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Semi-Annual Technical Progress Report

PREFERRED WATERFLOOD MANAGEMENT PRACTICES FOR THE SPRABERRY TREND AREA

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US/DOE Patent Clearance is not required prior to the publication of this document.

DISCLAIMER

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Objectives

The objective of this report is to significantly increase field-wide production in the Spraberry Trend in a short time frame through the application of preferred practices for managing and optimizing water injection. Our goal is to dispel negative attitudes and lack of confidence in water injection and to document the methodology and results for public dissemination to motivate waterflood expansion in the Spraberry Trend.

Germania Spraberry Field Demonstration Status

The water injection began on Feb 3, 2003 from six injectors. The six injectors consist of three wells converted to water injection (17, 407A and 410A), two wells returned to water injection (11W and 22W) and a new injection well (214W) as shown in Fig. 1. We developed preferred management practices based on all prior experience in the ET O'Daniel Pilot Area and also based on the response measured during old water injection performance as discussed in previous report (Schechter et al, 2003). We monitor the water injection response by associating the water injection rate with the expected response in near-trend and on-trend producers as presented in Table. 1. An average of 270 bpd water is injected through each of those six injectors (Fig. 2). Up to now some wells have responded to water injection. Production GSU well 308A has increased from average 10 bopd to 19 bopd (Fig. 3). The water production from this well shows almost similar response to oil production rate, which indicates this well is strongly dependent on water injection. However, as of this date other wells still do not show a definite response.

In order to observe the response of water injection, we also included the wells outside the Germania Lease as shown in Fig. 4. These wells were included to track the response of water injection since the water injection may travel to great distance as observed in our previous work in ET O'Daniel Pilot Area. Oil, water and gas production are carefully monitored in wells along the entire perimeter of the area expected to respond within the Germania Unit. The production rate history of on-trend and off-trend wells were totaled and plotted prior to water injection as can be seen in Figs. 5 and 6. These production data will be updated until the end of the project. Any increase in oil production during the waterflood period will be identified and used for our economic analysis.

Development of Reservoir Management Database Software

Properly managing a reservoir that is so large and communicates, via the fractures, over great distances, poses a complicated technological and data management constraint. This problem acts as a deterrent for waterflood operations in Spraberry reservoirs. Reservoir engineering, by definition, requires precise injection, production and pressure data. Acquisition and control of this data has always been a constraint to providing the optimum method for water injection. The result is large volumes of oil that could have been recovered via water injection remain untapped. We believe by proper data acquisition and precise reservoir engineering techniques, any lack of confidence in waterflooding can be overcome.

In this report period, even though we are still using Oil Field Manager (OFM^{TM}) as our production database system, we are also developing our own database system to perform a better analysis for this particular area. This database software is written using a visual basic programming language. It has the capability to perform similar tasks as the OFM database system such as decline curve analysis, material balances, bubble map plot and in addition it would have unique features such as plotting the ellipse map following the fracture trend, PVT analysis, risk analysis, well trajectory and simulation.

This program would be applicable for any type of reservoir. The current progress is intended to show the use of this program for managing the data in the Germania Unit. Fig. 7 shows the front page of the database software. The production and injection input data format follows the TOW data format for an easy access updating of the production data. Figure 8 shows the result of uploading the well location, well information, and production/injection data. Once we have uploaded the well data, we can zoom-in and zoom-out the picture to find specific information on a certain well in the cluster location (Fig. 9). The zoom-in result can be seen in Fig. 10. By pointing the cursor to a certain well, the menu bar in the right hand side shows some information on the selected well. For the wells that have a different status, we created a note at the bottom as seen in Fig. 11. Figure 12 shows the two menu bars, Task menu and Petroleum Tools menu. Task menu consists of production history, data entry and a well diagram. Figure 13 shows an example of the production history of well 1-Meek C with unique API, surface location and present operator. We can view the data graphically by clicking the view chart button in the table. In the graph dialog, we can perform decline analysis with a user-defined range. We have three options for decline analysis: exponential, harmonic and hyperbolic declines. We can also allow the program to select the best-fit option automatically based on extended Spivey algorithm (1986). The example of decline curve analysis using hyperbolic option is presented in Fig. 15.

In addition, Petroleum Tools has several engineering applications such as PVT (Figs. 16 and 17), directional survey (Figs. 18 and 19), bubble mapping and material balances (Fig. 20). We are going to add more features in this menu in the near future.

References

1. Schechter *et al.*: "Preferred Waterflood Management Practices for the Spraberry Trend Area," Semi-Annual Report (DOE Contract No.: DE-FC26-01BC15274), March – Sept 2002.
2. Spivey, J.P.: "A New Algorithm for Hyperbolic Decline Curve Fitting," paper SPE 15293 presented at the Symposium on Petroleum Industry Application of Microcomputers, June 18-20, 1986.

Table 1 – Coupling between injectors and producers

GSU #11 WIW	GSU #17 WIW	GSU #214 WIW
119A on trend	124A on trend	113A on trend
142A (PUD) on trend	131A near trend	144A (PUD) near trend
205A near trend	16 near trend	215A (PUD) near trend
206A near trend	207A near trend	308A on trend
212A near trend	311A near trend	324A on trend
309A near trend	326A near trend	325A near trend
31 near trend	331A (PUD) on trend	
316A on trend	5 on trend	
323A near trend		

GSU #22 WIW	GSU #407 WIW	GSU #410 WIW
132A near trend	117A on trend	26 on trend
14 on trend	13 near trend	318A near trend
146A (PUD) on trend	145A (PUD) on trend	412A near trend
317A near trend	21 near trend	413 (PUD) near trend
330A (PUD) near trend	216A (PUD) near trend	
408A near trend	310A on trend	
	327A on trend	
	329A (PUD) near trend	
	409A near trend	

Table 2 – List of well locations associated with water injections

Off Trend Wells	Near Trend Wells	On Trend Wells	Water Injectors
114A	13	113A	11 WIW
115A	131A	117A	17 WIW
116A	132A	119A	214 WIW
118A	144A (PUD)	124A	22 WIW
120A	16	14	407 WIW
121A	205A	142A (PUD)	410 WIW
122A	206A	145A (PUD)	
123A	207A	146A (PUD)	
125A	21	26	
127A	212A	308A	
128A	215A (PUD)	310A	
133A	216A (PUD)	316A	
134A	309A	324A	
14	31	327A	
141A (PUD)	311A	331A (PUD)	
2	317A	5	
208A	318A		
213A (PUD)	323A		
25	325A		
28	326A		
312A	329A (PUD)		
313A	330A (PUD)		
314A	408A		
319A (PUD)	409A		
320A (PUD)	412A		
321A	413 (PUD)		
322A			
328A			
332A (PUD)			
405A			
411A			
415A (PUD)			
502A			
503A			
602A			
603A			

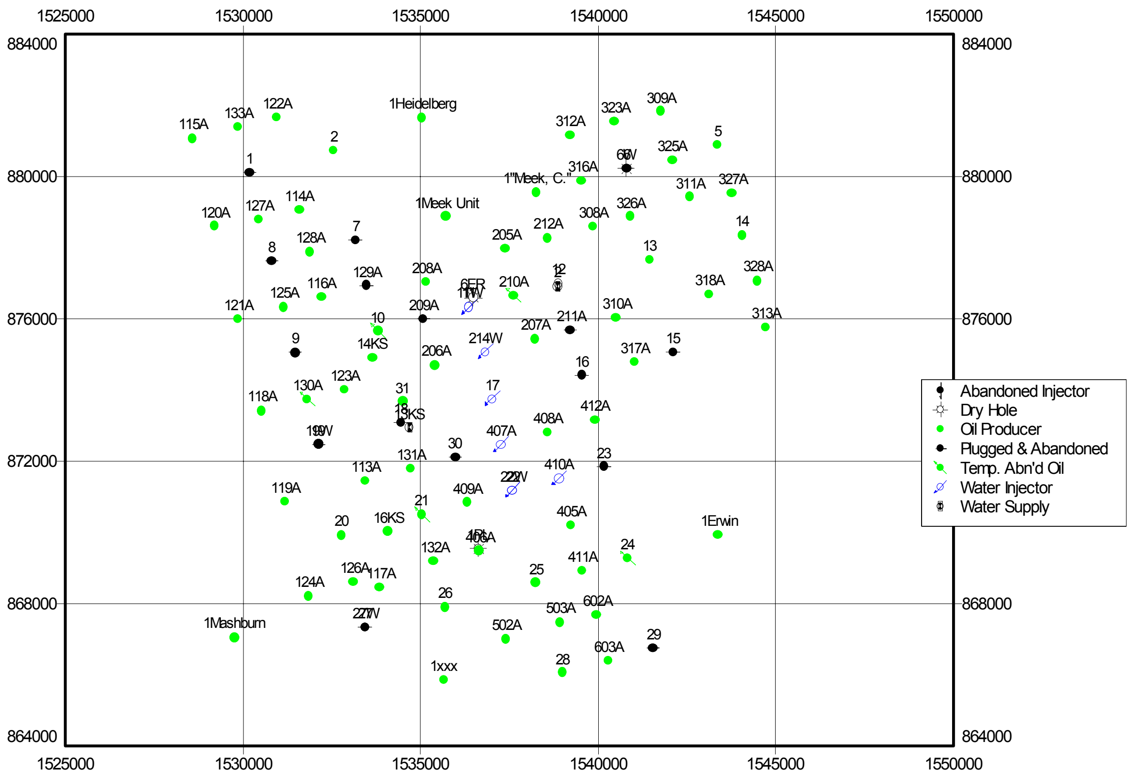


Fig.1 – Location of new water injection wells in Germania Spraberry Unit

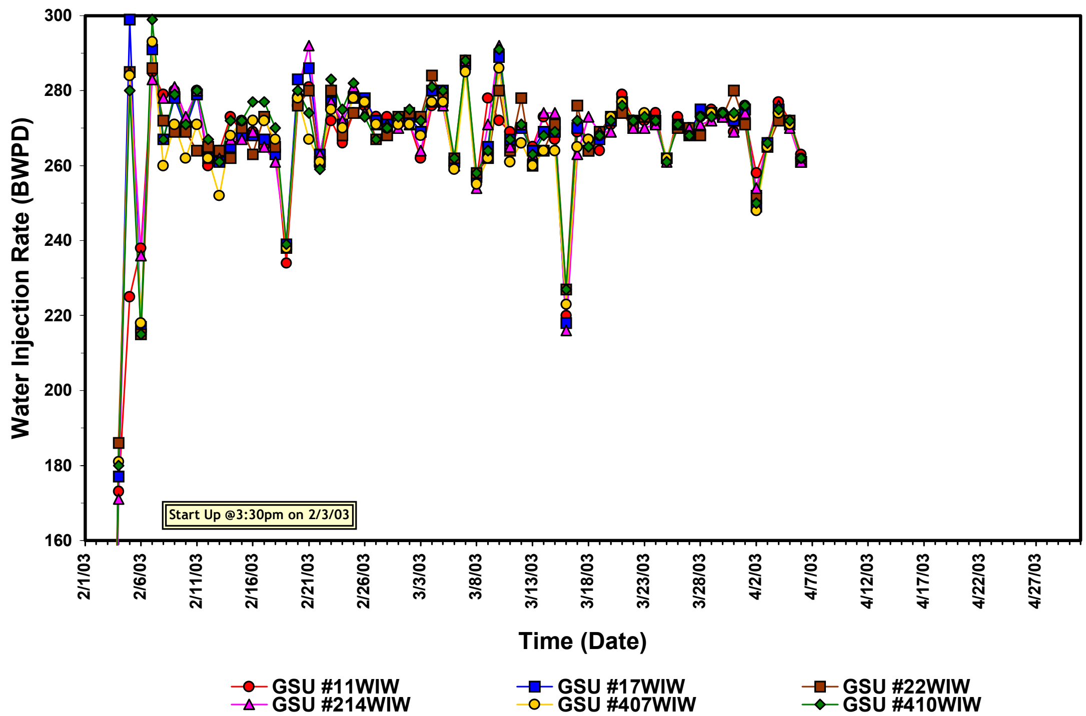


Fig. 2 – Water injection rate from six injectors

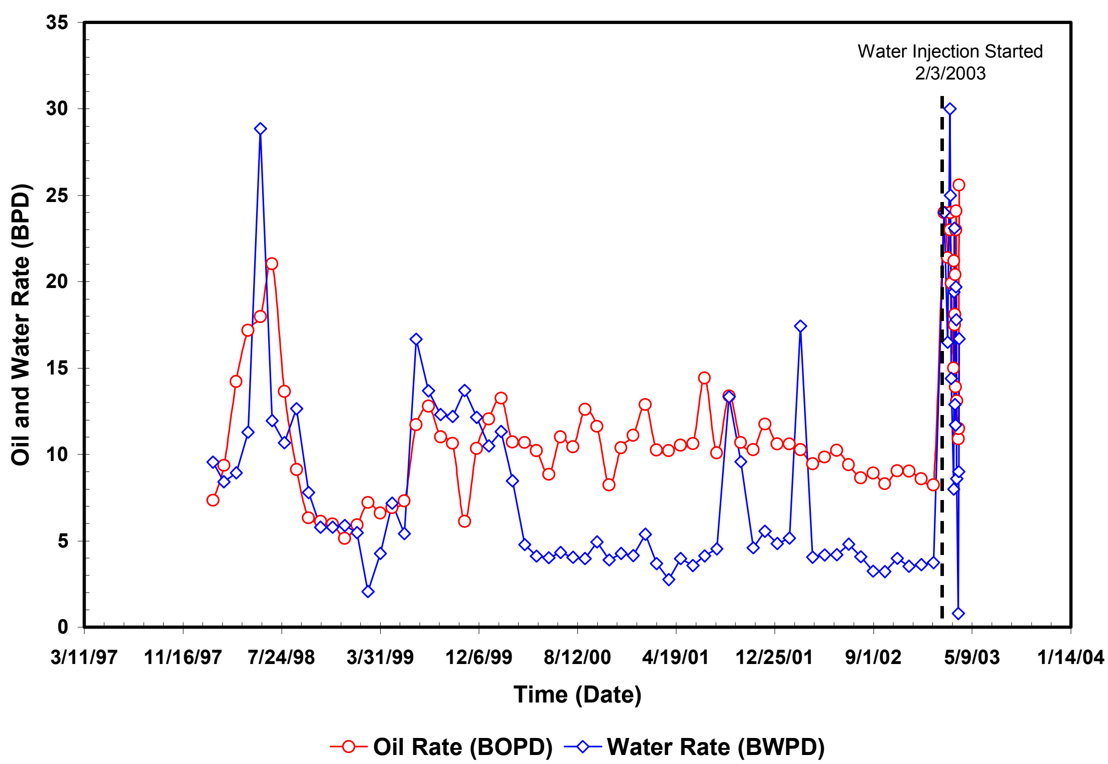


Fig. 3 – Response of GSU well 318A to water injection

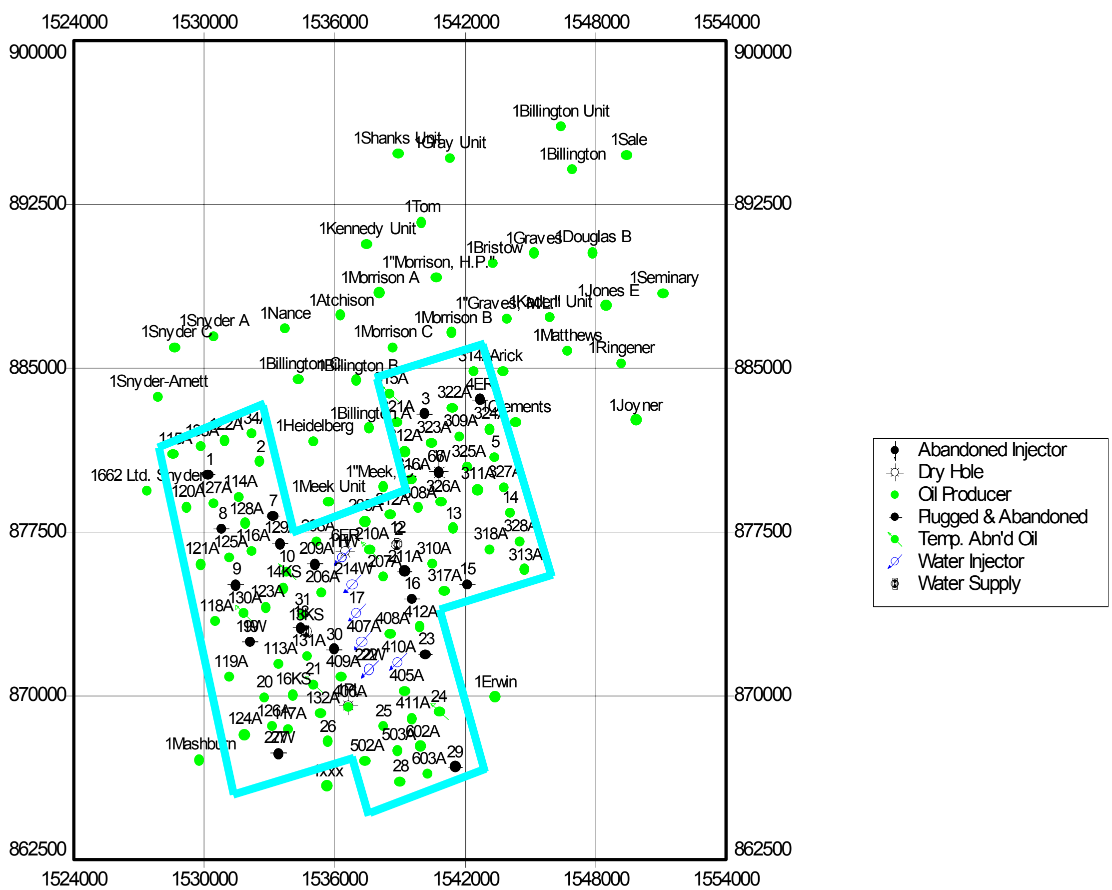


Fig. 4 – Database of Germania Unit Area with wells outside the unit

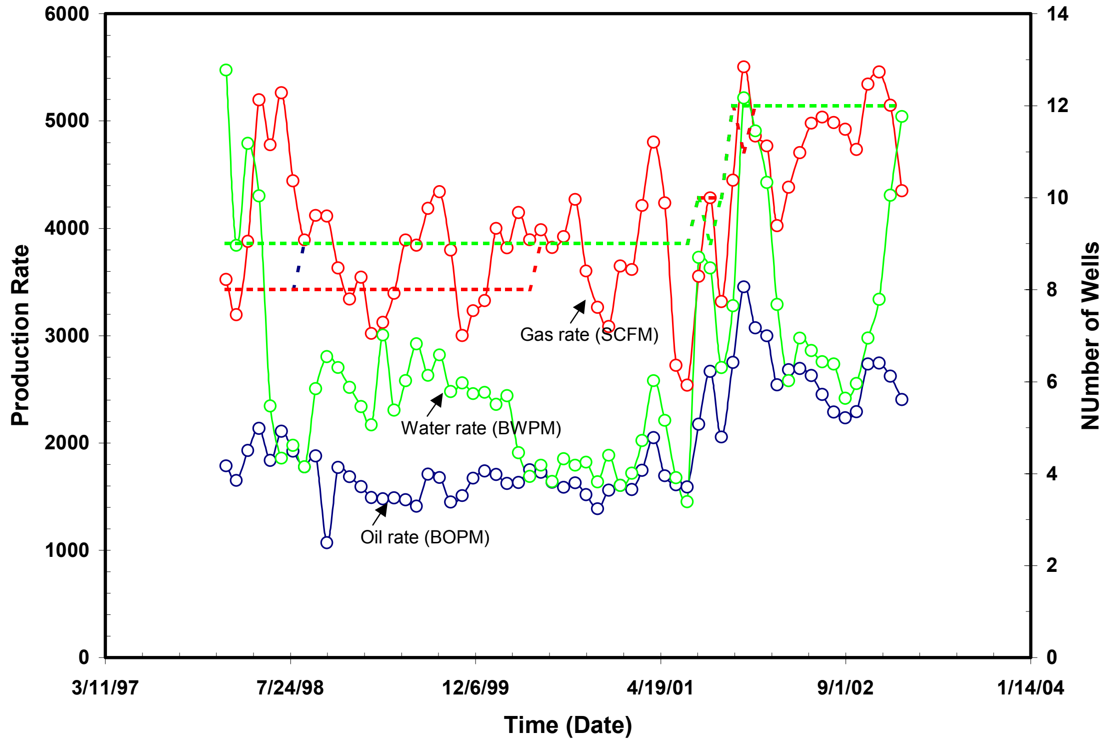


Fig.5 – Production history of on-trend wells

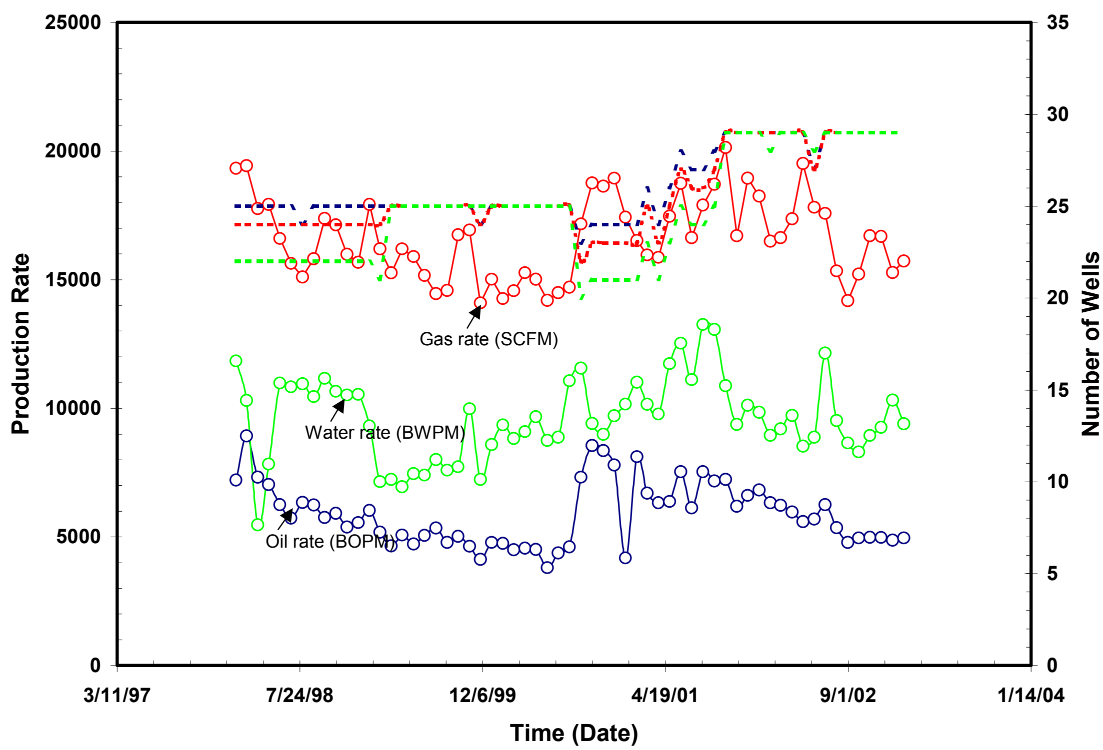


Fig.6 – Production history of off-trend wells

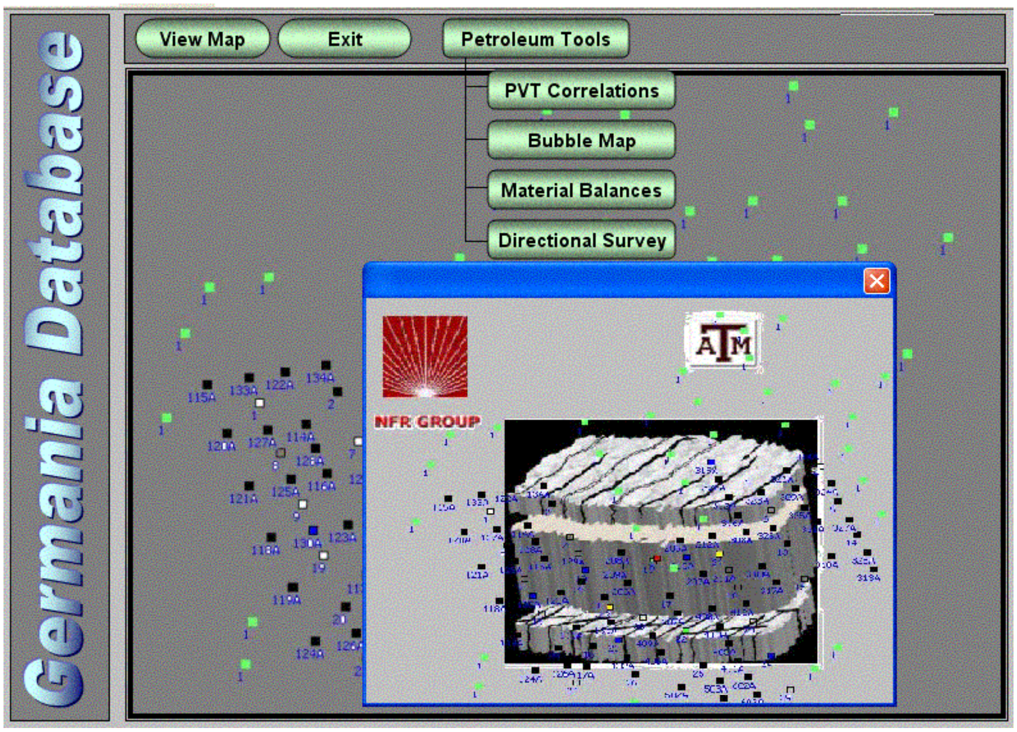


Fig. 7 – Germania database front page

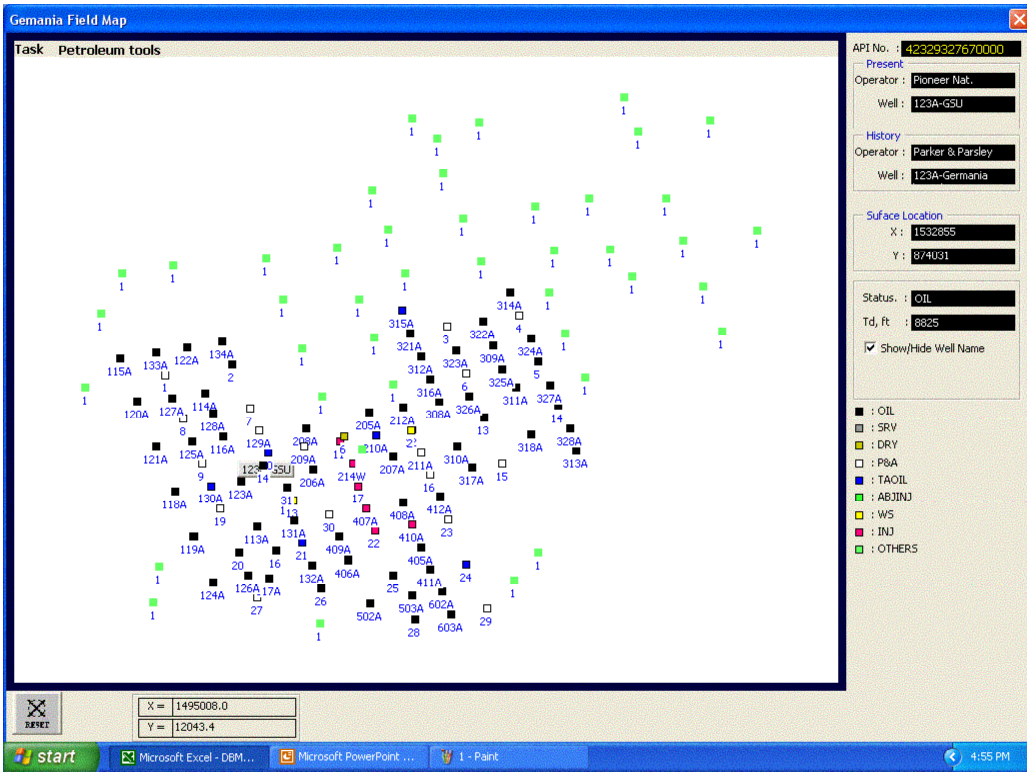


Fig. 8 – Well location and information in Germania Unit

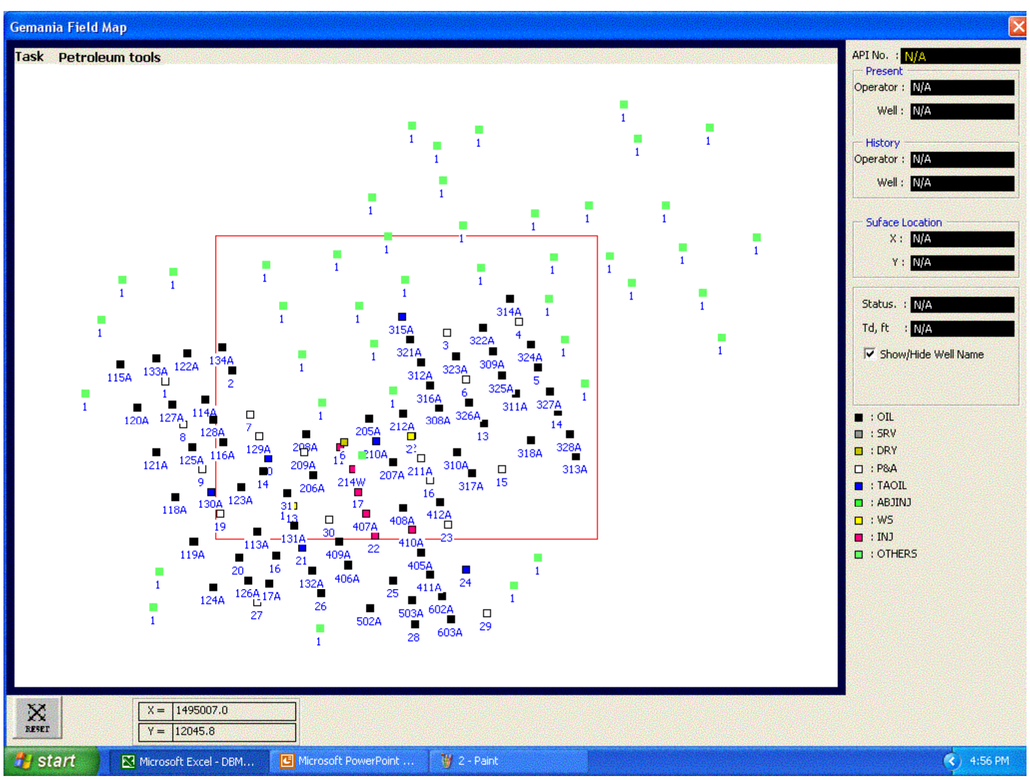


Fig. 9 – Zoom-in and zoom-out features

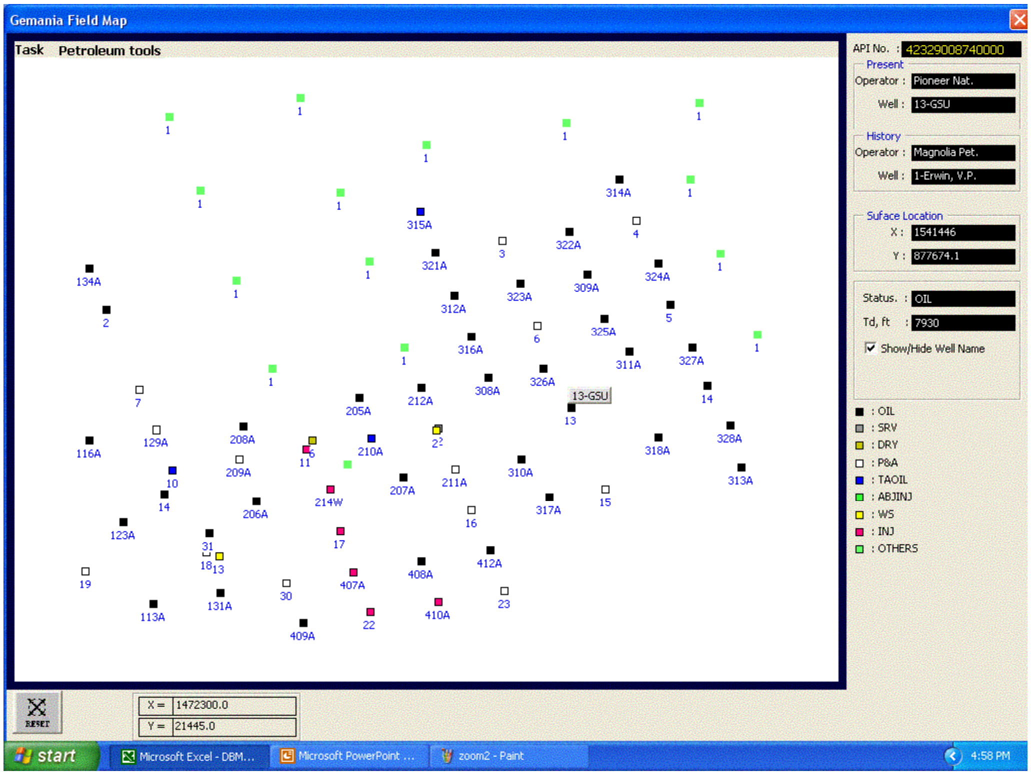


Fig. 10 – Result of zoom-in feature

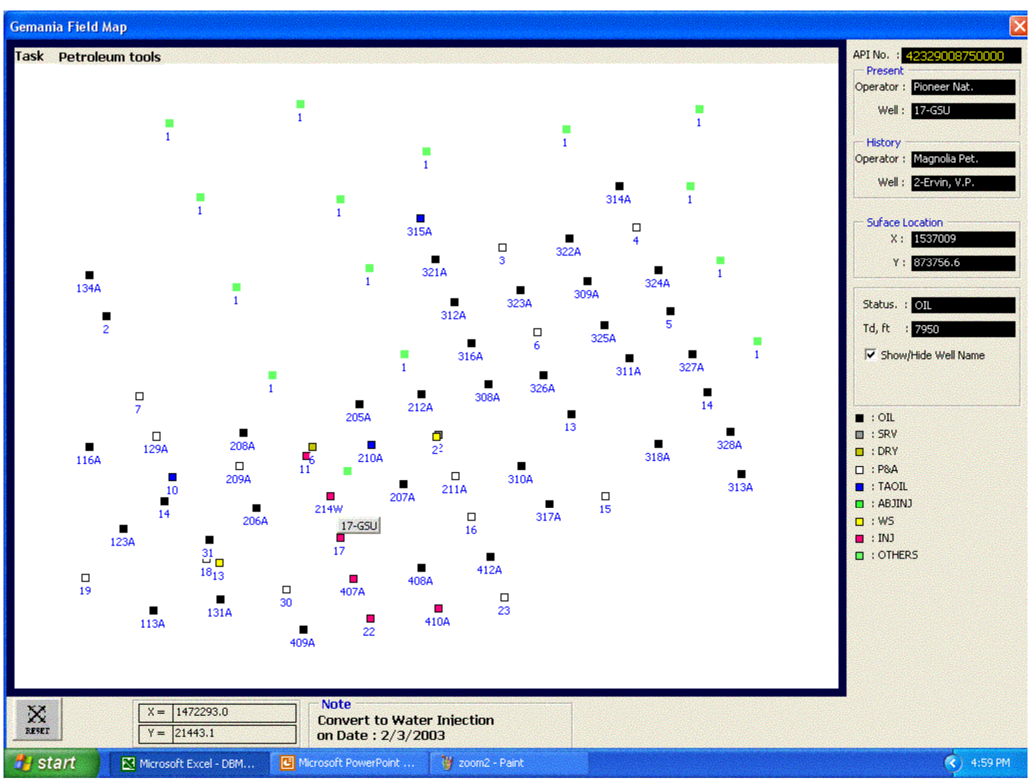


Fig. 11 – A note feature in the Germania map

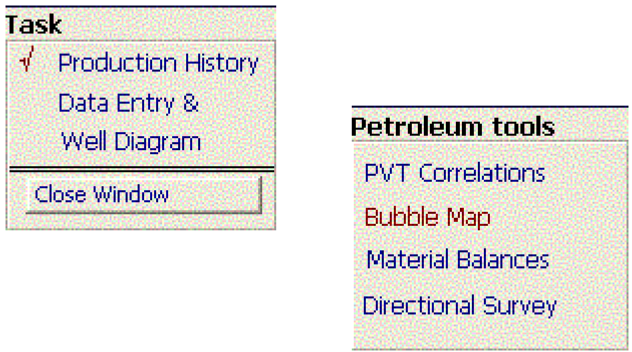
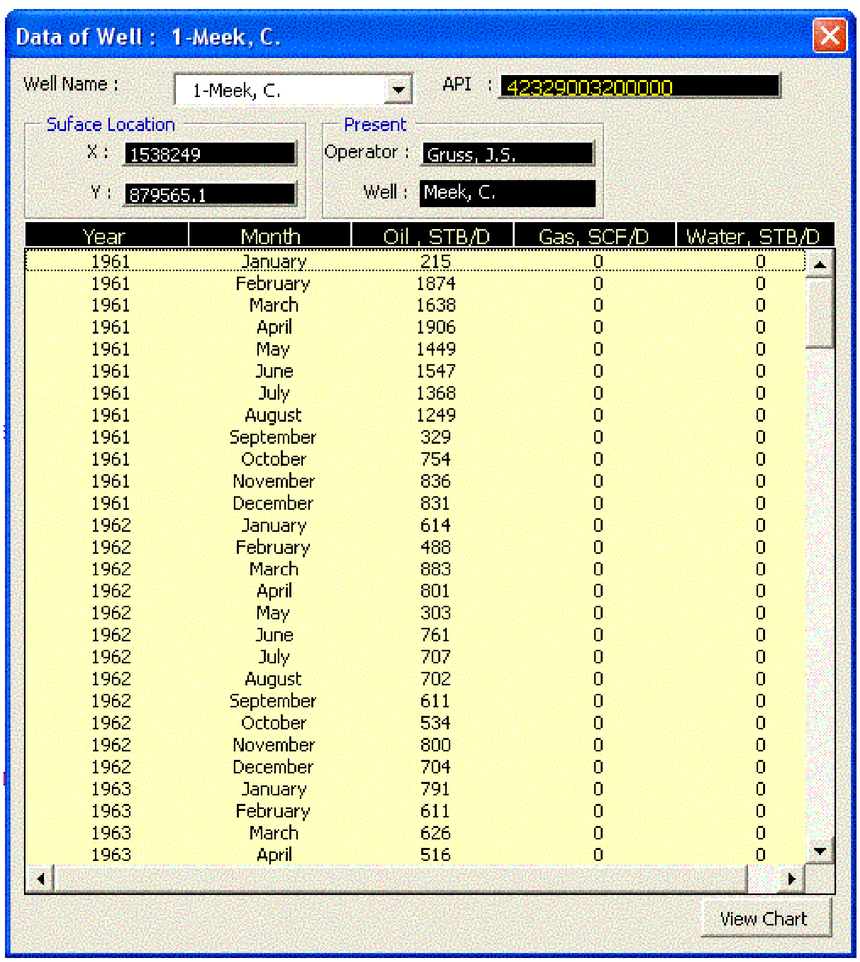


Fig. 12 – Task and petroleum tools in menu bars



Year	Month	Oil , STB/D	Gas, SCF/D	Water, STB/D
1961	January	215	0	0
1961	February	1874	0	0
1961	March	1638	0	0
1961	April	1906	0	0
1961	May	1449	0	0
1961	June	1547	0	0
1961	July	1368	0	0
1961	August	1249	0	0
1961	September	329	0	0
1961	October	754	0	0
1961	November	836	0	0
1961	December	831	0	0
1962	January	614	0	0
1962	February	488	0	0
1962	March	883	0	0
1962	April	801	0	0
1962	May	303	0	0
1962	June	761	0	0
1962	July	707	0	0
1962	August	702	0	0
1962	September	611	0	0
1962	October	534	0	0
1962	November	800	0	0
1962	December	704	0	0
1963	January	791	0	0
1963	February	611	0	0
1963	March	626	0	0
1963	April	516	0	0

Fig. 13 – Example of production history of well 1-Meek, C

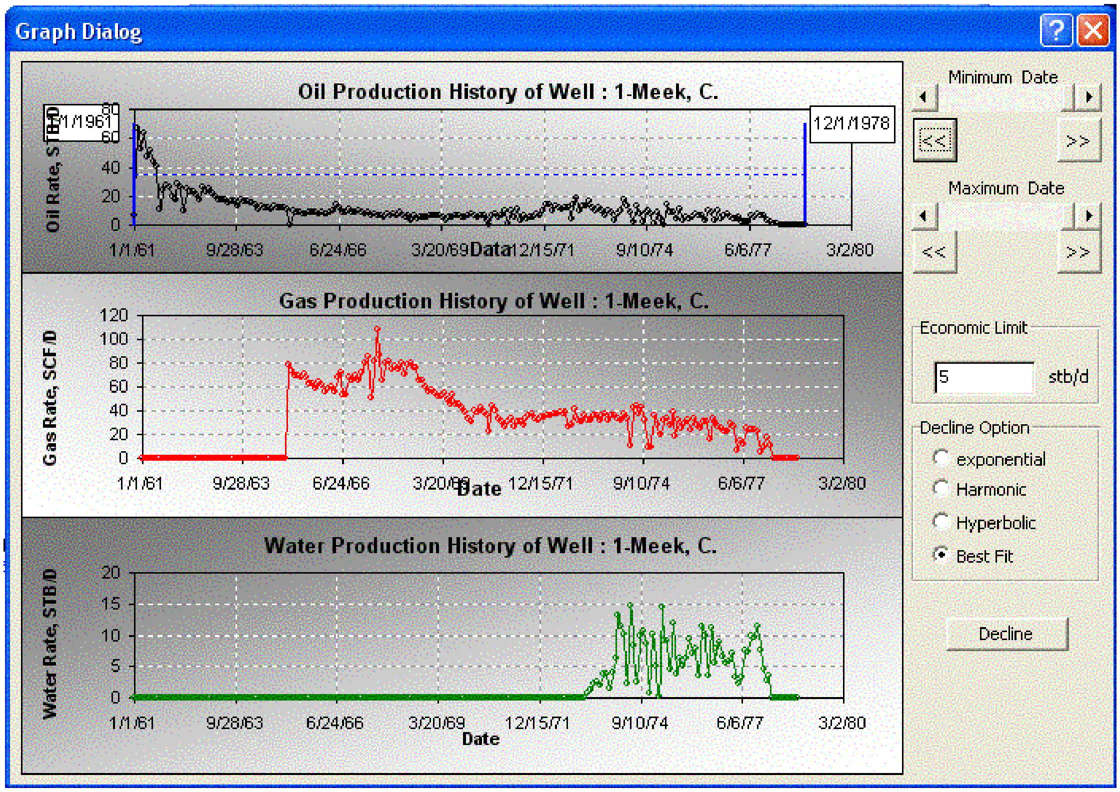


Fig. 14 – Graph dialog feature

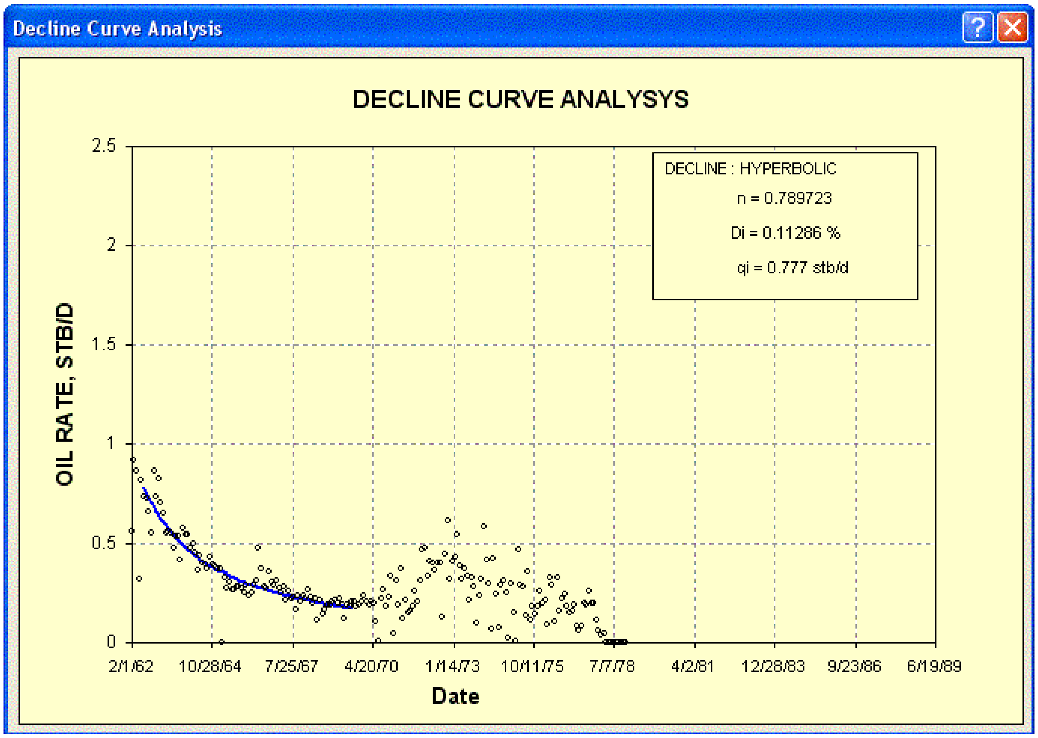


Fig. 15 – Example of decline curve analysis using hyperbolic option

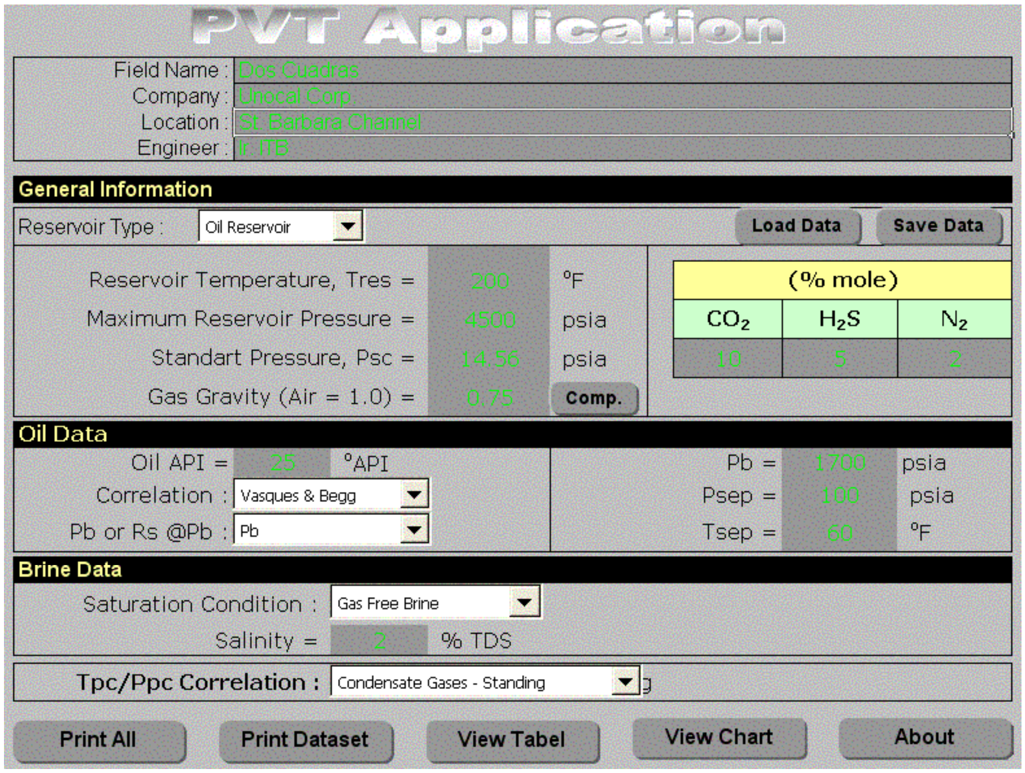


Fig. 16 – PVT application front page

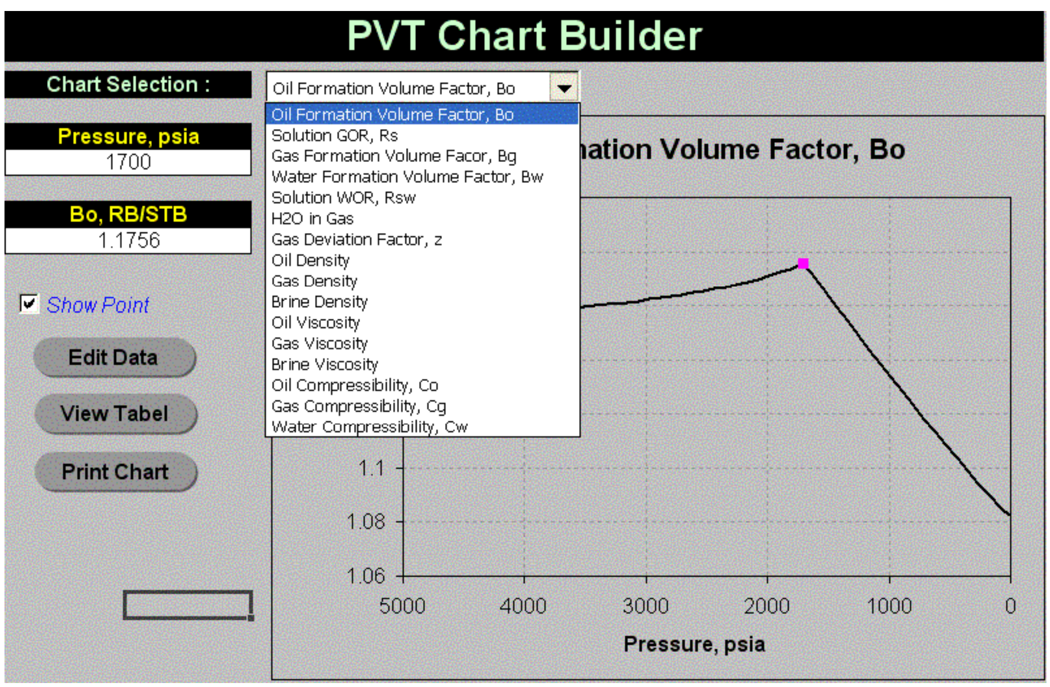


Fig. 17 – PVT chart builder

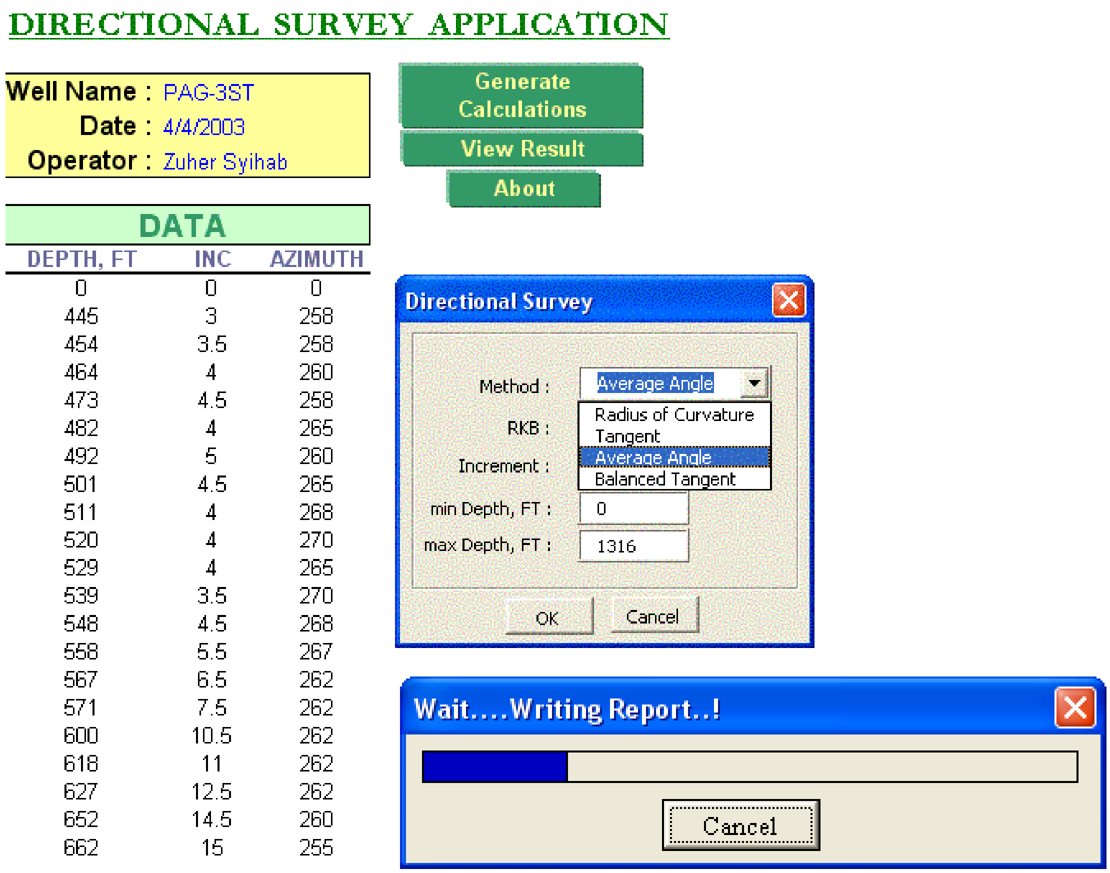


Fig. 18 – Directional survey application

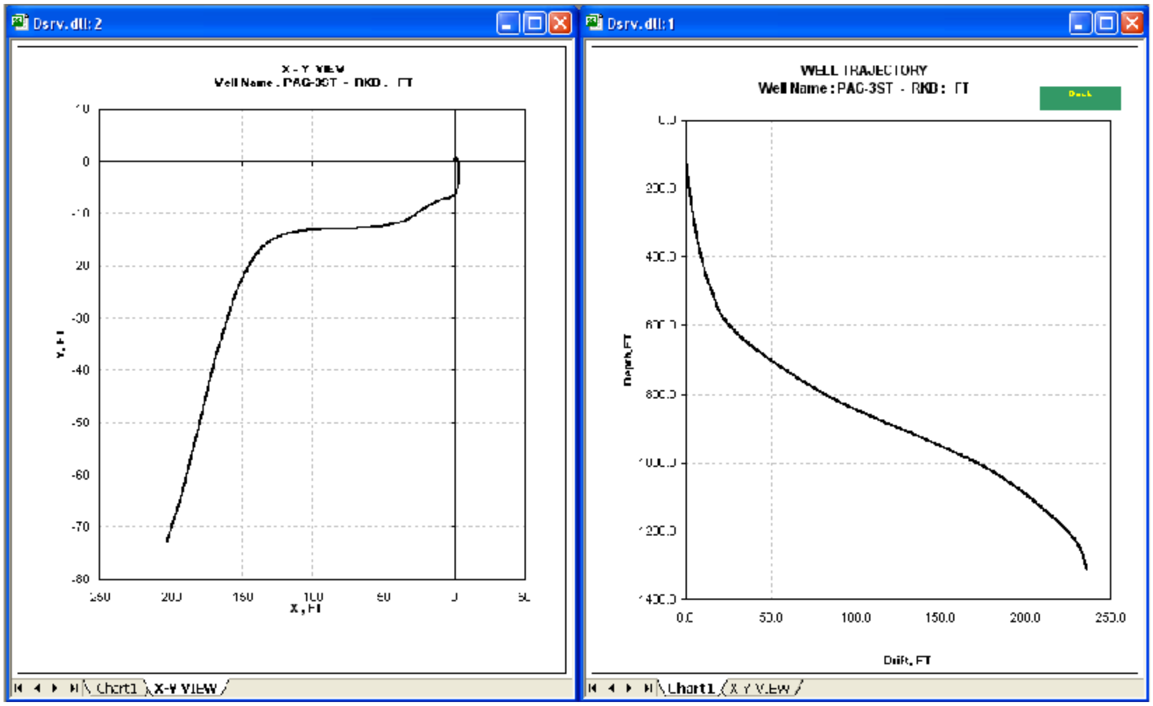


Fig. 19 – Well trajectory chart

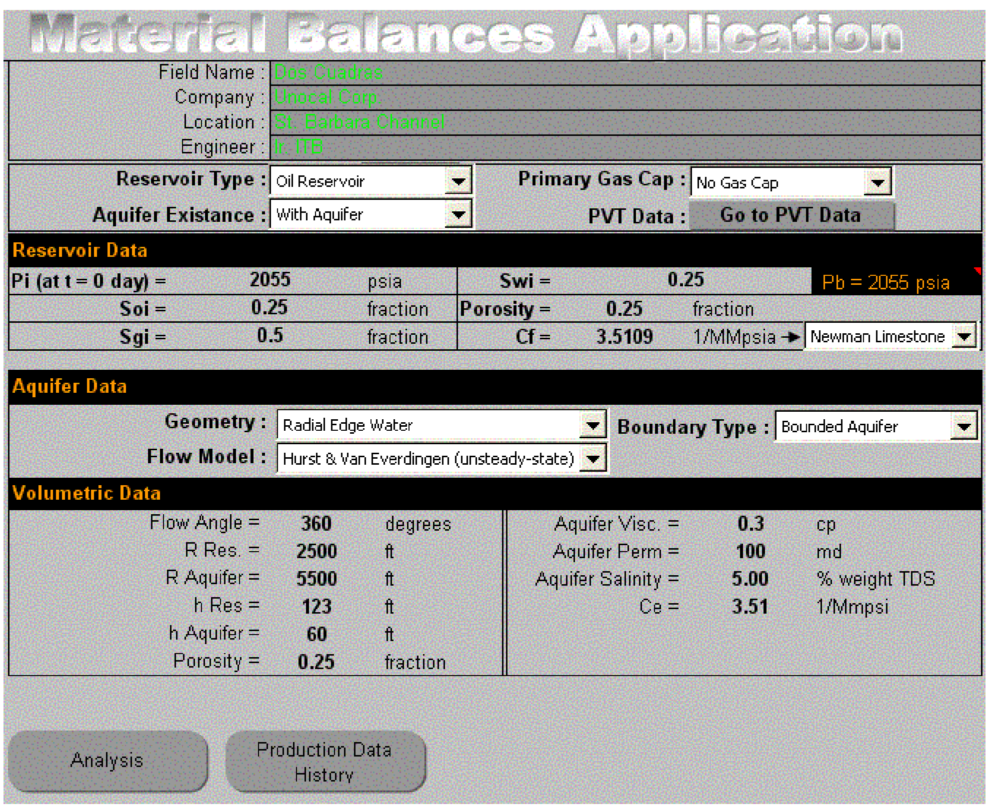


Fig. 20 – Material balances application