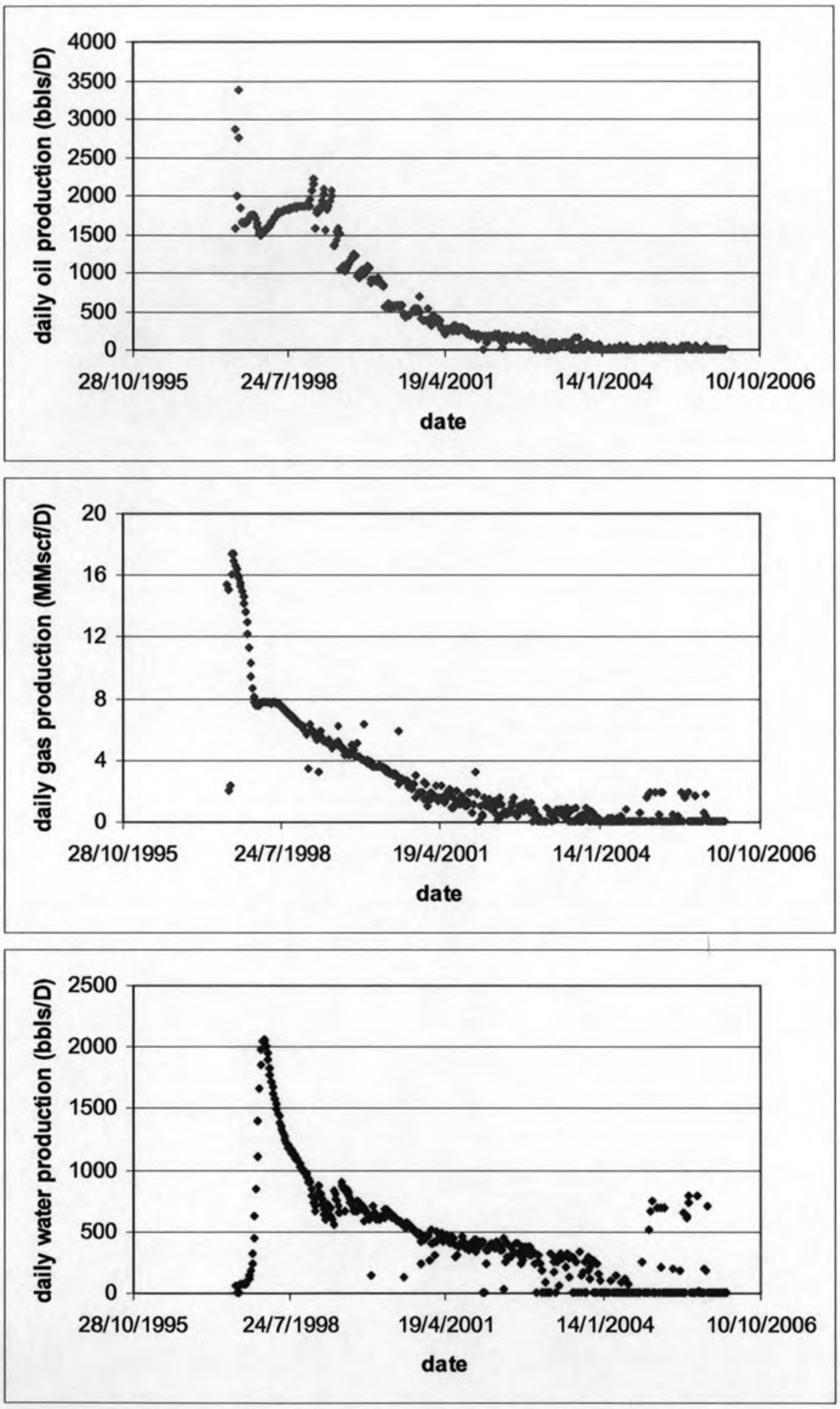


Figure 4.31: Production profiles of oil, gas and water for well C-14 using perforation strategy 2.

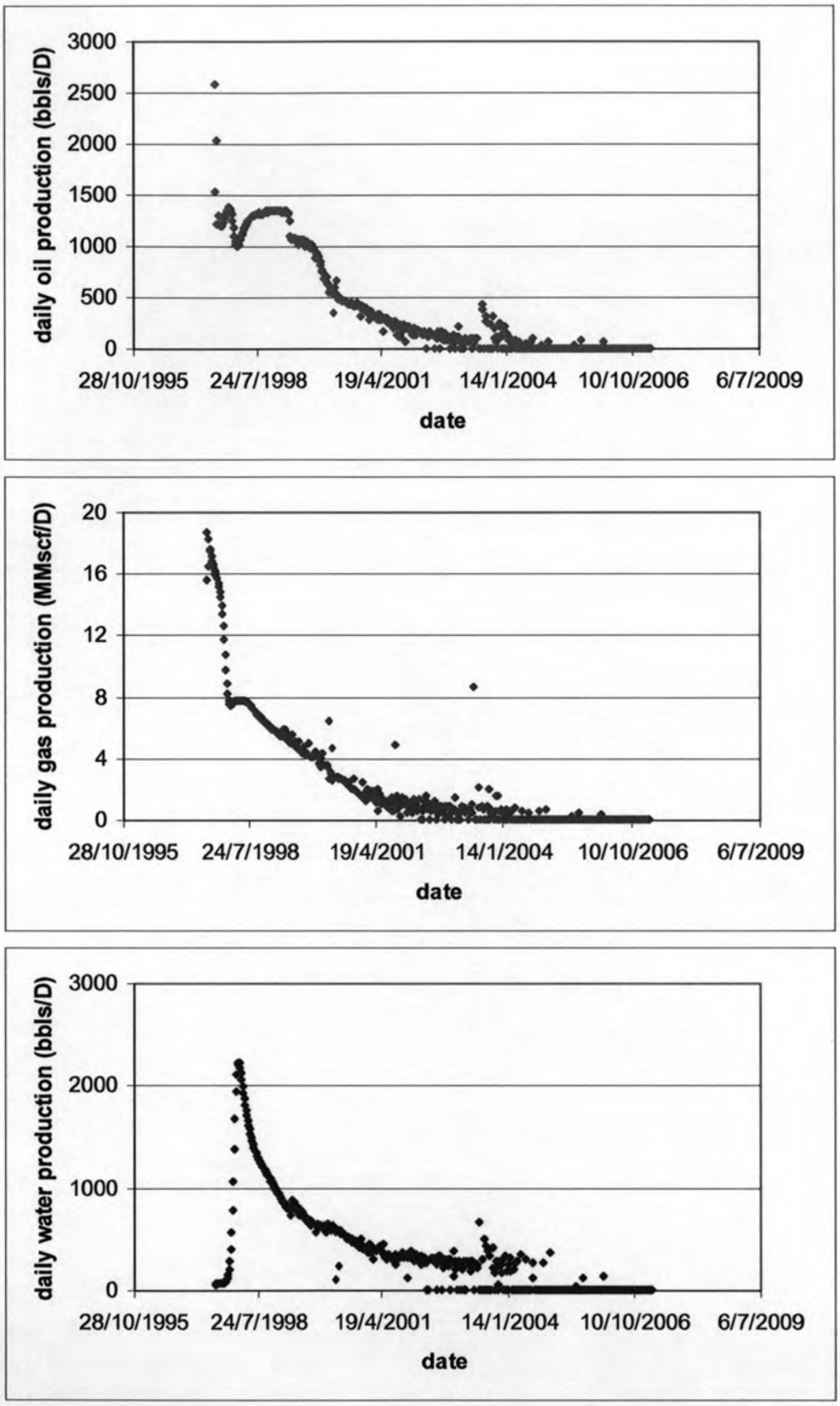


Figure 4.32: Production profiles of oil, gas and water for well C-14 using perforation strategy 3.

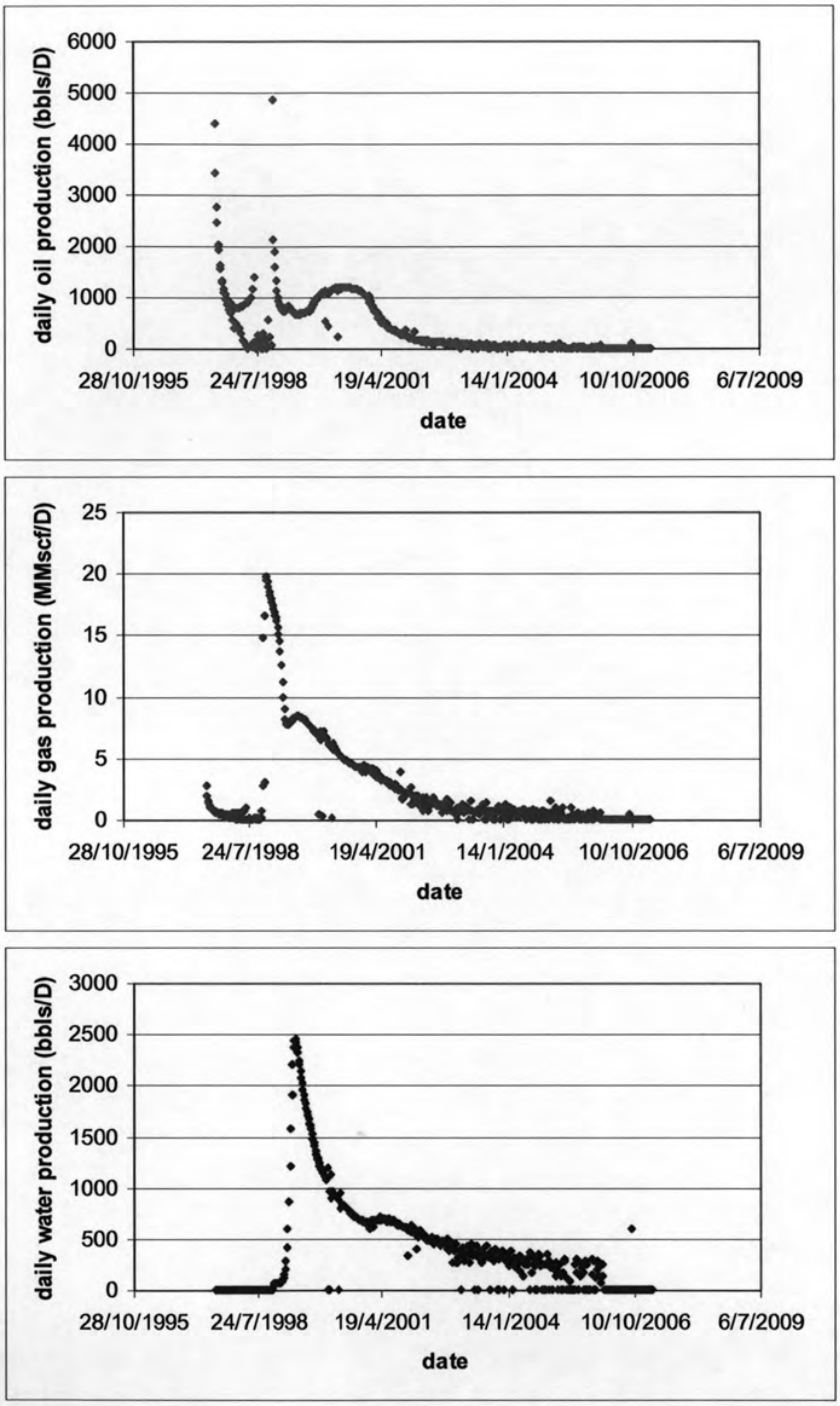


Figure 4.33: Production profiles of oil, gas and water for well C-14 using perforation strategy 4.

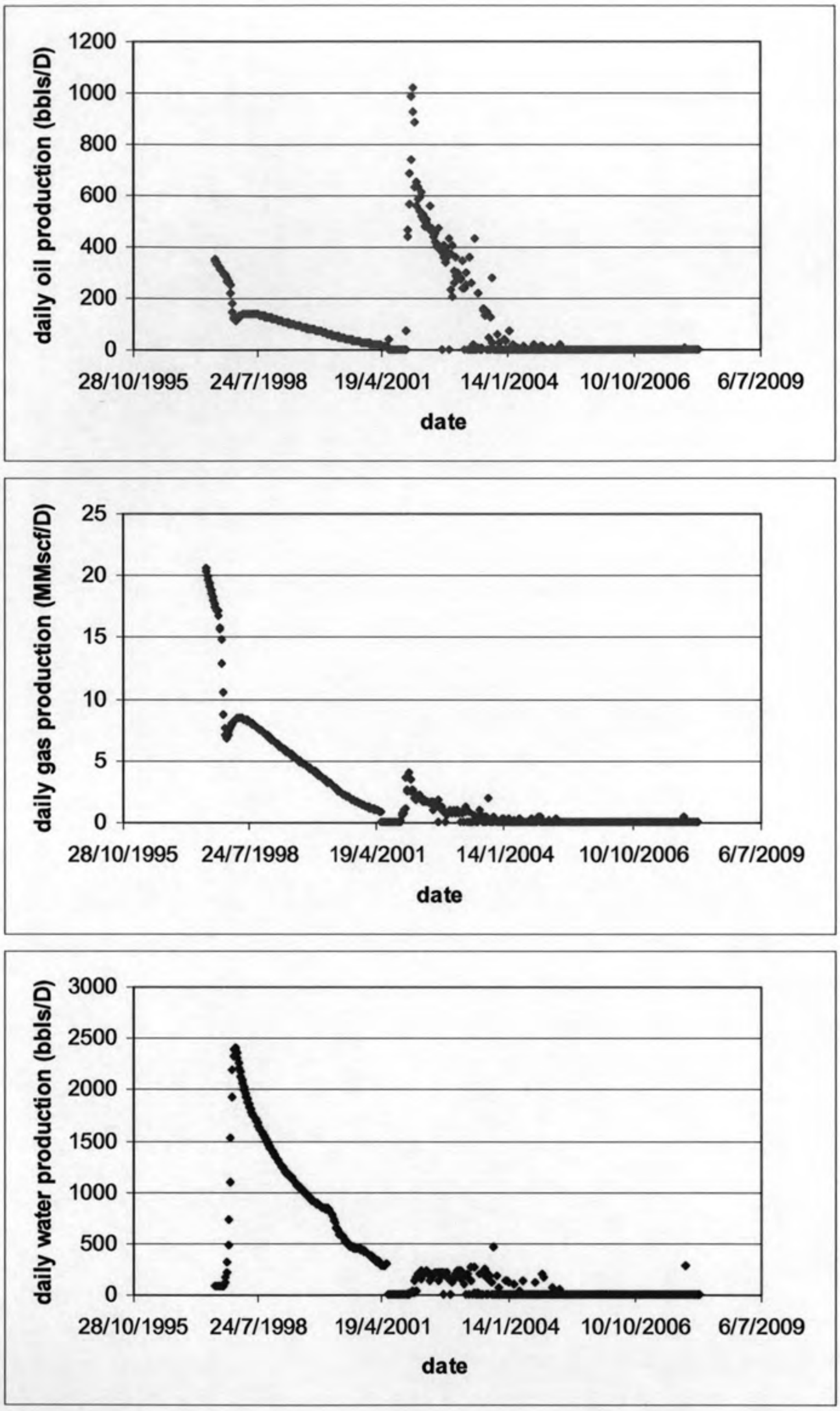


Figure 4.34: Production profiles of oil, gas and water for well C-14 using perforation strategy 5.

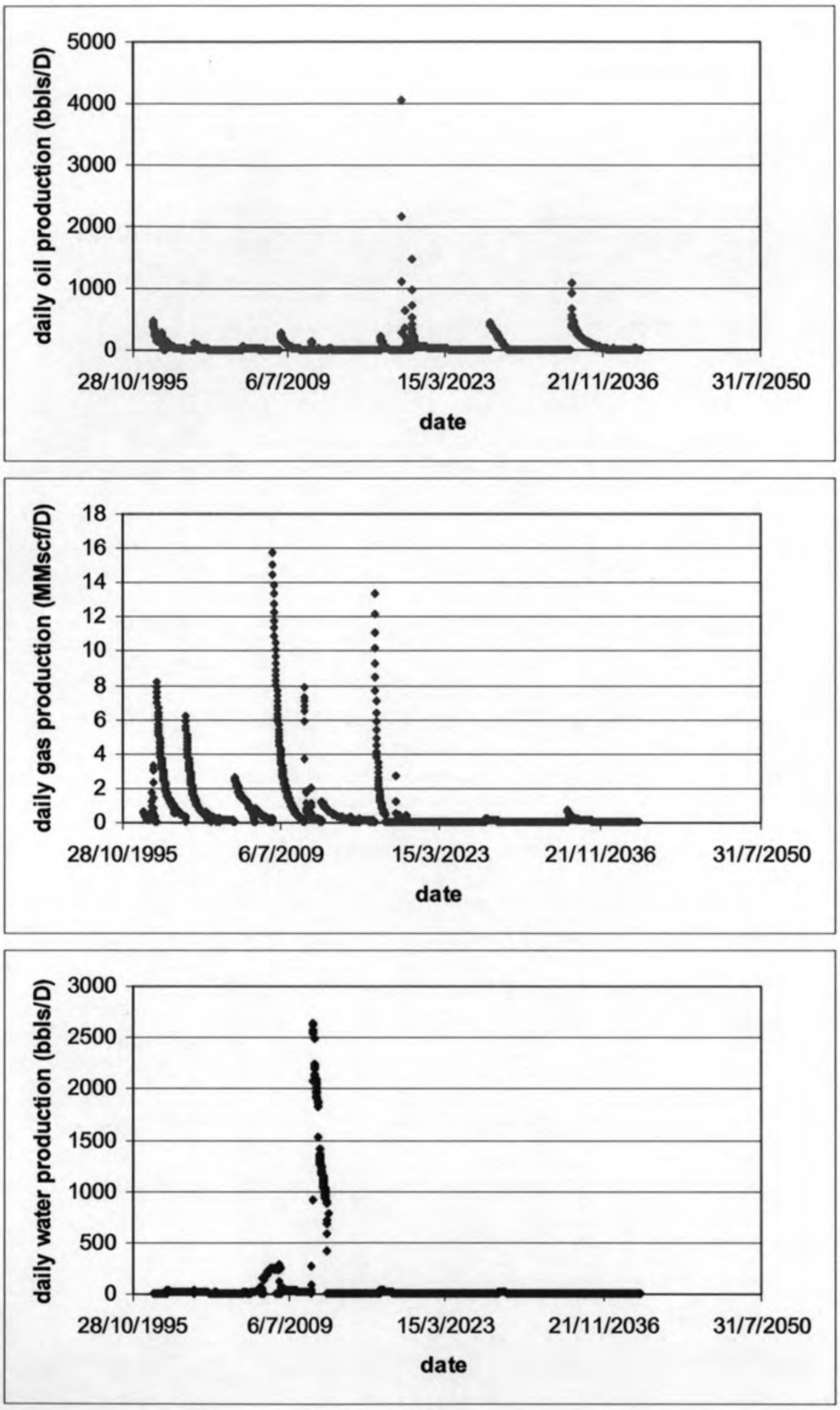


Figure 4.35: Production profiles of oil, gas and water for well C-14 using perforation strategy 6.

4.2.4 Example 4: Well C-15

A schematic for well C-15 is shown in Figure 4.36. The well penetrates through 14 sands: four of which are gas sands and seven are oil sands. Two sands have oil water contacts while the other one have gas oil and water contacts. The well produces at its best with strategy 3 because it perforates all gas and oil zones are perforated together. This well has a solution GOR around 650 SCF/STB and the gas from the gas sands helps lifting the fluid up. Strategy 6 which is bottom up perforation also delivers a good result because the cross flow does not take place. Table 4.5 summarizes the results of these strategies:

Table 4.5: Cumulative production for C-15.

C-15	cum oil (STB)	cum water (MMSTB)	cum gas (MMscf)	BOE
Strategy 1	253,692	0.447	8,208	1,621,681
Strategy 2	182,139	0.111	3,871	827,296
Strategy 3	**262,843**	0.633	7,622	1,533,104
Strategy 4	234,033	0.169	5,549	1,158,909
Strategy 5	73,246	**0.040**	6,597	1,172,779
Strategy 6	241,029	1.943	**11,783**	**2,204,901**

Strategy 3 gives the best oil recovery but not the best BOE recovery. The best strategy for BOE is strategy 6 which also gives the highest gas recovery. This is due to the fact that strategy 6 recovers a lot more gas than strategy 3.

Strategy 5 gives the lowest oil production because the gas sands were depleted and the water influx into the wellbore loaded the well before the oil sands were produced.

The important point to keep in mind for this well is that there is a GWC sand at the upper most level of this well. This sand should be perforated at the last batch to avoid water loading up in the well. Even though, selective shut off with tubing patch can be performed but it will be more difficult to run the operation below the patched depth.

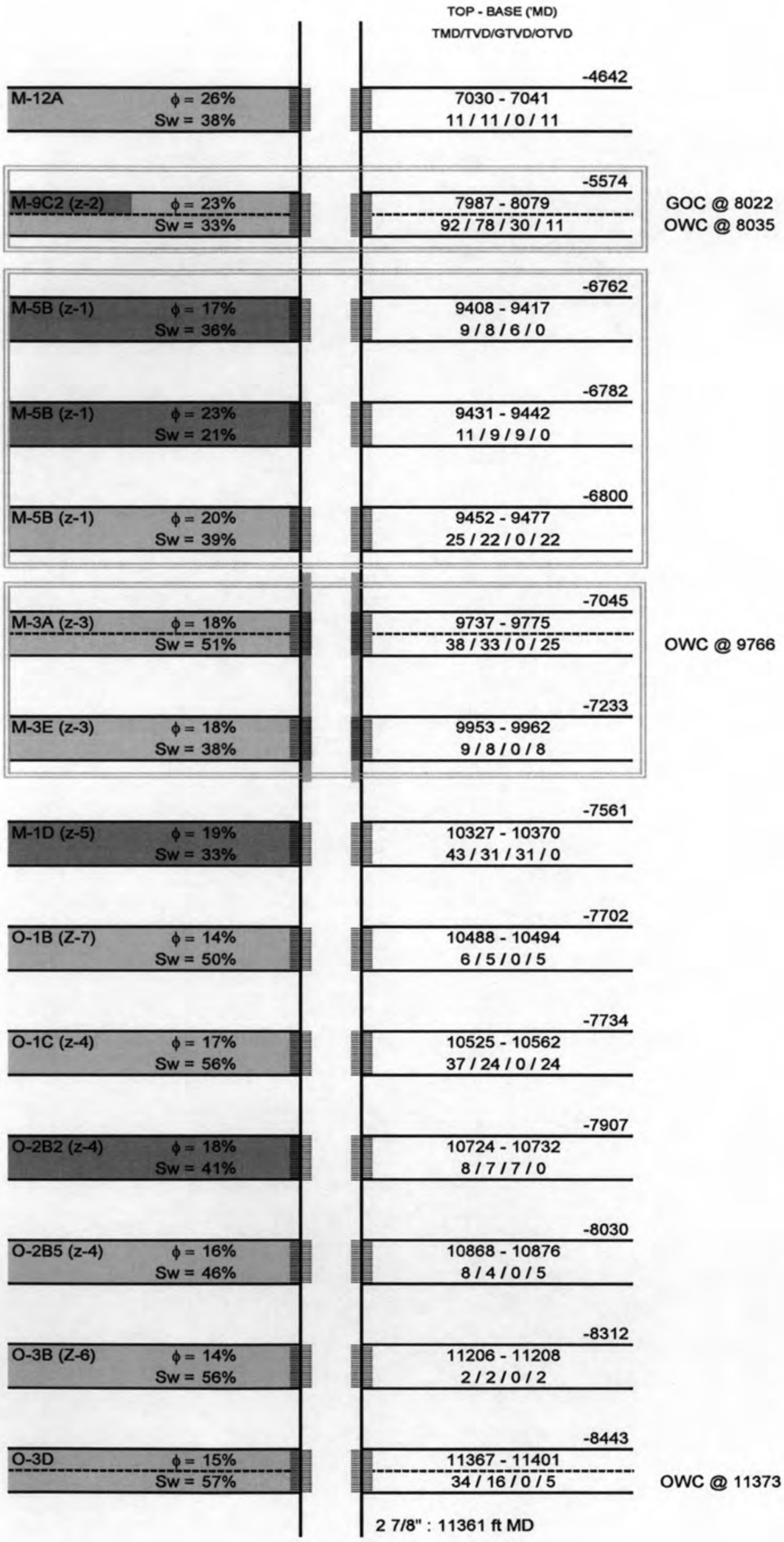


Figure 4.36: Well schematic for C-15.

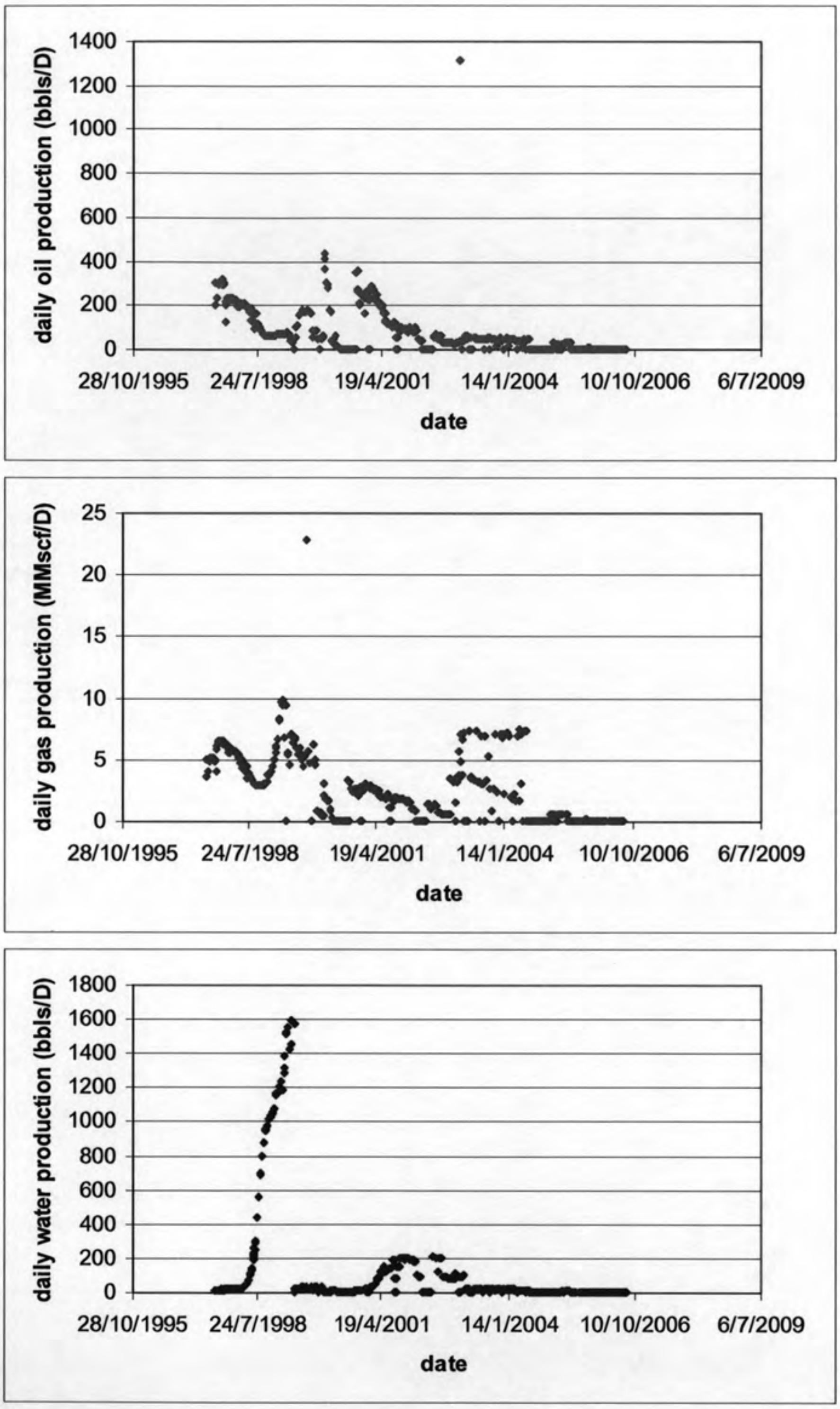


Figure 4.37: Production profiles of oil, gas and water for well C-15 using perforation strategy 1.

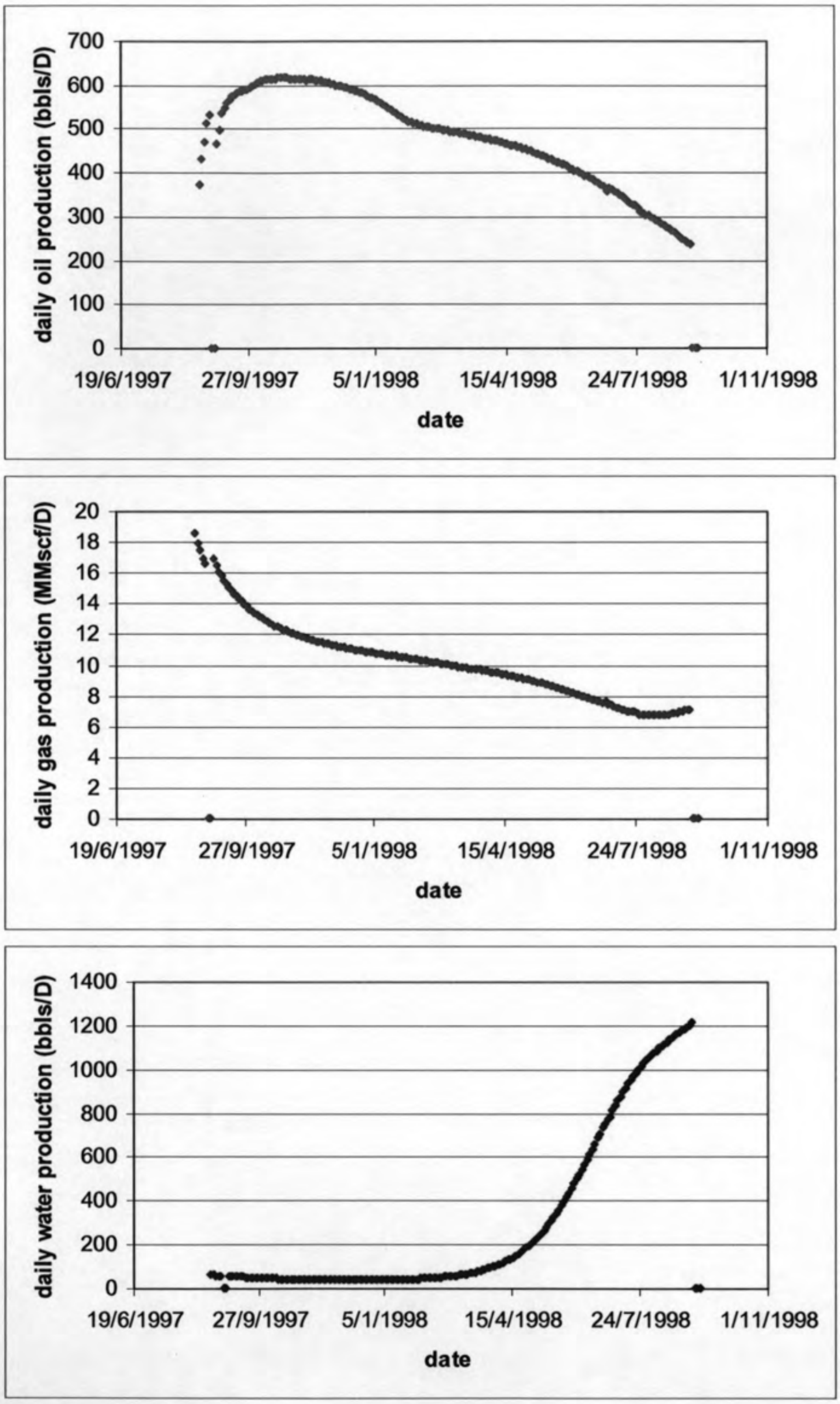
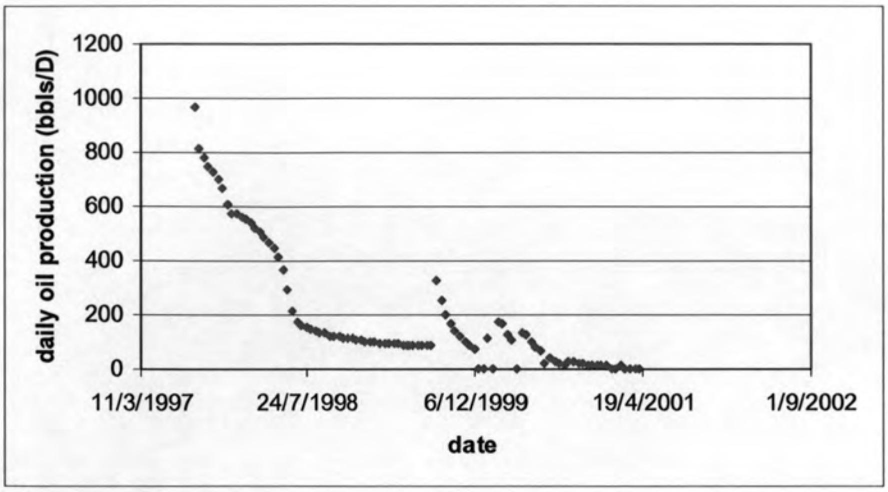
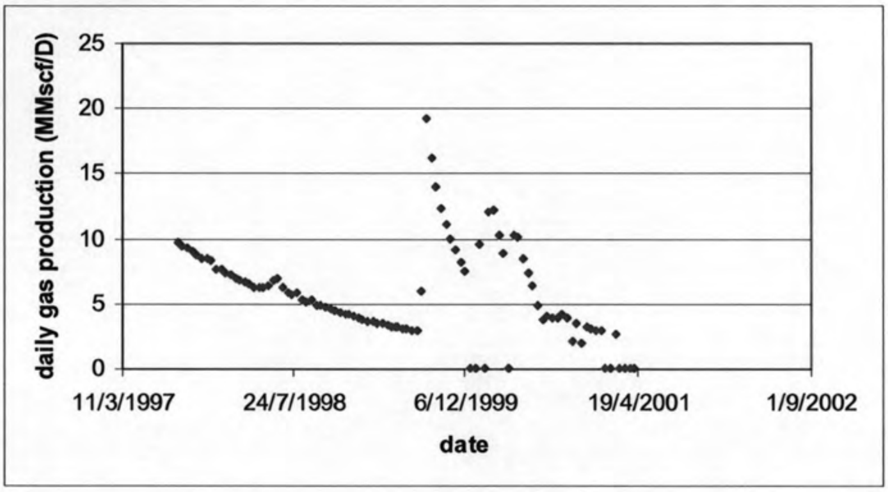


Figure 4.38: Production profiles of oil, gas and water for well C-15 using perforation strategy 2.





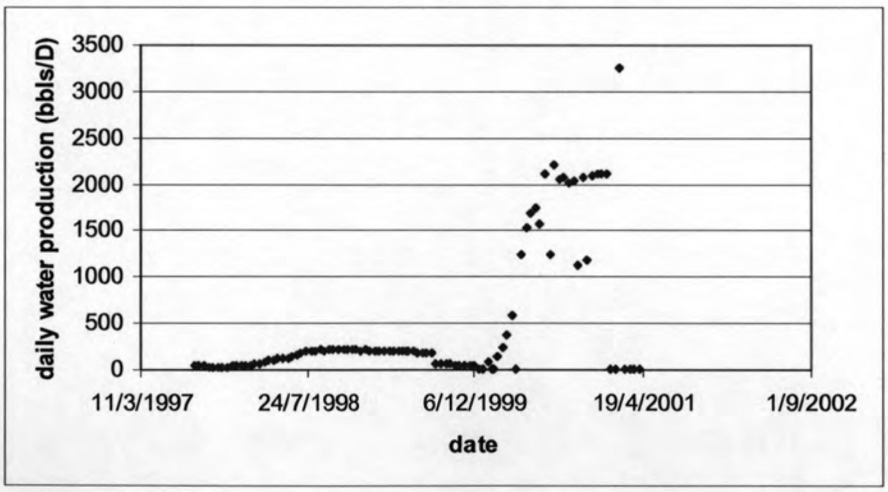


Figure 4.39: Production profiles of oil, gas and water for well C-15 using perforation strategy 3.

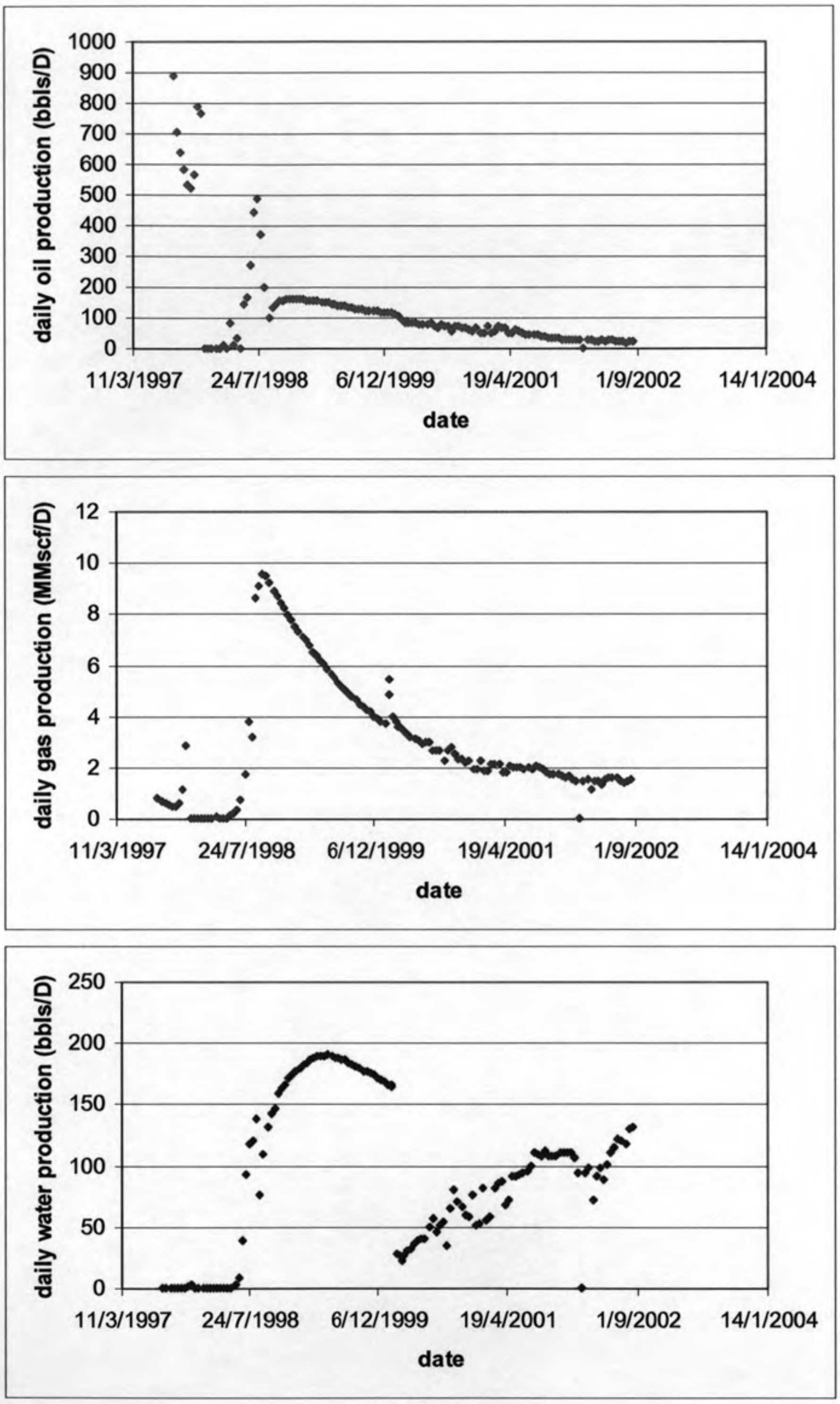


Figure 4.40: Production profiles of oil, gas and water for well C-15 using perforation strategy 4.

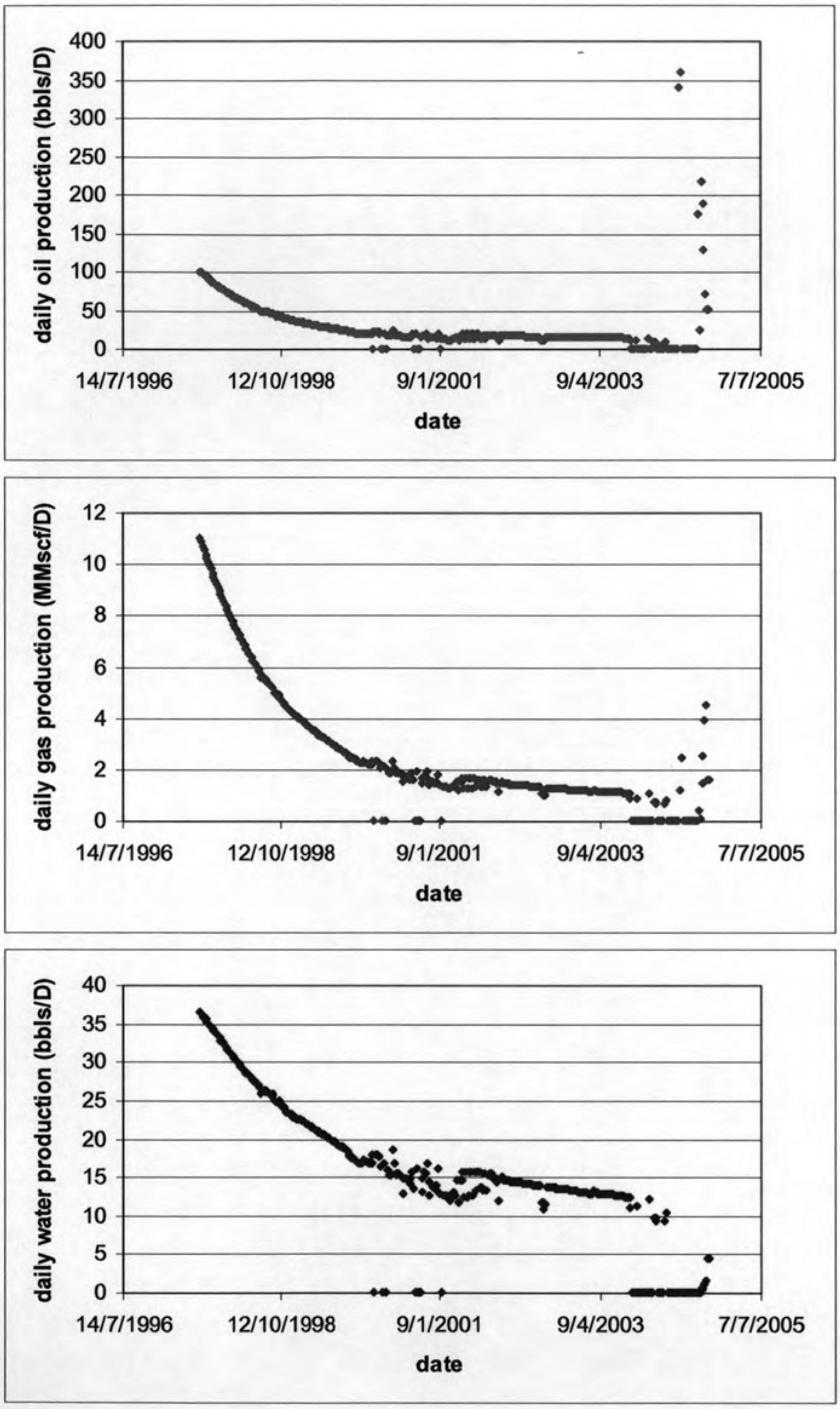


Figure 4.41: Production profiles of oil, gas and water for well C-15 using perforation strategy 5.

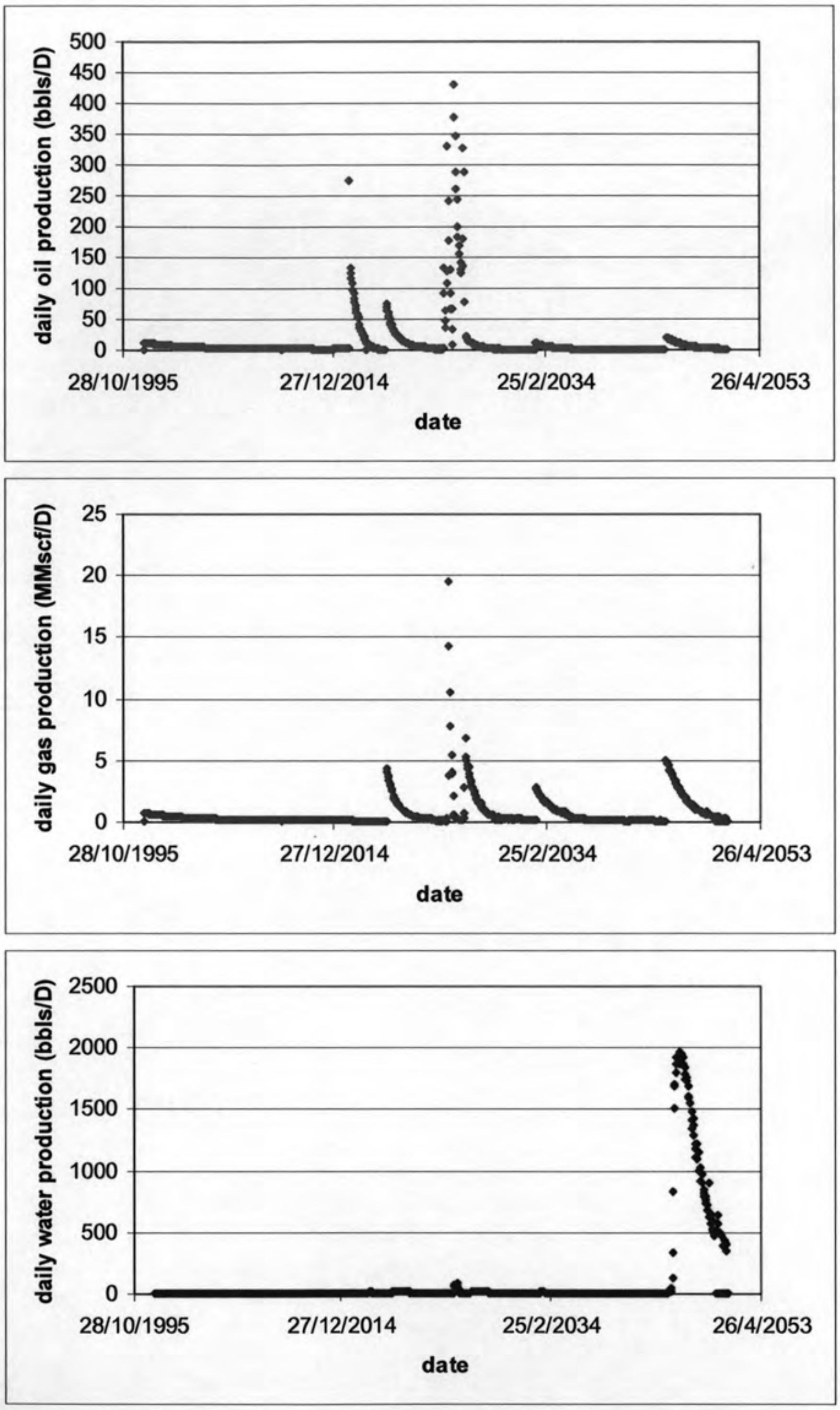


Figure 4.42: Production profiles of oil, gas and water for well C-15 using perforation strategy 6.

From Figure 4.42, most of water production come from shallow gas oil water contact sand.

4.2.5 Example 5: Well C-16

Figure 4.43 shows the schematic of well C-16. The well penetrates through 4 gas sands that two of which are gas sands and two are gas water contact sands. The table 4.6 summarizes the results from all the strategies.

Table 4.6: Cumulative Production for C-16

C-16	cum oil (STB)	cum water (MMSTB)	cum gas (MMscf)	BOE
Strategy 1	79,867	0.180	3,690	694,804
Strategy 2	92,148	0.256	4,401	825,631
Strategy 3				
Strategy 4	90,433	0.256	4,432	829,079
Strategy 5				
Strategy 6	94,116	0.193	4,567	855,250

There is a close tie in the results delivered by this well and almost all of them except strategy 1 have delivered good results. Since we are looking for the ultimate in the oil recovery, we select the highest value regardless of gas production or the low cost for low water handling facilities. Strategy 6 delivers the most favourable result due to the fact that this well comprises of only 4 gas sands in which, two are full to base and the other two are contact sands. So, the cumulative production turns out to be close. The production profiles are shown in Figures 4.44-4.47.

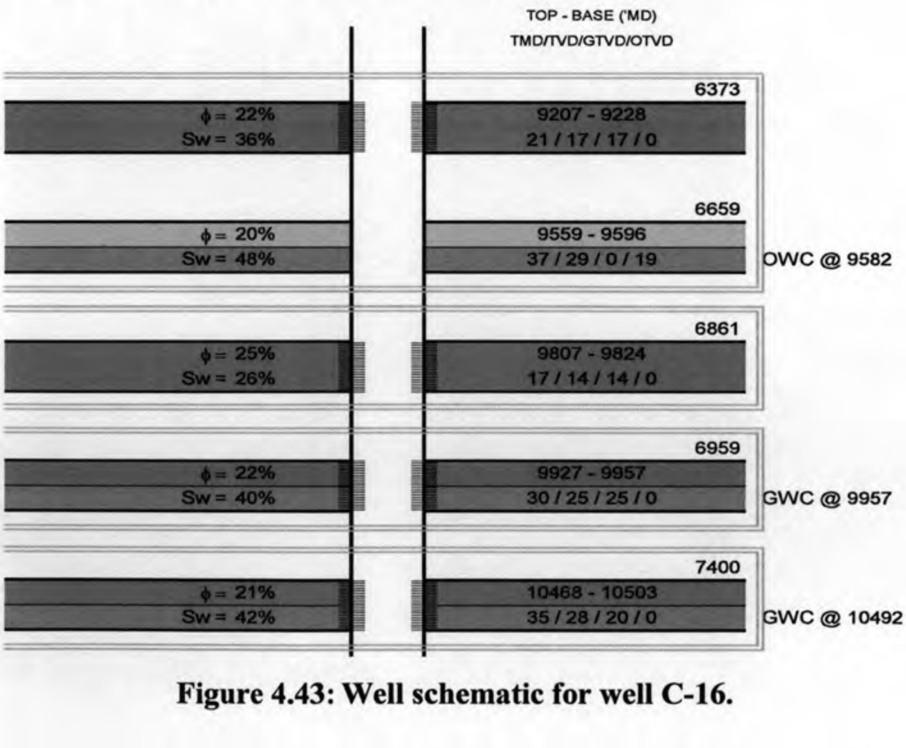


Figure 4.43: Well schematic for well C-16.

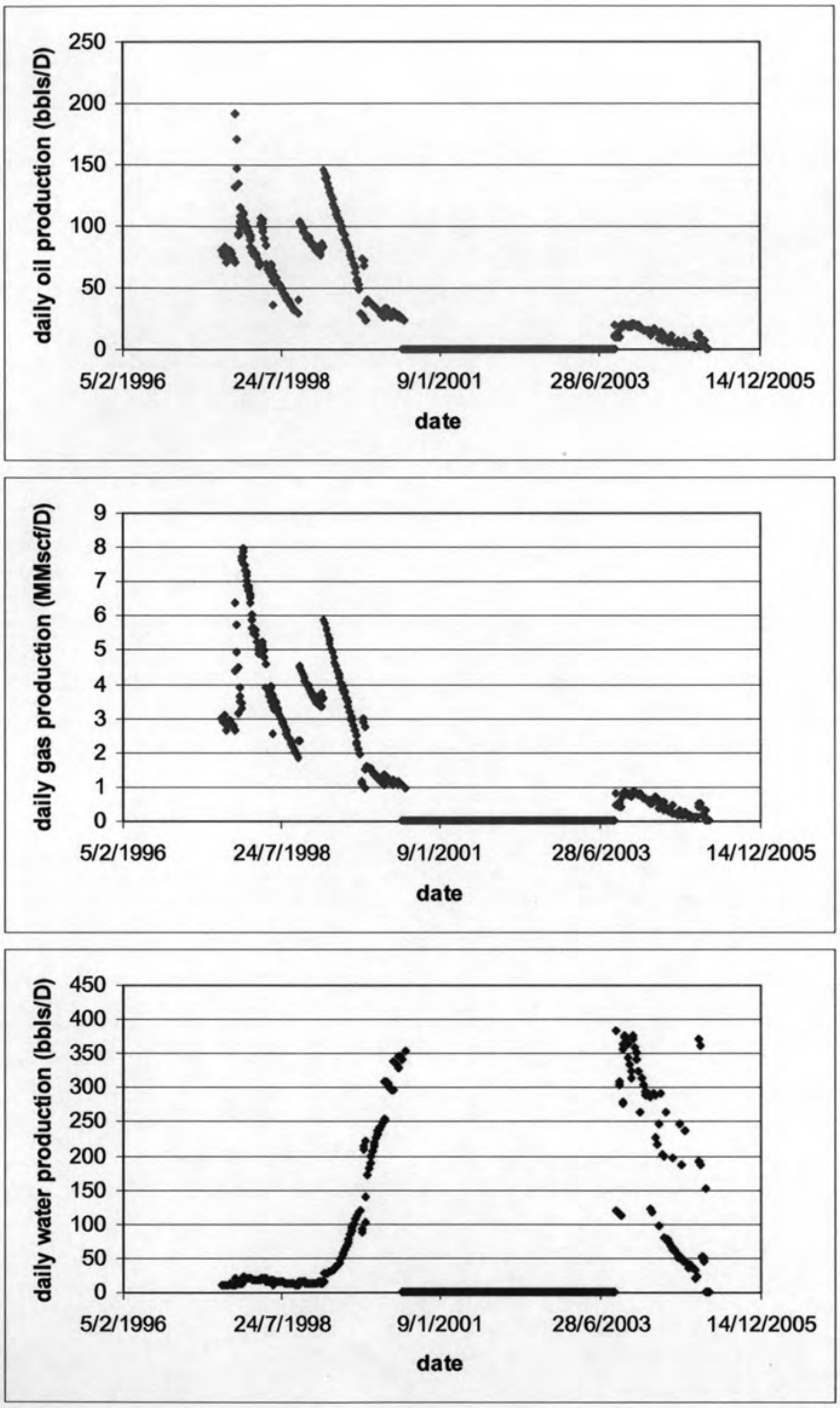


Figure 4.44: Production profiles of oil, gas and water for well C-16 using perforation strategy 1.

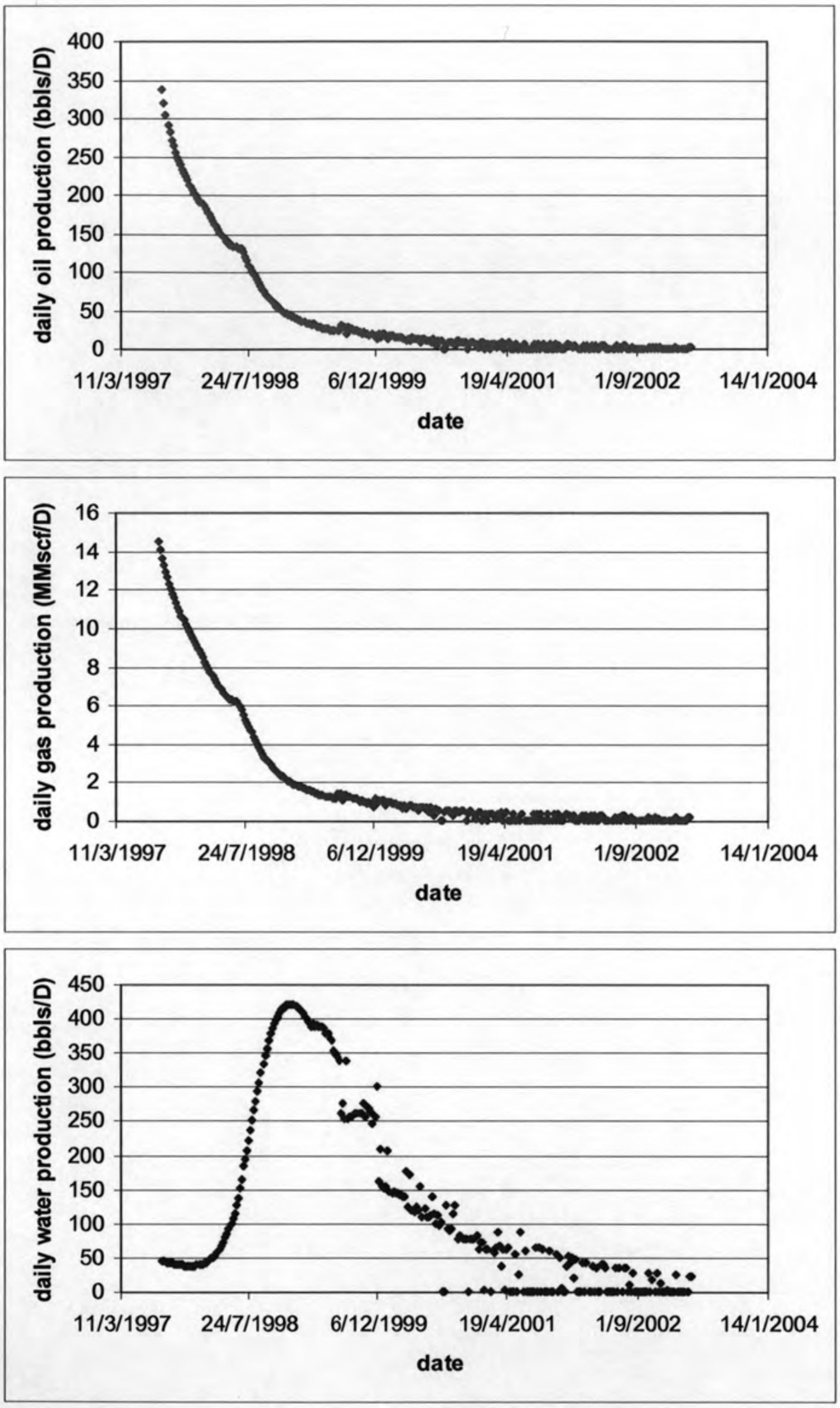


Figure 4.45: Production profiles of oil, gas and water for well C-16 using perforation strategy 2.

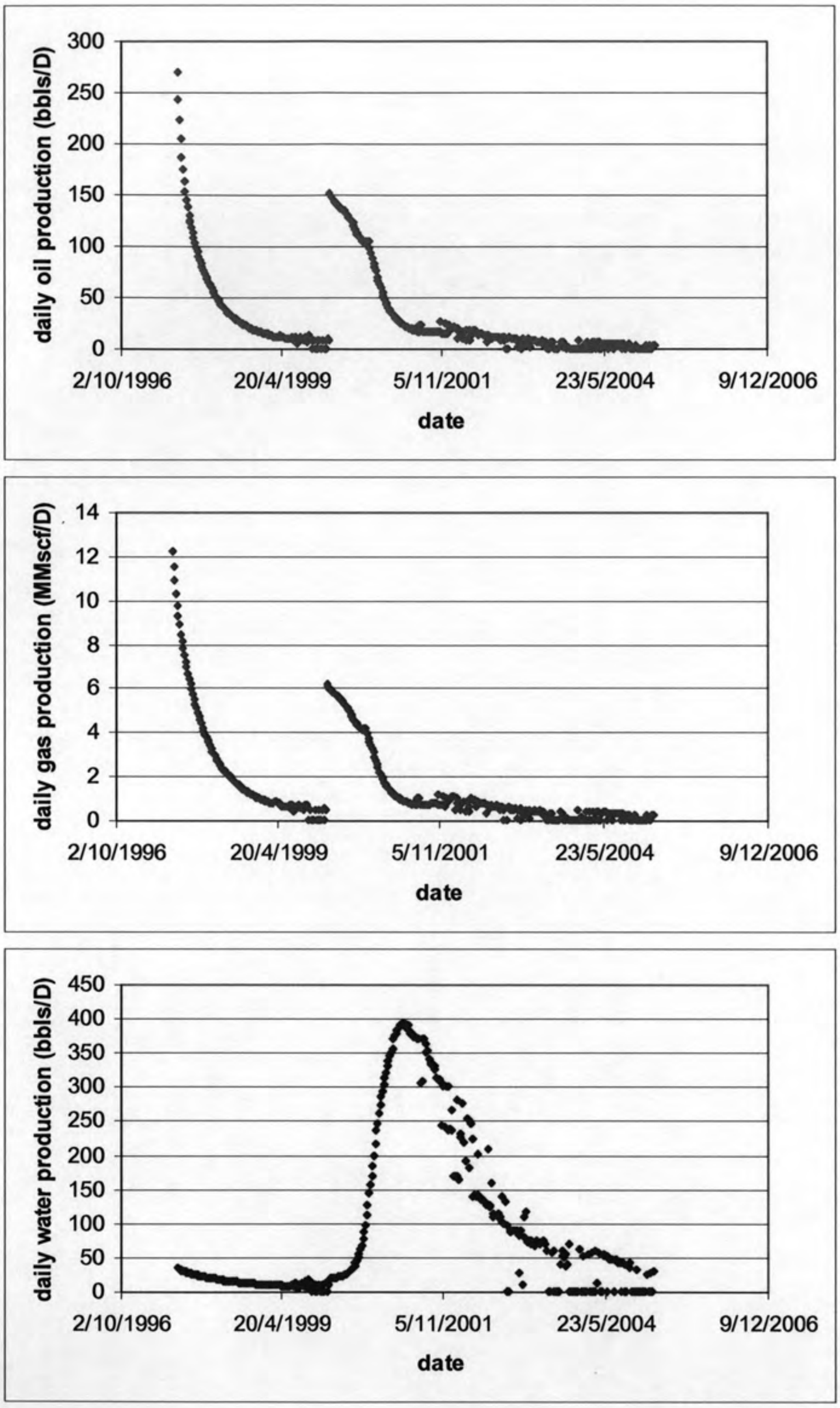


Figure 4.46: Production profiles of oil, gas and water for well C-16 using perforation strategy 3-5.

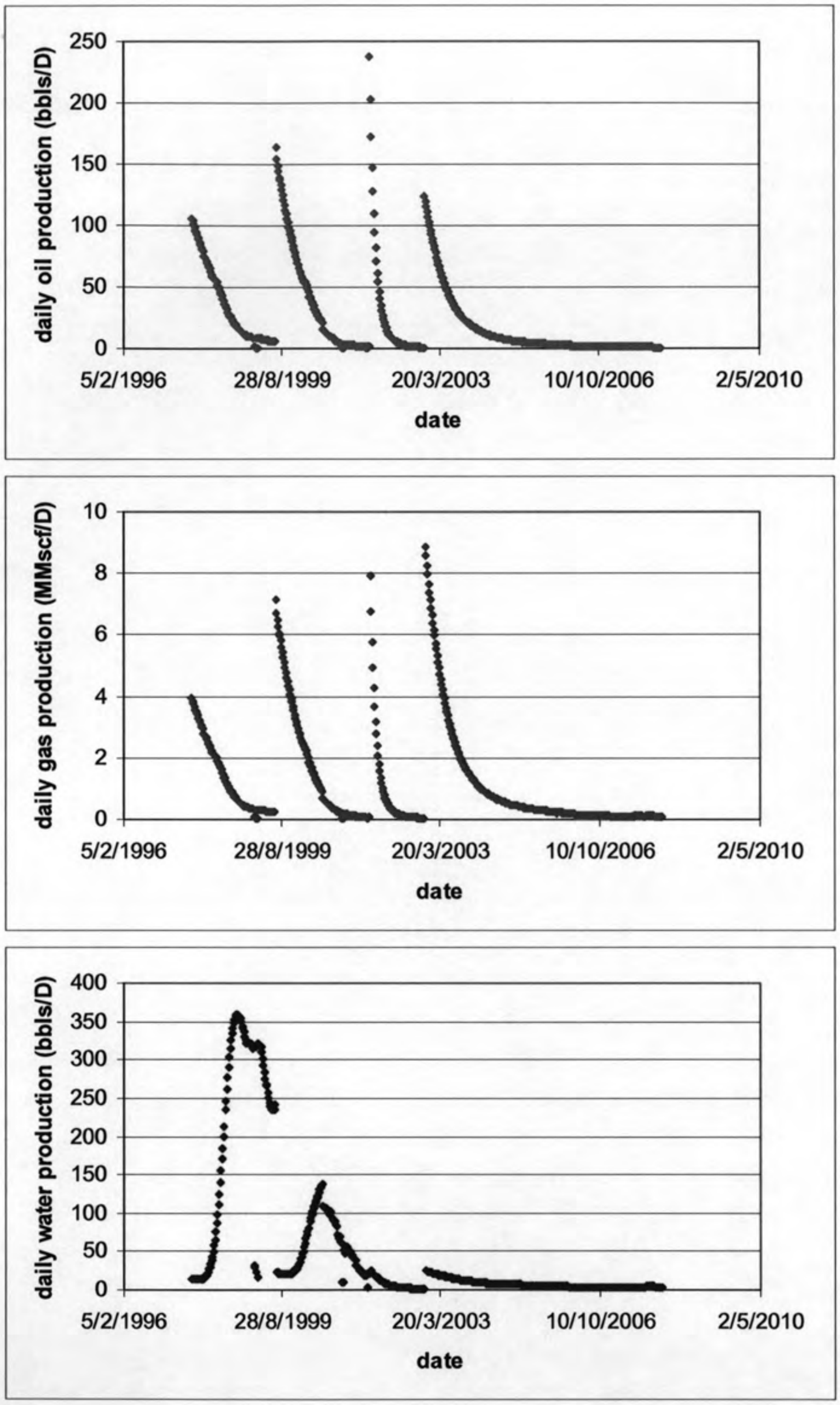


Figure 4.47: Production profiles of oil, gas and water for well C-16 using perforation strategy 6.

4.2.6 Example 6: Well C-19

Table 4.7: Cumulative production for C-19.

C-19	cum oil (STB)	cum water (MMSTB)	cum gas (MMscf)	BOE
Strategy 1	338,267	0.068	220	374,889
Strategy 2 Strategy 3 Strategy 4 Strategy 5	379,336	0.089	243	419,766
Strategy 6	392,630	0.049	248	433,982

This well has just only three full to base oil sands already produced. So, the perforation strategies 2-5 are the same. Figure 4.48 shows only three full to base oil sands already perforated in the actual production, and the production profiles for 6 perforation strategies are shown in Figures 4.49 to 4.51.

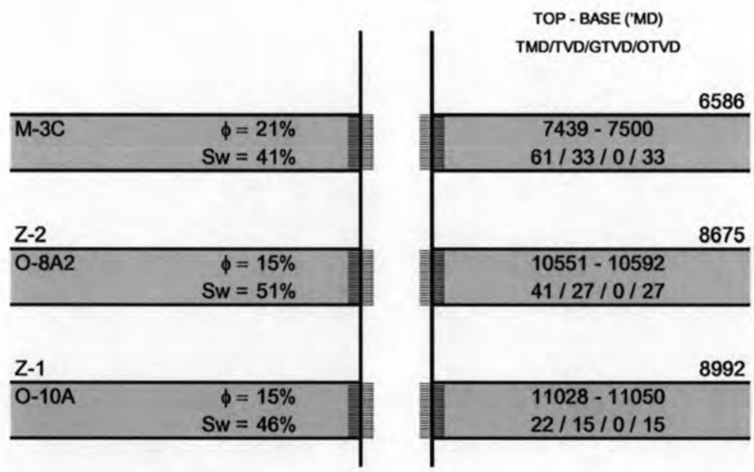


Figure 4.48: Well schematic of C-19 – have only three full to base oil sand perforated.

Figures 4.49-4.51 show that strategy 6 gives the highest oil, gas, and BOE production since the oil reservoir has been produced one at a time. When one reservoir was totally depleted, it was shut off before new perforation commences. This strategy will avoid cross flow and reduce bottom hole pressure due to high water production as well.

Strategy 1 gives the lower oil production compare to strategies 2-5, this might be the effect of cross flow when second perforation was commenced.

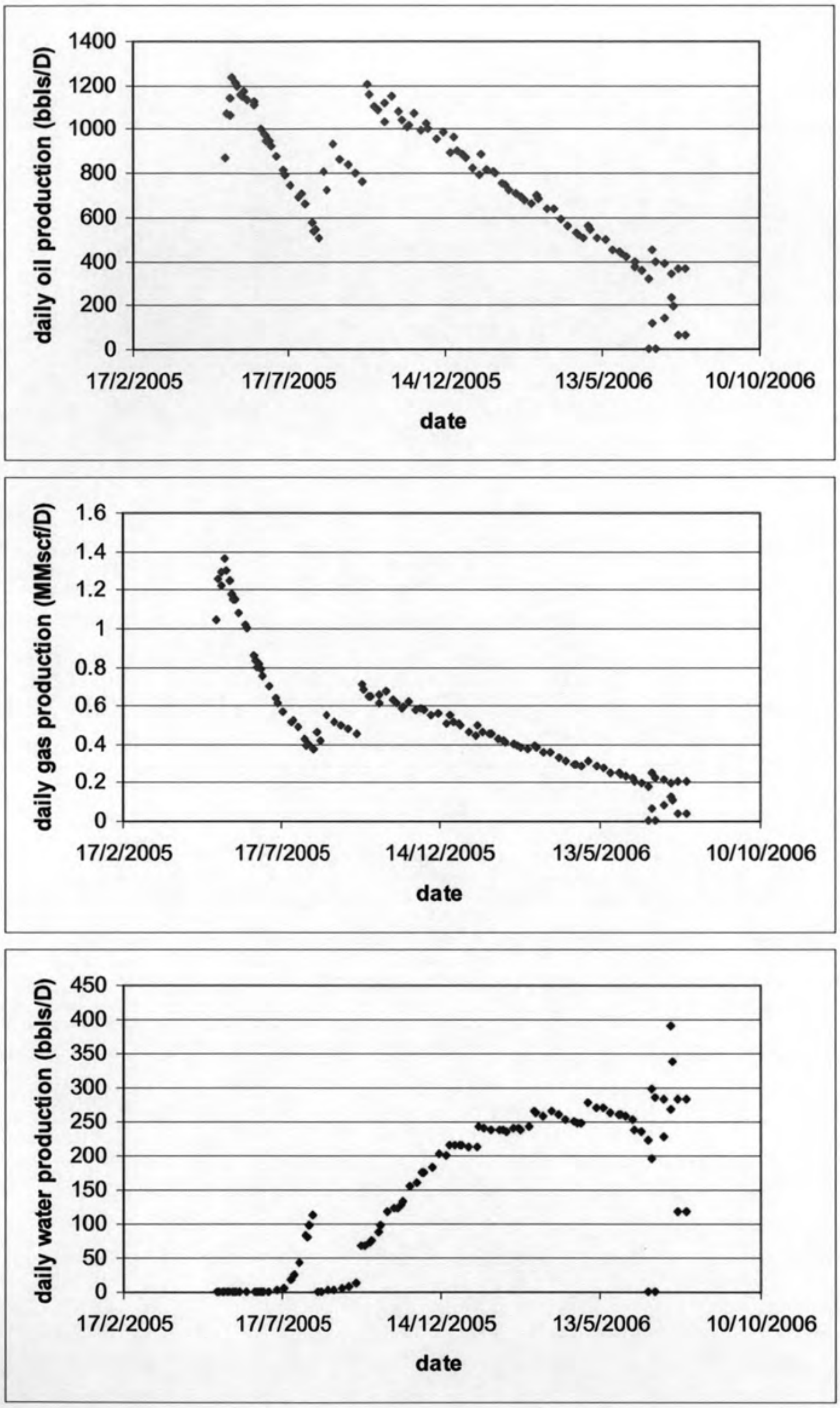


Figure 4.49: Production profiles of oil, gas and water for well C-19 using perforation strategy 1.

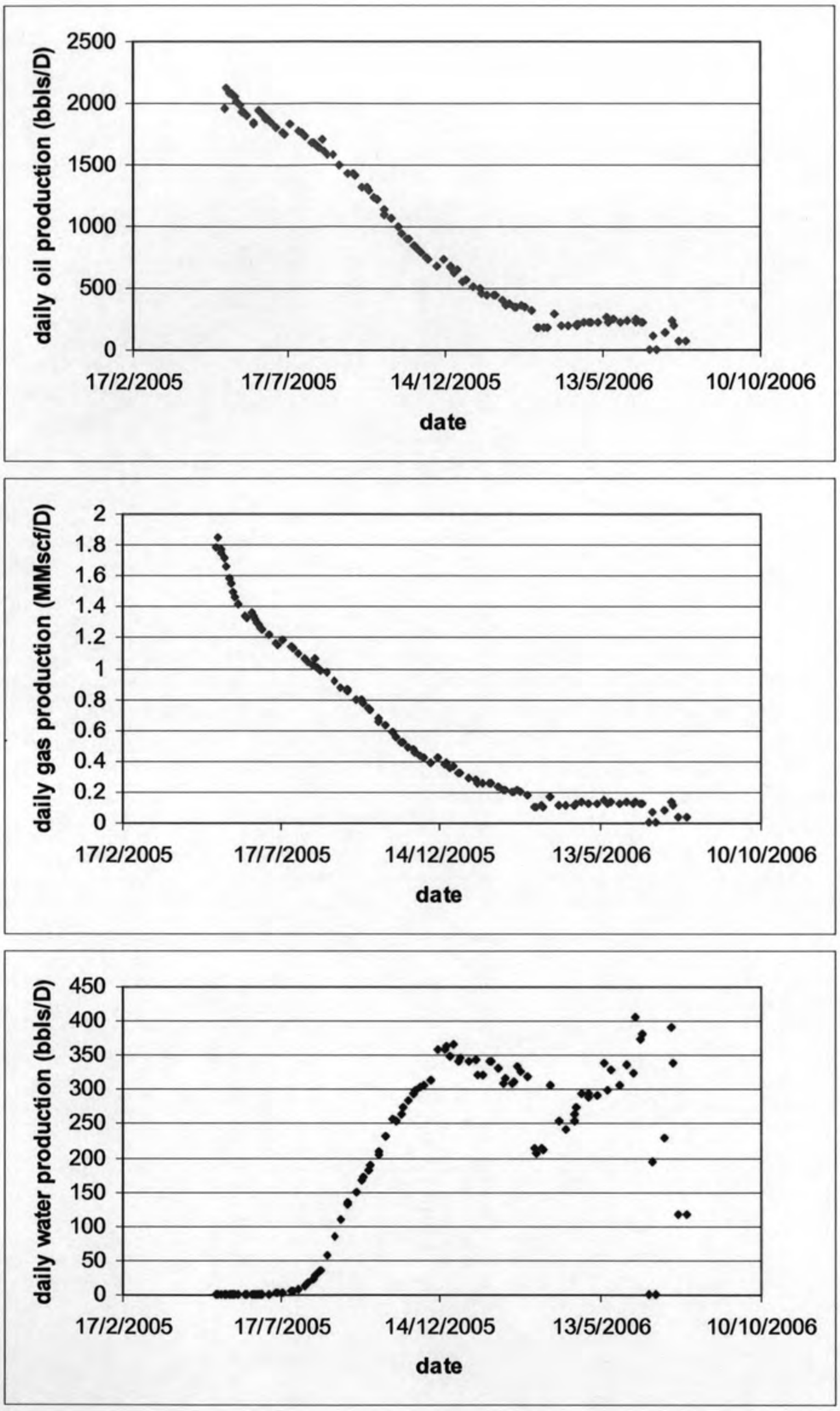


Figure 4.50: Production profiles of oil, gas and water for well C-19 using perforation strategy 2-5.

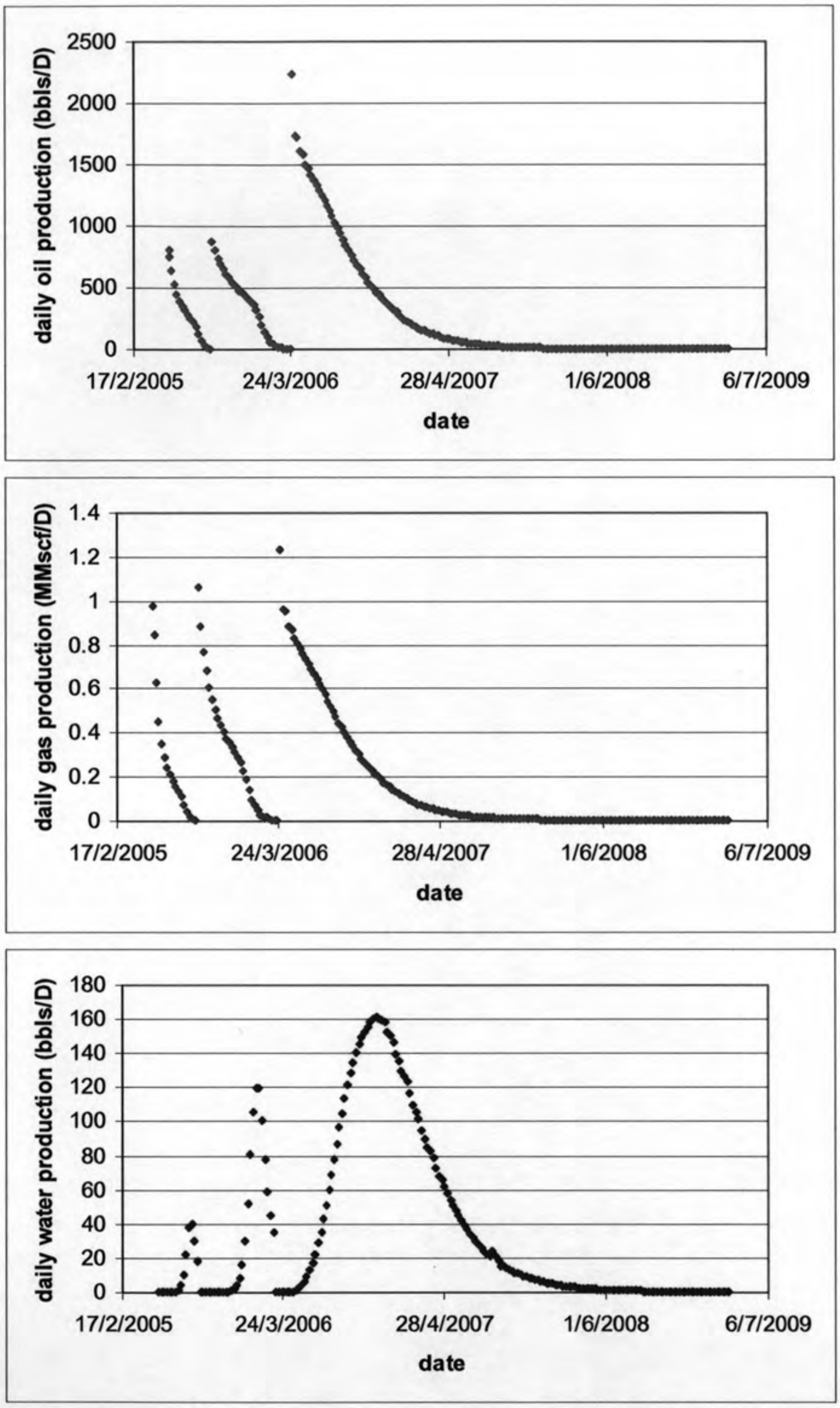


Figure 4.51: Production profiles of oil, gas and water for well C-19 using perforation strategy 6.

4.2.7 Example 7: Well C-21

This is a relatively simple well having just a few layers of sands and is easy to interpret. The well schematic is in Figure 4.52.

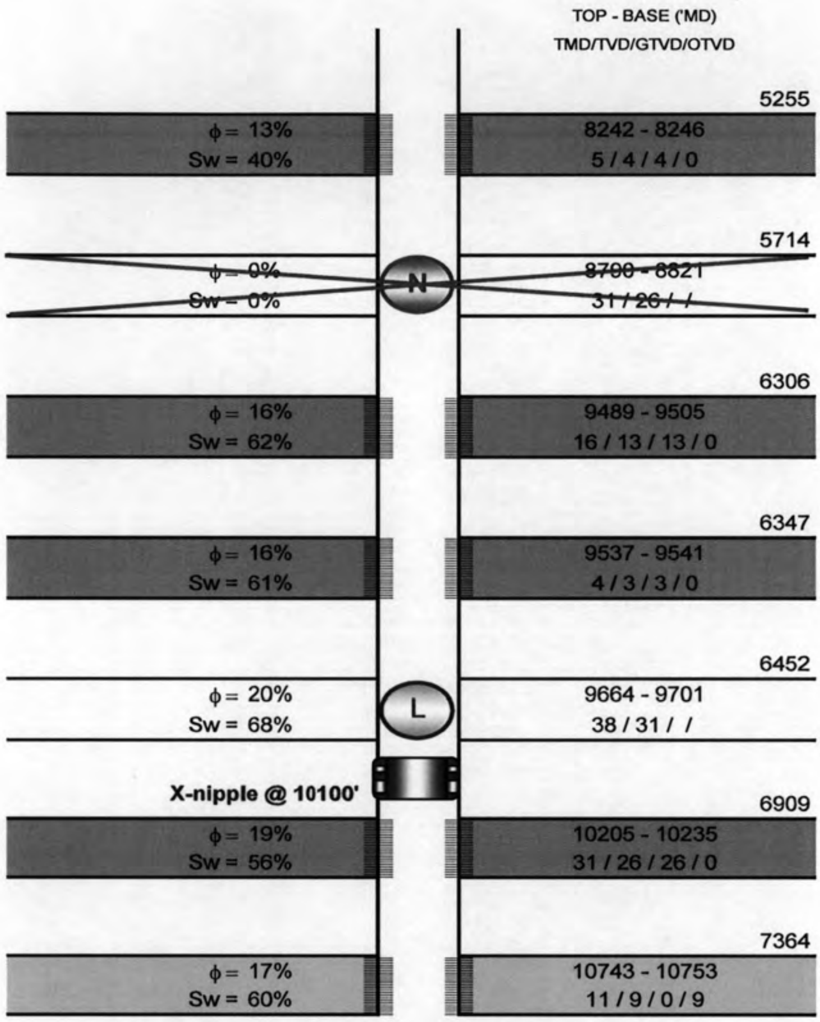


Figure 4.52: Well schematic for C-21.

This well has only five sands and one of them is full to base oil sand. Another four sands are full to base gas sand which has very low permeability, being less than 1 md and high water saturation.

Since SCF/STB of the oil recovery is from a single oil tank which has a solution GOR of 680, the drive mechanism of this well reservoir is solution gas drive. When the reservoir is depleted, other gas reservoirs will be perforated to lift up the fluid. So, strategy 4 gives the highest ultimate oil recovery. Table 4.8 shows the results, and the production profiles of each strategy are shown in Figures 4.53-4.57.

Table 4.8: Cumulative production for C-21.

C-21	cum oil (STB)	cum water (MMSTB)	cum gas (MMscf)	BOE
Strategy 1	7,254	**0.016**	83	21,087
Strategy 2 **Strategy 3**	6,622	0.118	138	29,653
Strategy 4	**7,519**	0.143	154	33,165
Strategy 5	1,204	0.155	172	29,866
Strategy 6	5,886	0.155	**179**	**35,663**

Figure 4.57 shows individual layer oil production. Most of the water production comes from the gas sands and hence loads up the well. So, if we perforate gas sands first, the well will load up faster than perforating gas sands later. This is the reason that strategy 2 & 3 has low oil recovery. Strategy 5 gives the lowest oil production because gas sands were depleted, and the water influx loads the well, followed by oil sand production.

Although strategy 4 gives the highest oil recovery, but when we convert to BOE recovery, strategy 6 gives the best result. The difference in the amount of gas is the reason that oil recoveries are different in mere thousands of barrels.

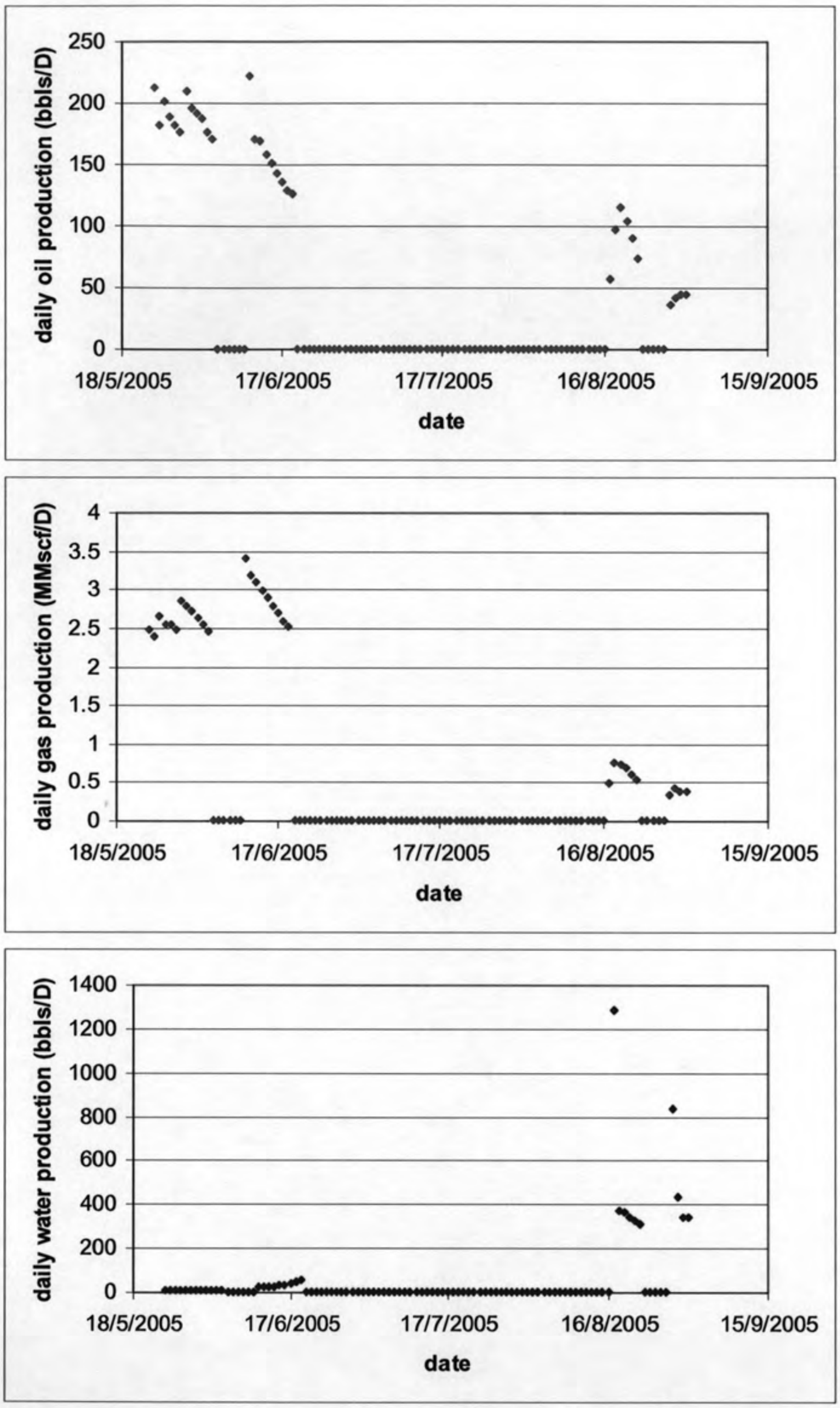


Figure 4.53: Production profiles of oil, gas and water for well C-21 using perforation strategy 1.

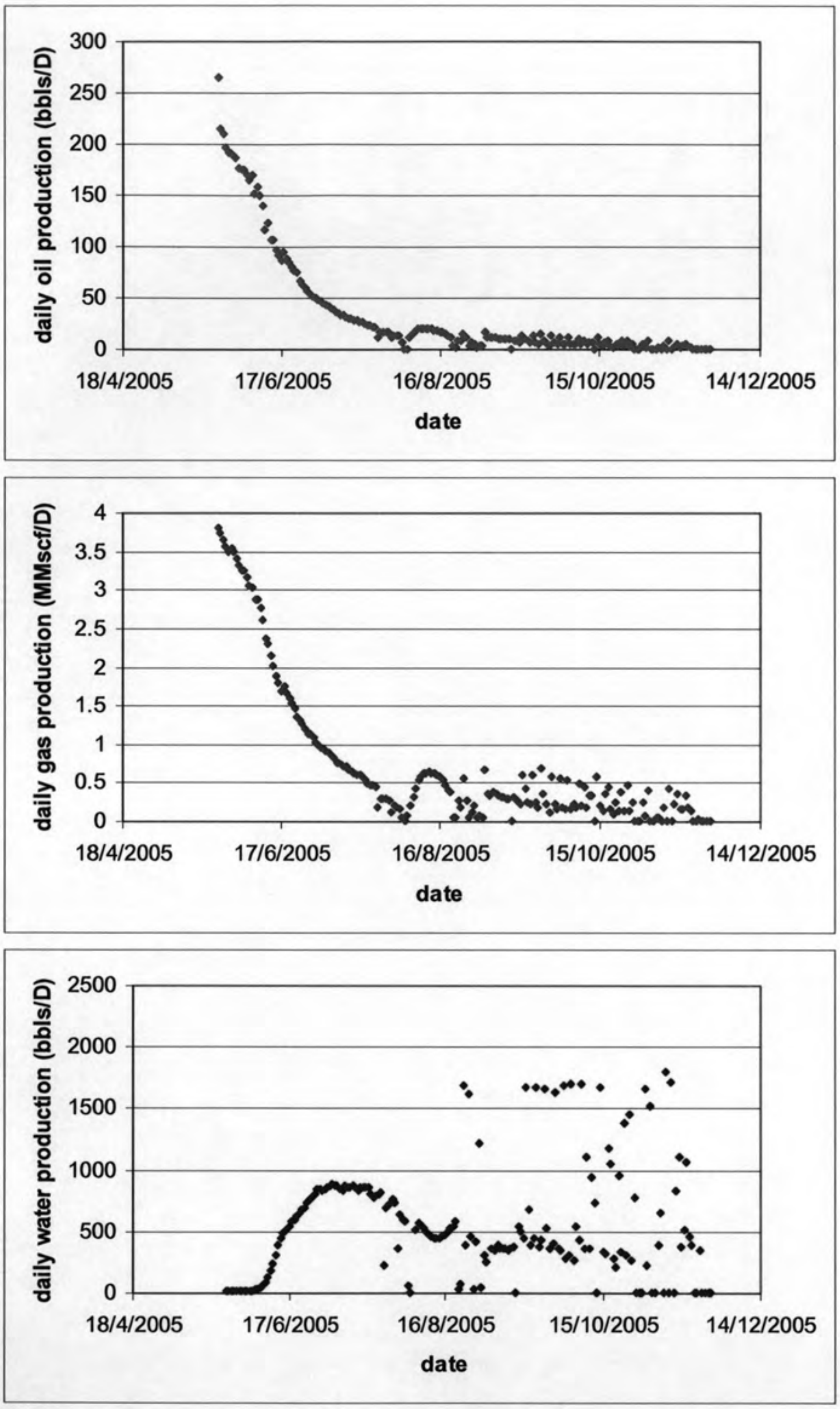


Figure 4.54: Production profiles of oil, gas and water for well C-21 using perforation strategy 2-3.

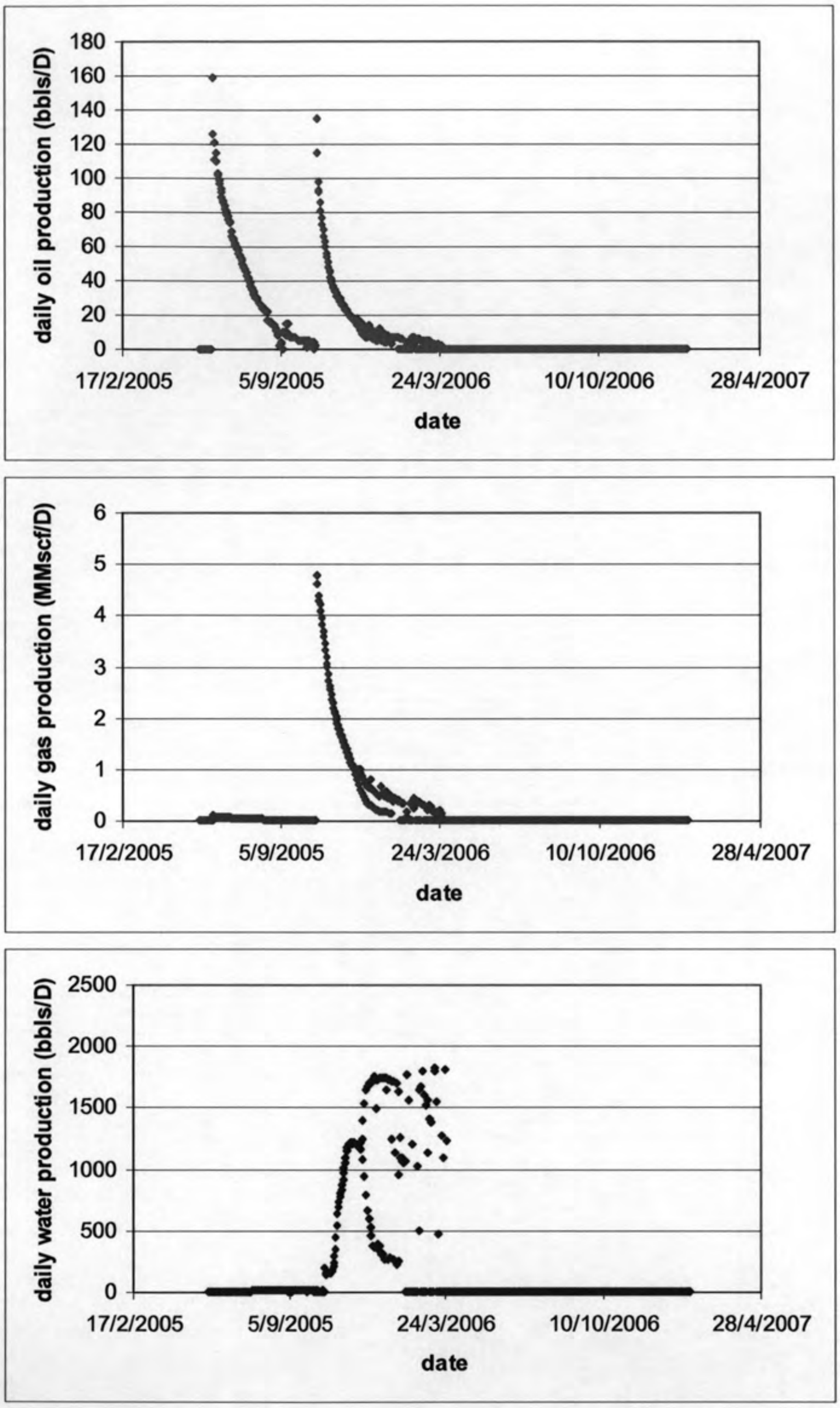


Figure 4.55: Production profiles of oil, gas and water for well C-21 using perforation strategy 4.

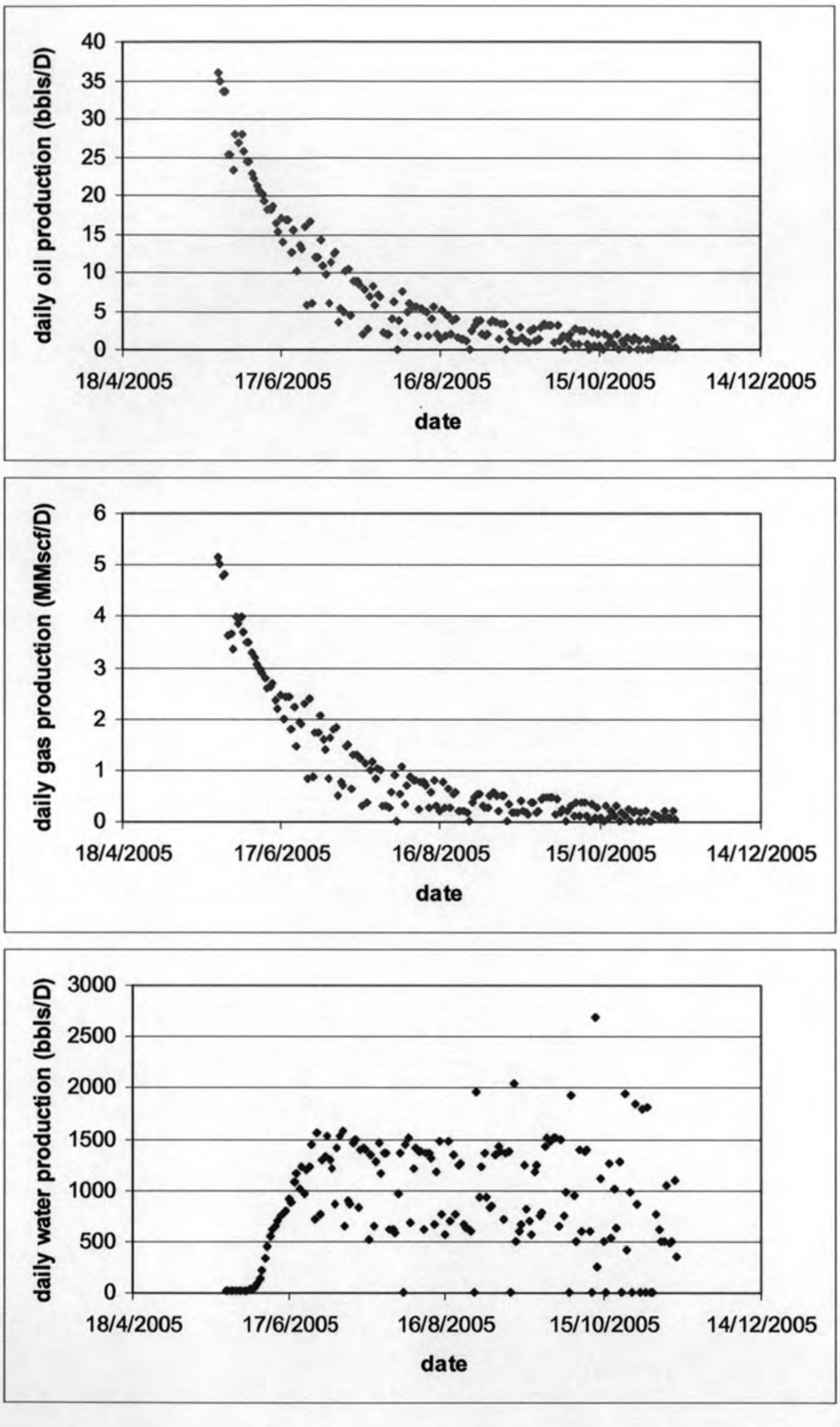


Figure 4.56: Production profiles of oil, gas and water for well C-21 using perforation strategy 5.

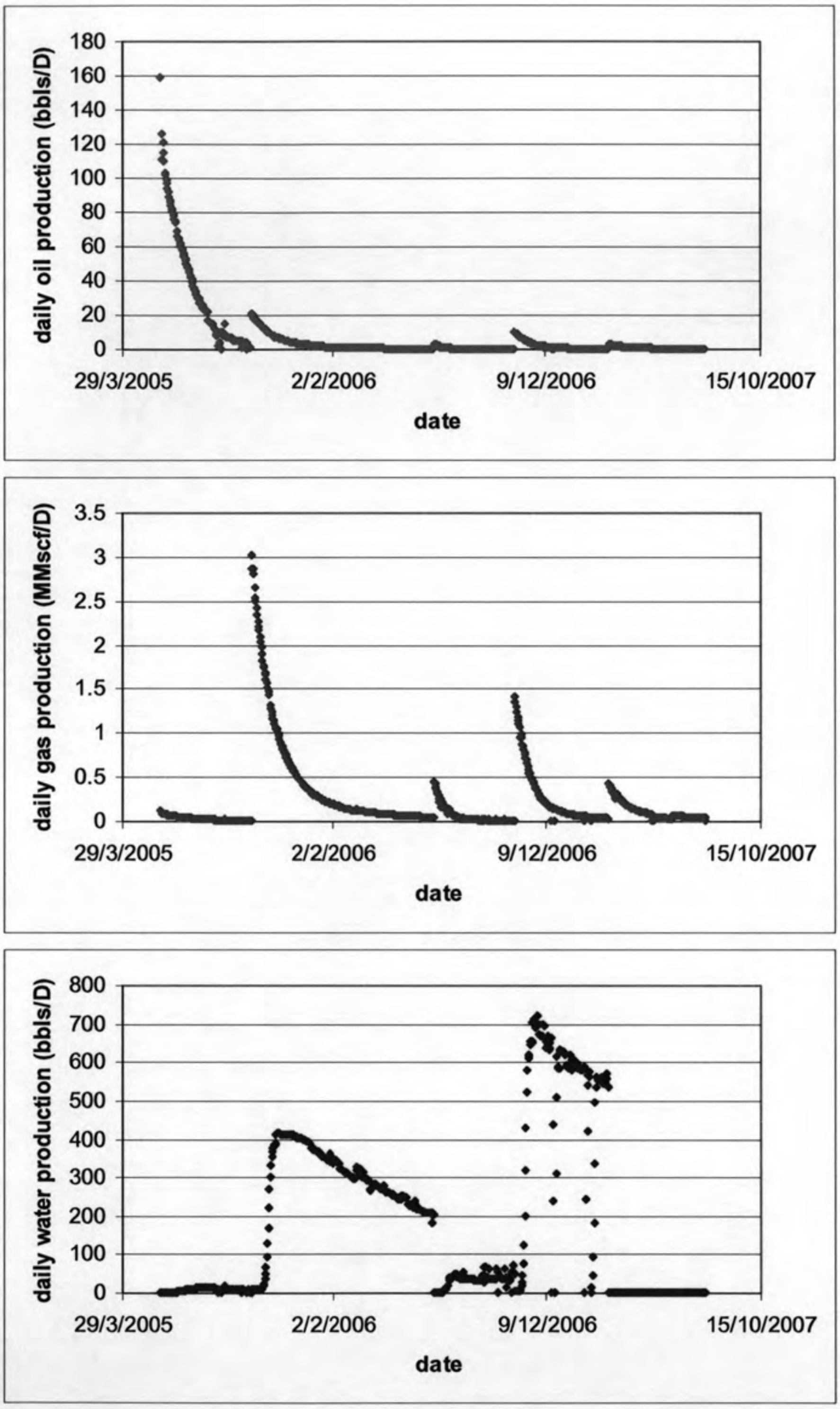


Figure 4.57: Production profiles of oil, gas and water for well C-21 using perforation strategy 6.

4.2.8 Example 8: Well C-22

When looking at the schematic of well C-22 (shown in Figure 4.58), most sands that are already perforated are gas sands. There is only one full to base oil sand. One gas oil water contact and another gas water contact sand are located at shallower depths. The top layer delivers most of the oil and strategy 6 which is bottom up perforation delivers the best outcome. Each layer is perforated one at a time and plugged after it has been depleted. This prevents any cross flow from taking place in the above layers as those layers still have the pressures intact. For other strategies, a lot of cross-flow takes place, and hence oil is lost in other depleted formations. The results obtained from each strategy are shown in Table 4.9:

Table 4.9: Cumulative Production for C-22

C-22	cum oil (STB)	cum water (MMSTB)	cum gas (MMscf)	BOE
Strategy 1	177,053	1.553	2,696	626,342
Strategy 2	256,231	1.899	3,249	797,807
Strategy 3	177,053	1.553	2,696	626,342
Strategy 4	303,029	2.010	2,338	692,679
Strategy 5	296,004	1.809	2,113	648,215
Strategy 6	369,705	3.237	4,083	1,050,235

The important point to note is that although strategy 6 delivers the highest oil and gas recovery but at the same time has a lot of water production. So, in order to go ahead with this strategy, water handling facilities or disposal of the formation water should be dealt with. Production profiles of each strategy are shown in Figures 4.59-4.64.

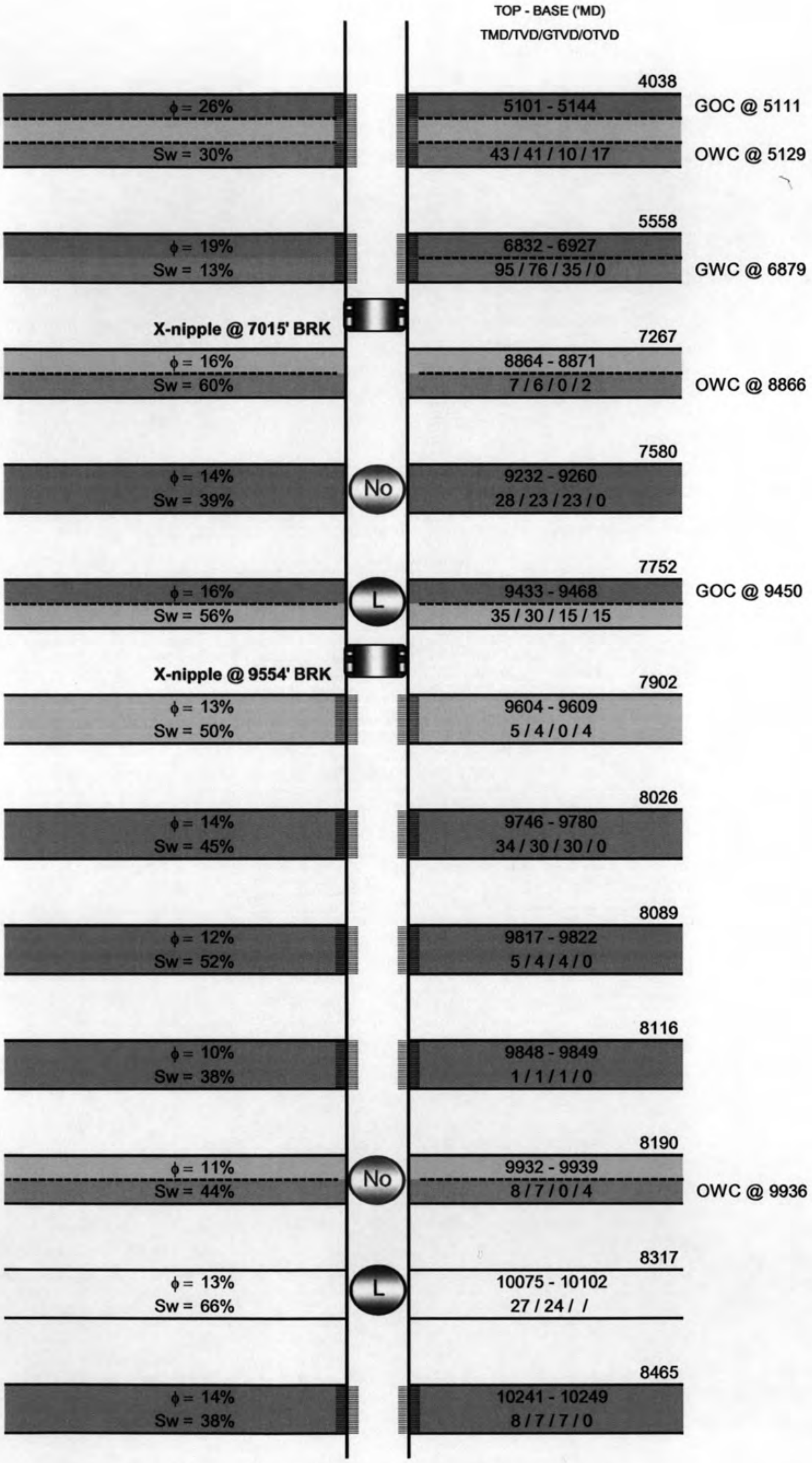


Figure 4.58: Well schematic for C-22.

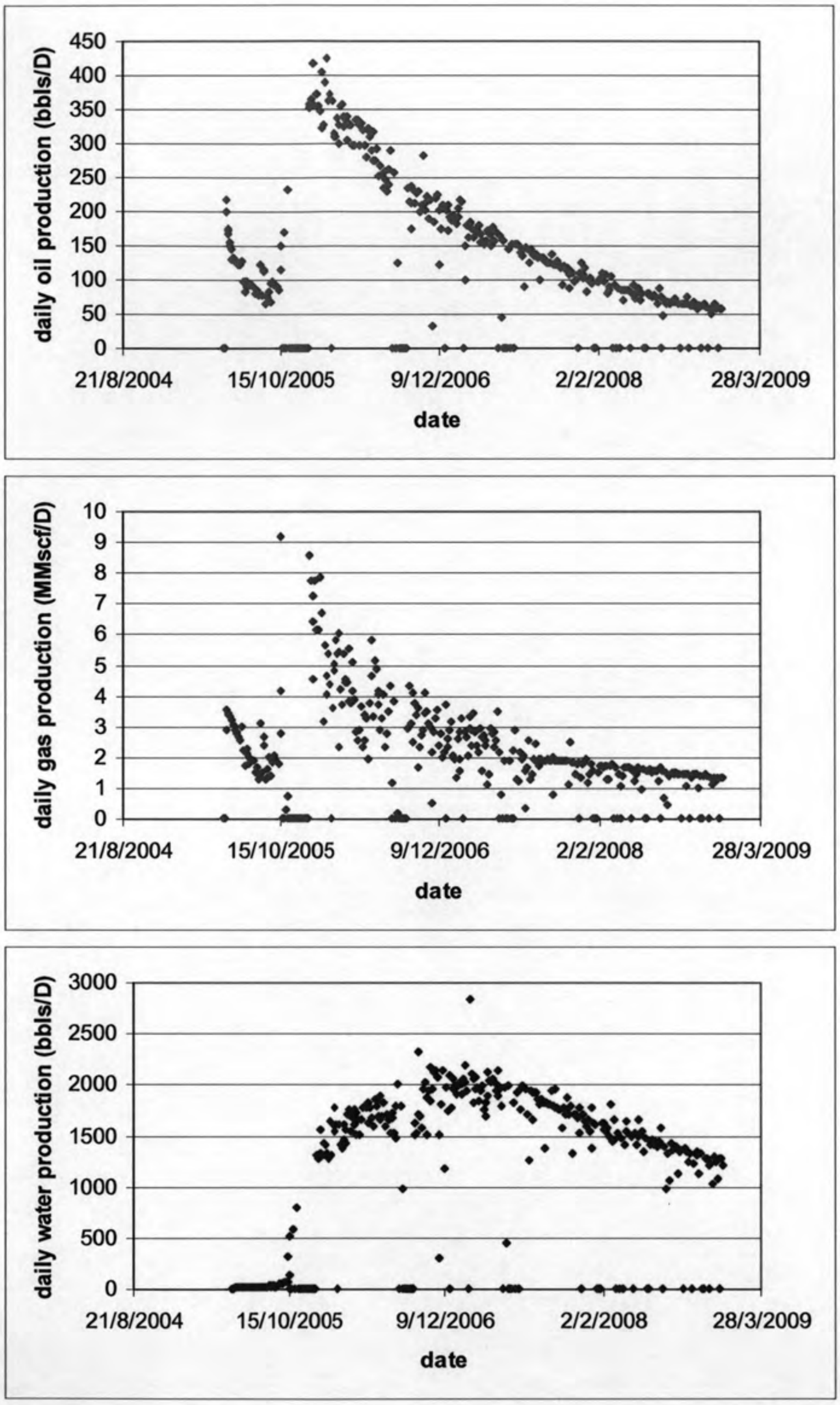


Figure 4.59: Production profiles of oil, gas and water for well C-22 using perforation strategy 1.

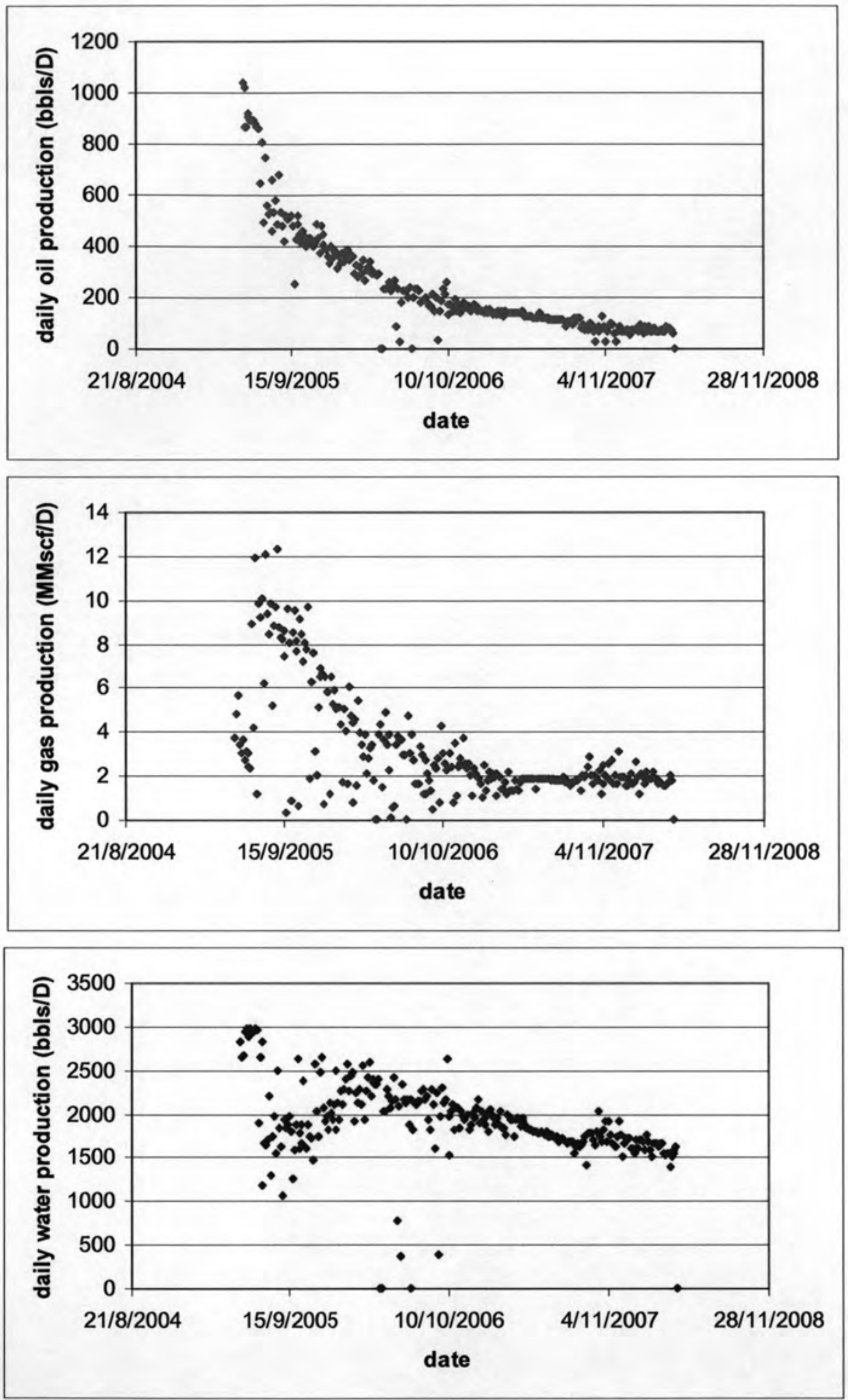


Figure 4.60: Production profiles of oil, gas and water for well C-22 using perforation strategy 2.

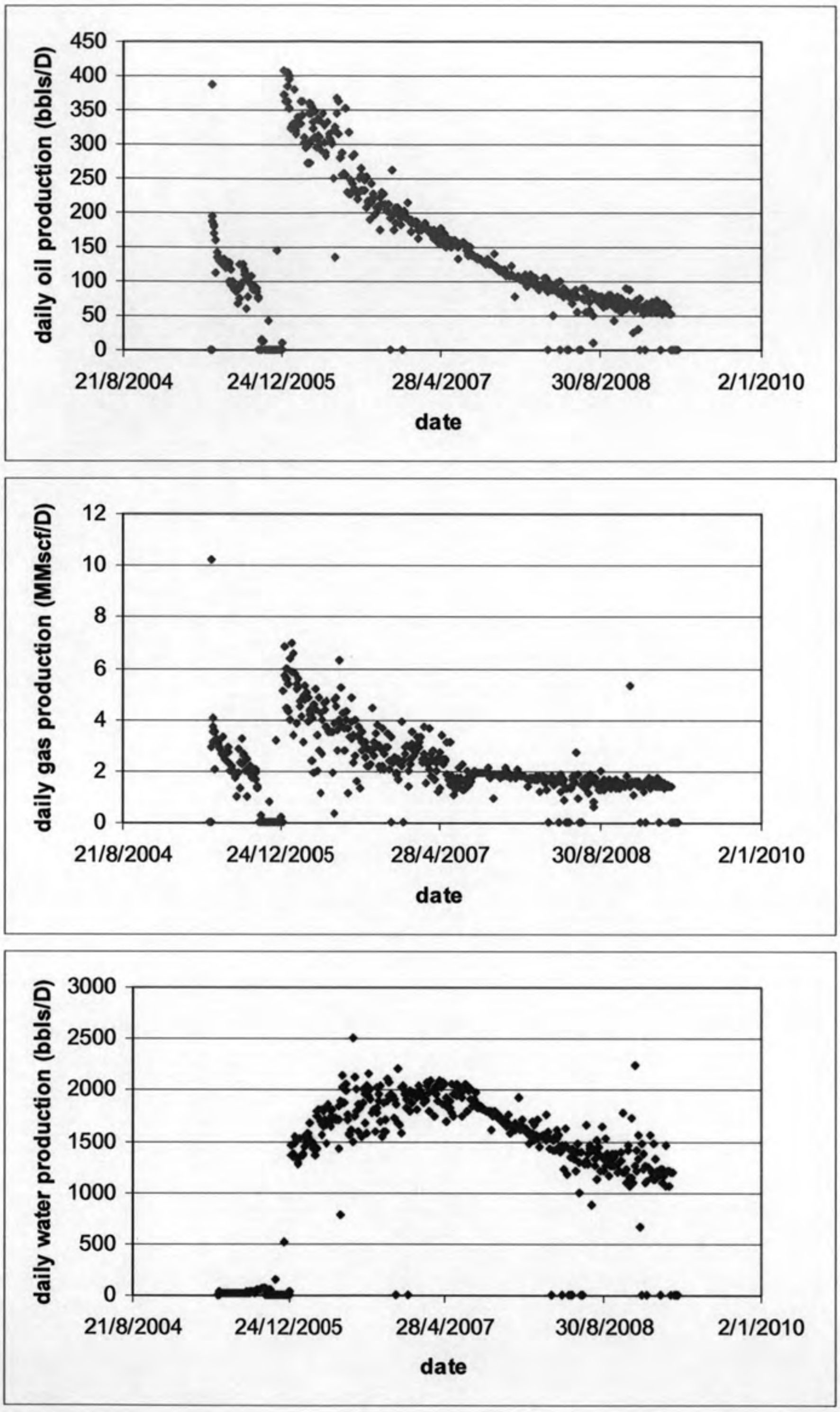


Figure 4.61: Production profiles of oil, gas and water for well C-22 using perforation strategy 3.

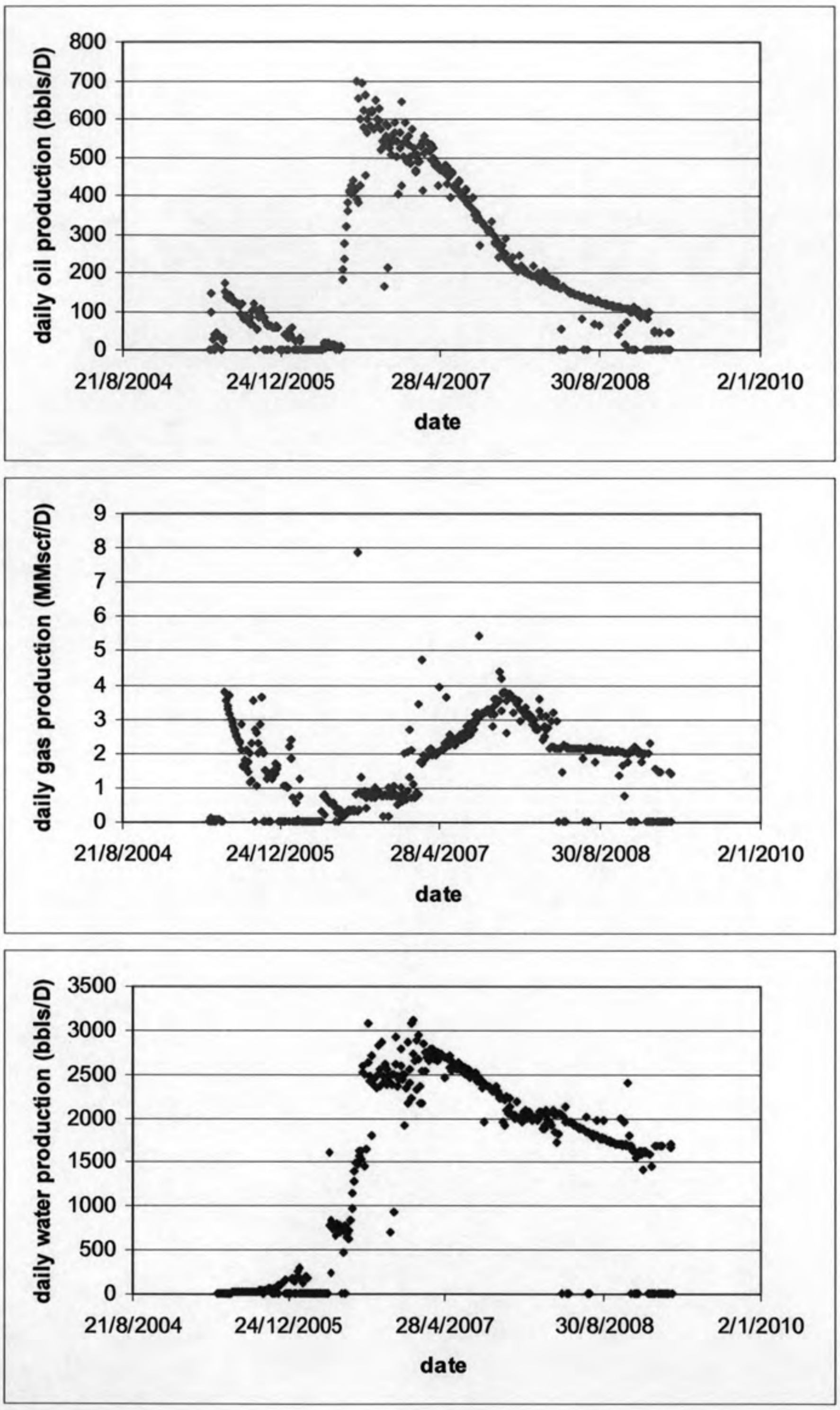


Figure 4.62: Production profiles of oil, gas and water for well C-22 using perforation strategy 4.

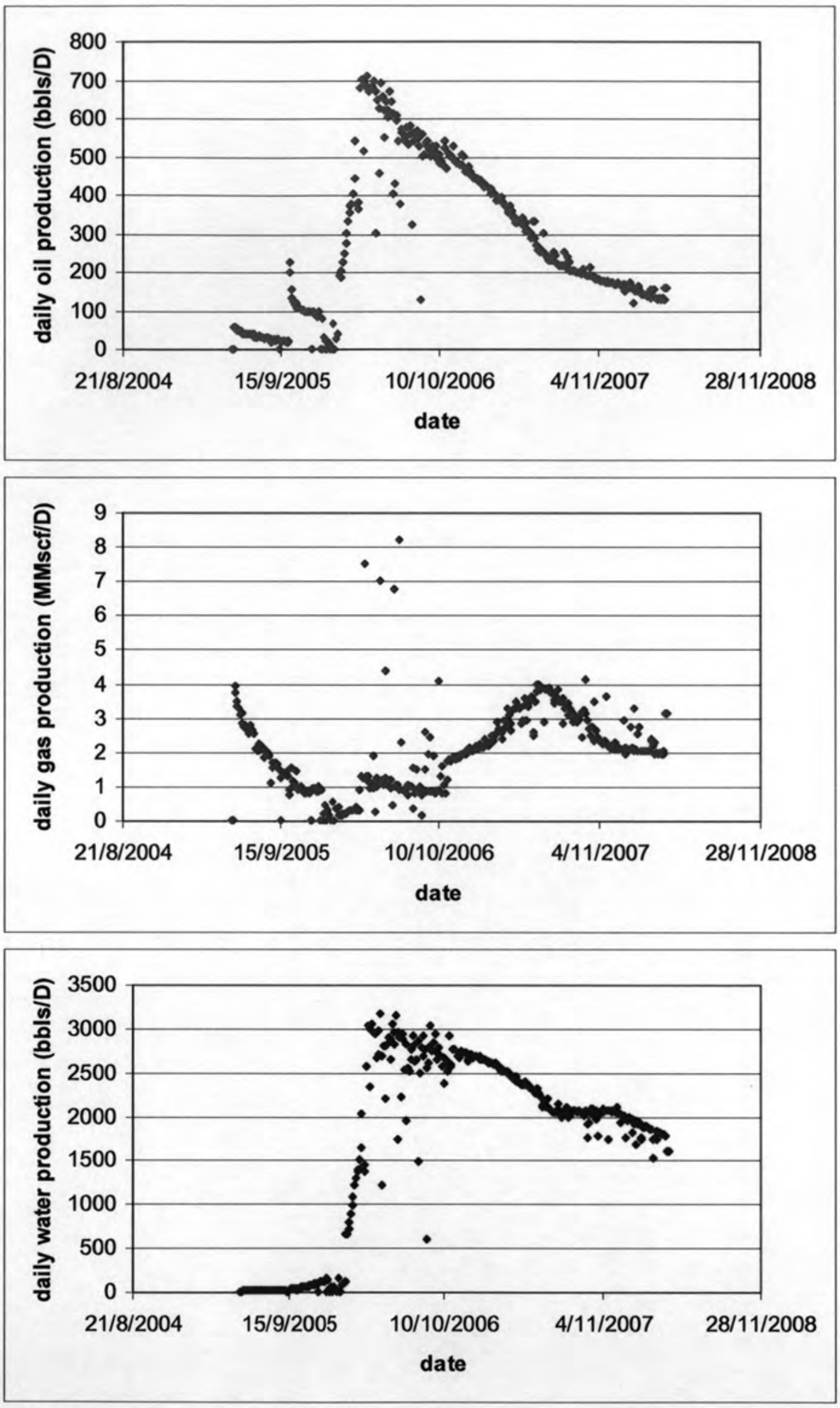


Figure 4.63: Production profiles of oil, gas and water for well C-22 using perforation strategy 5.

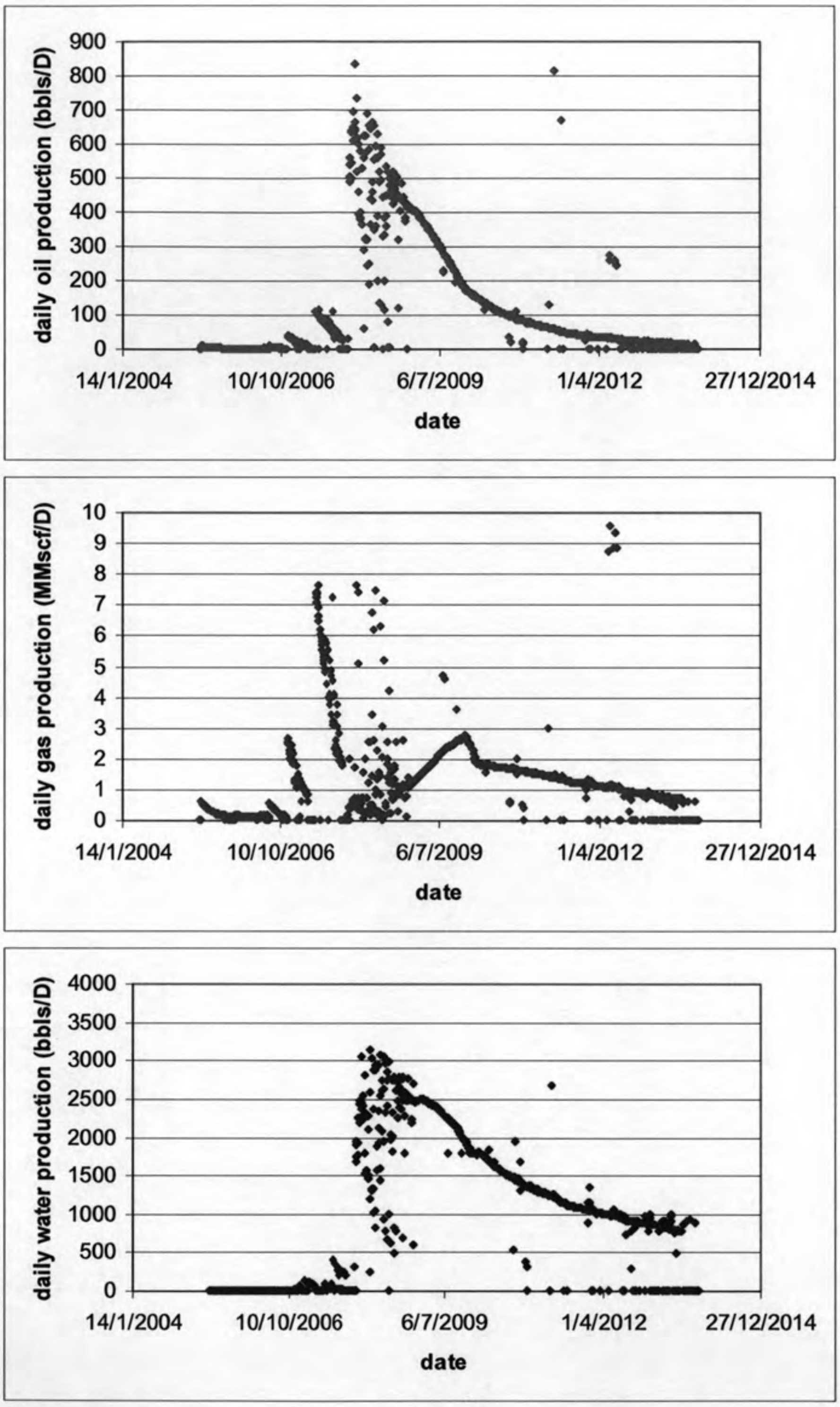


Figure 4.64: Production profiles of oil, gas and water for well C-22 using perforation strategy 6.

4.2.9 Summary of Perforation Strategies

After history matching and simulating the performances of the well under different perforation strategies, the results for 17 wells (both good and poor match) are summarized in Table 4.10:

Table 4.10: Summary of best perforation strategy.

	Best Strategy				
	oil	water	gas	BOE	
C-1	3	1	4	4	poor match
C-2	4	1	3	4	poor match
C-4	3	6	3	1	poor match
C-5	4	2	1	1	poor match
C-6	2	4	6	6	good match
C-8	4	5	6	6	poor match
C-9	4	1	3	2	good match
C-11	4	3	6	4	poor match
C-12	1	1	6	6	poor match
C-14	2	1	1	2	good match
C-15	3	5	6	6	good match
C-16	6	1	6	6	good match
C-17	3	1	3	3	poor match
C-18	6	6	6	6	poor match
C-19	6	6	6	6	good match
C-21	4	1	6	6	good match
C-22	6	1	6	6	good match

The number of times each strategy delivers the highest ultimate recovery is counted and is tabulated in Table 4.11.

Table 4.11: Number of times each strategy delivers the most favorable recovery.

		number of wells					
		strategy 1	strategy 2	strategy 3	strategy 4	strategy 5	strategy 6
good match	oil	0	2	1	2	0	3
	gas	1	0	1	0	0	6
	water	5	0	0	1	1	1
	BOE	0	2	0	0	0	6
poor match	oil	1	0	3	4	0	1
	gas	1	0	3	1	0	4
	water	4	1	1	0	1	2
	BOE	2	0	1	3	0	3
total	oil	1	2	4	6	0	4
	gas	2	0	4	1	0	10
	water	9	1	1	1	2	3
	BOE	2	2	1	3	0	9

There are a total of 8 wells that have a good history match and it would be appropriate to consider these wells as a strong support of the perforation strategy results obtained from the simulation runs. The comparison graph shown below gives a clear idea on which strategy achieves the desired results:

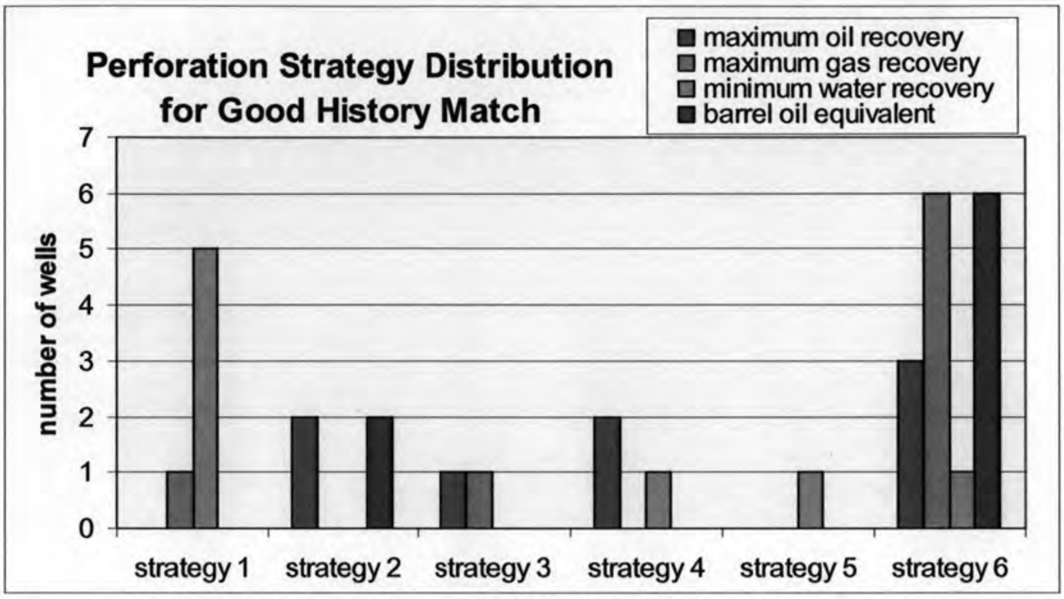


Figure 4.65: Perforation strategy performance comparison.

From Figure 4.65, the strategy that stands out for minimum water recovery is strategy 1 whereas strategy 2, 4 and strategy 6 is best for maximum oil recovery, and strategy 6 achieves both the highest gas recovery and the highest BOE recovery. These strategies are for deviated wells. Horizontal wells may give different results. However, the results gives a clear indication that the strategy currently employed fails to give the highest gas and oil recoveries and is only achieving minimum water recovery.

The results of the poor match wells are shown in Figure 4.66. The wells that do not deliver a good history match also achieved the minimum water recovery by strategy 1 and highest gas recovery by strategy 6. However, for the highest oil recovery there is a tie between strategy 3 and strategy 4. For the highest BOE recovery there is a tie between strategy 4 and strategy 6.

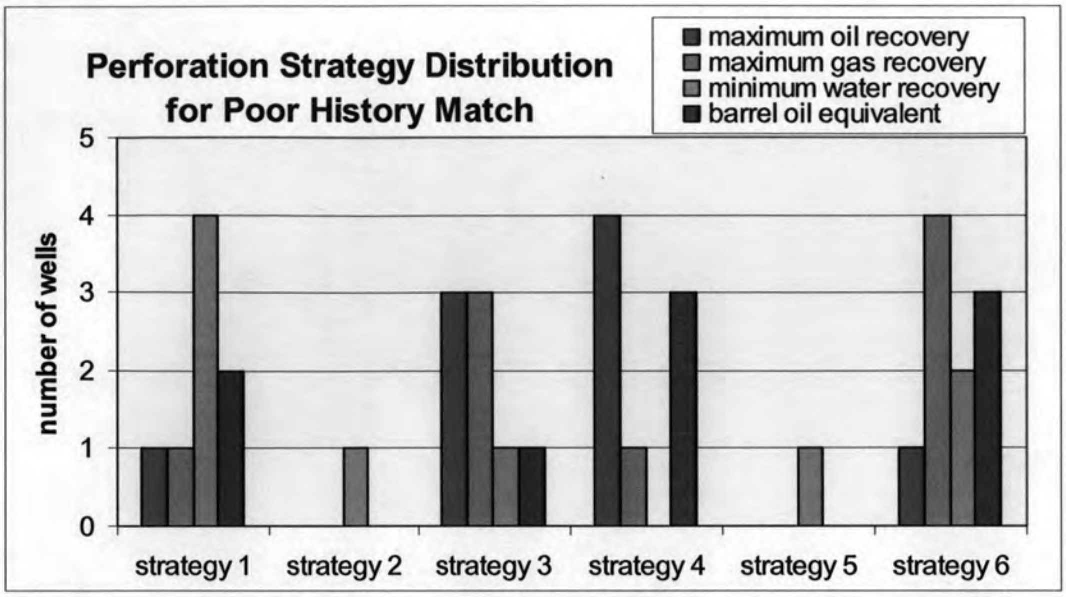


Figure 4.66: Performance comparison for wells which did not deliver good history match.

The results from both good history match wells and poor history match wells yield the following result shown in Figure 4.67:

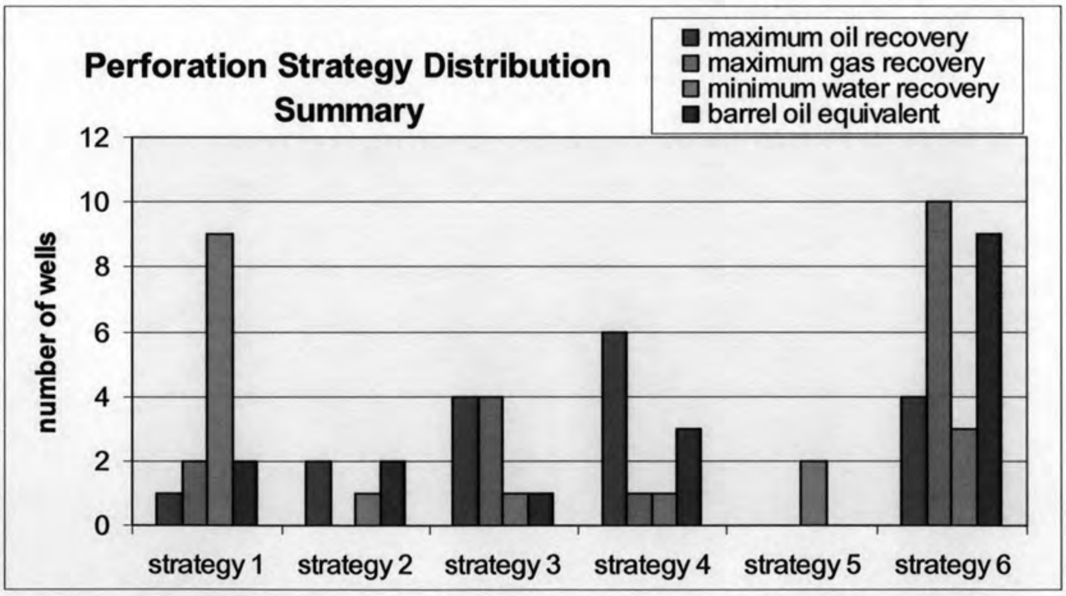


Figure 4.67: Result from combination of good match and poor match wells.

It is clearly observed that strategy 1 recovers minimum water and strategy 6 is in for maximum gas recovery and maximum BOE recovery. The unsolved highest oil recovery strategies are strategy 3, 4 and 6. In general, more focus should be paid on the wells that have a good history match as the mismatch wells are not a good indicator of the recoverability of the strategies used.