YEARLY TECHNICAL PROGRESS REPORT
(9th Year – 2003-2004)

ADVANCED OIL RECOVERY TECHNOLOGIES FOR IMPROVED RECOVERY FROM SLOPE BASIN CLASTIC RESERVOIRS, NASH DRAW BRUSHY CANYON POOL, EDDY COUNTY, NM

DOE Cooperative Agreement No. DE-FC-95BC14941

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Award Date:	September 25, 1995
Anticipated Completion Date:	September 24, 1998 - Budget Period I
	September 30, 2005 - Budget Period II
Award Amount for Current Fiscal Year:	$2,017,435
Award Amount for Budget Period II:	$5,013,760
Name of Project Manager:	Mark B. Murphy
Contracting Officer's Representative:	Dan Ferguson
Reporting Period:	October 1, 2003-September 30, 2004

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

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OBJECTIVE

The overall objective of this project is to demonstrate that a development program-based on advanced reservoir management methods-can significantly improve oil recovery at the Nash Draw Pool (NDP). The plan includes developing a control area using standard reservoir management techniques and comparing its performance to an area developed using advanced reservoir management methods. Specific goals are (1) to demonstrate that an advanced development drilling and reservoir management program can significantly improve oil recovery compared to existing technology applications and (2) to transfer these advanced methodologies to oil and gas producers in the Permian Basin and elsewhere throughout the U.S. oil and gas industry.

ABSTRACT

The Nash Draw Brushy Canyon Pool (NDP) in southeast New Mexico is one of the nine projects selected in 1995 by the U.S. Department of Energy (DOE) for participation in the Class III Reservoir Field Demonstration Program. The goals of the DOE cost-shared Class Program are to: (1) extend economic production, (2) increase ultimate recovery, and (3) broaden information exchange and technology application. Reservoirs in the Class III Program are focused on slope-basin and deep-basin clastic depositional types.

Production at the NDP is from the Brushy Canyon formation, a low-permeability turbidite reservoir in the Delaware Mountain Group of Permian, Guadalupian age. A major challenge in this marginal-quality reservoir is to distinguish oil-productive pay intervals from water-saturated non-pay intervals. Because initial reservoir pressure is only slightly above bubble-point pressure, rapid oil decline rates and high gas/oil ratios are typically observed in the first year of primary production. Limited surface access, caused by the proximity of underground potash mining and surface playa lakes, prohibits development with conventional drilling. Reservoir characterization and 3-D seismic interpretations are being used to design extended-reach/horizontal wells to tap into predicted "sweet spots" that are inaccessible with conventional vertical wells.

The activity at the NDP during the past year has included the commingling of the toe zone and “H” zone in the NDP Well #36 deviated/horizontal well, the deepening an testing of the NDP Well #33 and the completion of additional zones in the heel section, the design of the NDP #34 directional/horizontal well and completion of the interpretation and analysis of data from the north 3-D seismic survey.

EXECUTIVE SUMMARY

The use of the Advanced Log Analysis techniques developed from the NDP project have proven useful in defining additional productive zones and refining completion techniques. The Advanced Log Analysis program proved to be especially helpful in locating and evaluating potential recompletion intervals, which has resulted in low development costs with only small incremental increases in lifting costs. To develop additional reserves at lower costs, zones behind pipe in existing wells were evaluated using techniques developed for the Brushy Canyon

interval. Log analysis techniques developed in Phase I have been used to complete a total of thirteen of the NDP wells in uphole zones. Four wells were recompleted in 1999, which allowed the development of economical reserves during a period of low crude oil prices. An additional four wells were recompleted during 2000, which resulted in 123,462 BO and 453,424 MCFG reserves being added at a development cost of $1.57 per B.O.E. Two wells, #29 and #38 were recompleted in 2001 which added 7,000 BO and 18 MMCFG to the reserves at a cost of $9.70 per BOE. NDP Wells #1, #12, #15 and #20 were completed in uphole zones during 2002-03 which added 128,000 BO and 150 MMCFG to the reserves at a cost of $1.64 per BOE. Overall, the weighted average development cost is $1.87 per B.O.E.

The NDP #36 well toe zone was completed in October 2001, then restimulated in April 2002. During the workover an additional zone in the deviated section of the well was added. In June 2004 the composite bridge plug was drilled out and the toe zone and "H" zone were commingled. Cumulative production through July 2004 is 116,378 BO, 398.904 MMCFG and 63,657 BW.

The NDP #33 well toe zone and "H" zone were completed in December 2002, the heel zone was completed in January 2004 and the composite bridge plug isolating the toe zone was drilled out May 2004. Cumulative production through July 2004 is 62,419 BO, 219.068 MMCFG and 148,200 BW.

Continued interpretation of the original 3-D seismic survey using the results from drilling NDP Well #36 and #33 has resulted in a more complete characterization of the Brushy Canyon reservoir. The new 3-D seismic survey has refined the original interpretation and added at least two (2) targets for additional development.

INTRODUCTION

The Nash Draw Pool (NDP) in Eddy County, New Mexico produces oil and associated gas from the Permian (Guadalupian) Brushy Canyon Formation. The Brushy Canyon is a relatively new producer in the Delaware Basin of West Texas, with most drilling having occurred since the late 1980s and many discoveries occurring in the 1990s. Regionally, the fine-grained sandstones of the Brushy Canyon contain as much as 400-800 MMbbls of oil-in-place and thus this formation represents a significant reservoir interval in the Permian Basin. However, low permeability and petrophysical heterogeneity limit primary recovery to only 10-16%.

The NDP is one of the project sites in the Department of Energy (DOE) Class III field demonstration program for slope-basin clastic reservoirs. The objective of the NDP Class III project is to demonstrate that an advanced development drilling and pressure maintenance program can significantly improve oil recovery compared to existing technology applications. A further goal of the project is to transfer these advanced methodologies to oil and gas producers in the Permian Basin and elsewhere throughout the U.S. oil and gas industry.

In the first phase of the NDP project, an integrated reservoir characterization study was performed to better understand the nature of Brushy Canyon production and to explore options for enhanced recovery. Results obtained in the NDP project indicate that a combination of early

pressure maintenance (gas injection) and secondary carbon dioxide flooding may maximize production in these complex, laterally variable reservoirs. Because of low permeabilities involved and high water-to-oil relative permeabilities, the use of gas instead of water is suggested as preferable as an oil-mobilizing agent.

Phase II is directed toward enhancing the ultimate recovery from the project. The plan includes directional/horizontal drilling of new wells in order to develop reserves under surface-restricted areas and potash mines and evaluation of prospects of early pressure maintenance.

RESULTS AND DISCUSSION

This is the ninth annual progress report on the project. Results obtained in the first eight years of the project are discussed in previous annual reports[1-8] and in technical papers.[9-16] Results obtained during this reporting period are summarized in this progress report.

Reporting

Early in the current project year, the eighth Annual Technical Progress Report was prepared and submitted to the DOE. Four quarterly reports have been prepared and submitted for the period September 25, 2003 through September 25, 2004.

Workovers

Two (2) workovers, to add additional pay zones and commingle zones, were performed on the Nash Draw #33 and #36. The work is summarized in the following table:

Well	Interval	Increase in Oil, BOPD	Increase in Gas, MCFD	Increase in Water, BWPD
33	2721.26-22.18, 2468.27-68.88, 2323.80-24.41 m	100	400	150
36	Commingle “H” zone and toe zone	50	0	185

Nash Draw #33

The analysis of the second seismic survey showed that the toe zone lies at the top of the “L” zone. This has resulted in a “K” and “K-2” zone completion with characteristically high water cuts and low oil cuts. In November 2003 the well was extended to a measured depth (MD) of 3029.11 m (9938 ft), by extending the open hole from 2917.86 m (9573 ft.) to 3029.11 m (9938 ft.), total 111.25 m (365 ft) (Fig. 1). The true vertical depth (TVD) changed from -2053.04 m (-6735.68 ft.) to -2069.55 m (-6789.83 ft), a total of 16.51 m (54.18 ft) (Fig. 2).

Good correlation was observed between offset logs and the observed drilling rates and sample shows through the “L” zone. The samples showed a high concentration of the ceramic proppant used in the fracture stimulation treatment. The percentage of proppant in the samples ranged from +90% initially to 10% at T.D. The drilling of the induced fracture indicated that the fracture orientation was longitudinal, in a northwest-southeast orientation. This orientation was not expected as reservoir strike and structural dip suggest a perpendicular orientation to the wellbore, with a northeast-southwest orientation. The fracture extended down into the “L” zone and the induced fracture length approximated the design length of 121.92 m (400 ft).

Apparently the “L” zone was stimulated during the initial completion and additional stimulation would not be beneficial. With the “L” zone stimulated, the production does not match the characterization of a good “L” zone completion.

To enhance production, a completion of three intervals in the heel area was started in December 2003 and completed in January 2004. A composite bridge plug was set at 2804.16 m (9200 ft) M.D. to isolate the toe zone. The additional intervals are at a MD of 2721.56-2722.18 m (8929-31 ft), 2468.27-2466.89 m (8098-8100 ft) and 2323.80-2324.41 m (7624-26 ft). Each zone was perforated using coiled tubing conveyed guns, with six shots per foot for each 2-ft interval, acidized and fracture stimulated.

A straddle packer assembly was planned to be used to acidize each interval separately. The packer assembly worked successfully on the first interval, the second and third interval could not be acidized due to tool failures and the straddle treatments were aborted. A string of 3.5 in. P-105 tubing was run with a fullbore packer, the packer was set at 2072.34 m (6799 ft). The three heel zones were acidized with 30,283.29 l (8,000 gallons) 7.5% NEFE acid and 30 biodegradable ball sealers every 9,539.24 l (60 barrels). The treating rate was 1271.90 to 1907.85 lpm (8 to 12 BPM), treating pressure was 26,200.08 kPa (3800 psi) with good ball action. The instant shut down pressure was 5,791.60 kPa (840 psi) and the 15 minute shut-in pressure was 3,723.17 kPa (540 psi). Treating pressures and shut down pressures indicated normal treating pressures and little if any tortuousity problems.

After load recovery the heel zones were fracture stimulated with 20,184.86 kg (44,500 pounds) of 16-30 sand carried by 75,708.24 l (20,000 gallons) spacer and prepad and 151,416.47 l (40,000 gallons) of micellar fluid. The treatment was terminated early due to a sudden increase in the treating pressure and a drop in rate. As shown in Fig. 2, at 3500 seconds the pressure increased to 51,710.68 kPa (7,500 psi) and the rate decreased to 3,815.70 lpm (24 BPM). This indicated a possible “sandout” and sand was stopped and the treatment flushed. This represented approximately one-third of the planned proppant of 65,317.30 kg (144,000 pounds). The well was cleaned out with coiled tubing and returned to production to test the heel zone.

On May 9, 2004 a coiled tubing unit was rigged up on the well and a 1.76 in. bit and motor assembly was run in the hole to dill a hole through the composite bridge plug. The plug was tagged at 2799.01 m (9183.1 ft) and drilled out to 2800.81 m (9189 ft). The hole was circulated clean and the well returned to production by gas lift.

Production prior to drilling the bridge plug was 99 BOPD, 133 BWPD and 390 MCFGD. Production after drilling the bridge plug is (7-12-04) 94 BOPD, 188 BWPD and 351 MCFG. Due

to increased water production, the partial depletion of the heel zones and higher producing B.H.P., it is believed that the heel zone is not contributing any substantial amounts to the production. As the gas increases and the produced column of fluid lightens the toe zone should start contributing. As seen in the daily production plot (Fig. 3), the gas volume is increasing and total fluid volume is increasing. A larger compressor to power the gas lift system is being located.

Cumulative production from the Nash Draw #33 through October 12, 2004 is 68,476 BO, 230,581 MCFG and 159,294 BW.

Nash Draw #36

The second generation seismic shows the #36 well toe zone is completed at the top of the ”L” zone and probably did not achieve penetration through all of the “L” zone pay. Initial testing showed good oil cuts**,** but final testing showed high water cuts consistent with “K” and “K-2” characterization. Based on the results of the deepening on #33 the deepening on #36 has been canceled.

On June 7, 2004 the tubing was pulled from the well and severe paraffin buildup was cleaned from the tubing. The tubing was run back in the well and the retrievable bridge plug between the toe zones and the “H” zone was pulled. Production prior to pulling the bridge plug was 46.7 BOPD, 406.2 MCFGD and 14.6 BWPD. After the bridge plug was removed the production has stabilized at 90 BOPD, 400 MCFGD and 180 BWPD. As seen in the daily production plot (Fig. 4), the production has stabilized and the G.O.R. has stabilized.

Artificial lift was added to the well to lift the increased fluid volume. Nine gas lift valves were installed in the tubing string and an 800 MCFDG compressor was installed to supply power gas.

After testing, the heel zone will be completed. A composite bridge plug will be set at +/- 2499.36 m (8200 ft) and two zones will be perforate at 2438.40-2439.01 m (8000-02 ft) and 2286.00-2286.61 m (7500-02 ft) with 6 shots per ft. A string of 3.5 in. frac tubing will be run and a packer set at +/-1962.91 m (6440 ft). It is planned to acidize the perforations with 15,141.65 l (4000 gallons) 7.5% NEFE acid with 36 biodegradable ballsealers. The planned hydraulic fracturing treatment is composed of 264,978.82 l (70,000 gallons) micellar fluid carrying 45,359.23 kg (100,000 pounds) of 16/30 ceramic proppant. After testing the composite bridge plug will be drilled out with coiled tubing and a small motor assembly and all zones will be commingled.

Cumulative production from the Nash Draw #36 through October 15, 2004 is 124,090 BO, 439,139 MCFG and 80,250 BW.

Problems - Solutions

Narrow fracture widths, toturosity and high treating pressures have been observed on all of the horizontal fracture stimulation treatments at the Nash Draw. During the fracture stimulation treatment on the heel zone in the ND #33 abnormally high pressures were observed and attributed to a potential sandout condition. This same phenomenon was observed on subsequent

treatments by the same service company. Further analysis attributed the high pressure to premature viscosity development and high friction pressure. In the future the stimulation fluid will be batch mixed to prevent inconsistent material metering during on-the-fly mixing.

Nash Draw #34

The preliminary interpretation of the second generation 3-D seismic survey has yielded a drilling target in the NE/4 of section 12 (Figure 5). A well is being planned from the #19 location to the NE/4 of section 12.

Testing of the #33 and #36 has confirmed that the "L" zone is as productive as the seismic predicts and the drilling of the #34 well is planned to be drilled through the NE/4 of section 12-T23S-R29E. The well is designed to be a directional/horizontal well with the directional section intersecting the "L" zone approximately 426.72 m (1400 ft) northeast of the surface location at an azimuth of 51.98^0. After intersecting the "L" zone the wellbore will continue horizontally to an approximate BHL at 121.92 m (400 ft) FSL and 121.92 m (400 ft) FEL of section 1. The bottom hole location is projected to be 548.64 m (1800 ft) east and 969.80 m (3181.74 ft) north of the surface location, a total of 1114.05 m (3655 ft) from the surface location at an azimuth of 25.50°. A representation of the proposed wellbore path is presented in Fig. 6.

Drilling rigs are currently not readily available due to high demand. One rig has been found, but may not be available until the first quarter of 2005.

Data and Databases

The NDP production database was updated through August 1, 2004. These data were added to the history of each well to update the decline curves and to project ultimate recoveries as well as to assess the effects of interference and production strategies.

The eight wells that are part of the Class III project (#12, 23, 24, 25, 29, 33, 36 and 38) have produced 365,410 BO, 2.28 BCFG and 1,610,403 BW as of July 1, 2004 (Fig. 7). Reserves associated with this project are summarized in the following table:

Table 1.	Oil, BBLS.	Gas, MCF	Water, BBLS.
Cumulative Production as of 8-1-04	450,437	2,722,720	1,899,285
Remaining Proved Developed Producing	299,346	1,741,130	
Proved Undeveloped (Drilling+Workovers)	680,008	3,502,758	
Total	**1,429,791**	**7,966,608**	

Other Applications

Strata has applied the characterization and 3-D seismic technology developed from the Nash Draw Project to two other fields in Eddy County and a new prospect west of the Nash Draw Unit. Another application is being modeled for a Bone Spring prospect in Lea County.

Two wells are being planned in the Forty Niner Ridge Field based on seismic interpretation using the Nash Draw parameters. Preliminary planning includes the drilling of seven wells, which are projected to produce 1,050,000 BO and 5 BCFG. The Forty-Niner Ridge Field is located approximately three miles east of the Nash Draw Unit.

Internet Homepage

The web site for the Nash Draw Project can be accessed at http://baervan.nmt.edu/nashdraw/. The site includes a project summary, list of participants, summary of the technical team, technical transfer including quarterly and annual reports, and future plans and current activities.

Technology Transfer

Disseminating technical information generated during the course of this project is a prime objective of the project. A summary of technology transfer activities during this quarter is outlined below.

Web Site: http://baervan.nmt.edu/nashdraw/

EXPERIMENTAL RESULTS

No experiments are associated with this project.

CONCLUSION

The production database was updated through August 2004. The use of the Advanced Log Analysis techniques developed from the NDP project have proven useful in defining additional productive zones and refining completion techniques. The 3-D seismic survey has proven to be a

useful tool to define areas for potential development. Drilling a deviated/horizontal well to develop reserves in an area not accessible by vertical drilling is possible and becomes easier as more wells are drilled. Evaluation of the completion, stimulation, and production testing and analysis of the Nash Draw #33 and #36 horizontal wells is continuing. Analysis of the seismic data has identified a target in the NE/4 of section 12 for the drilling of the next deviated/horizontal well.

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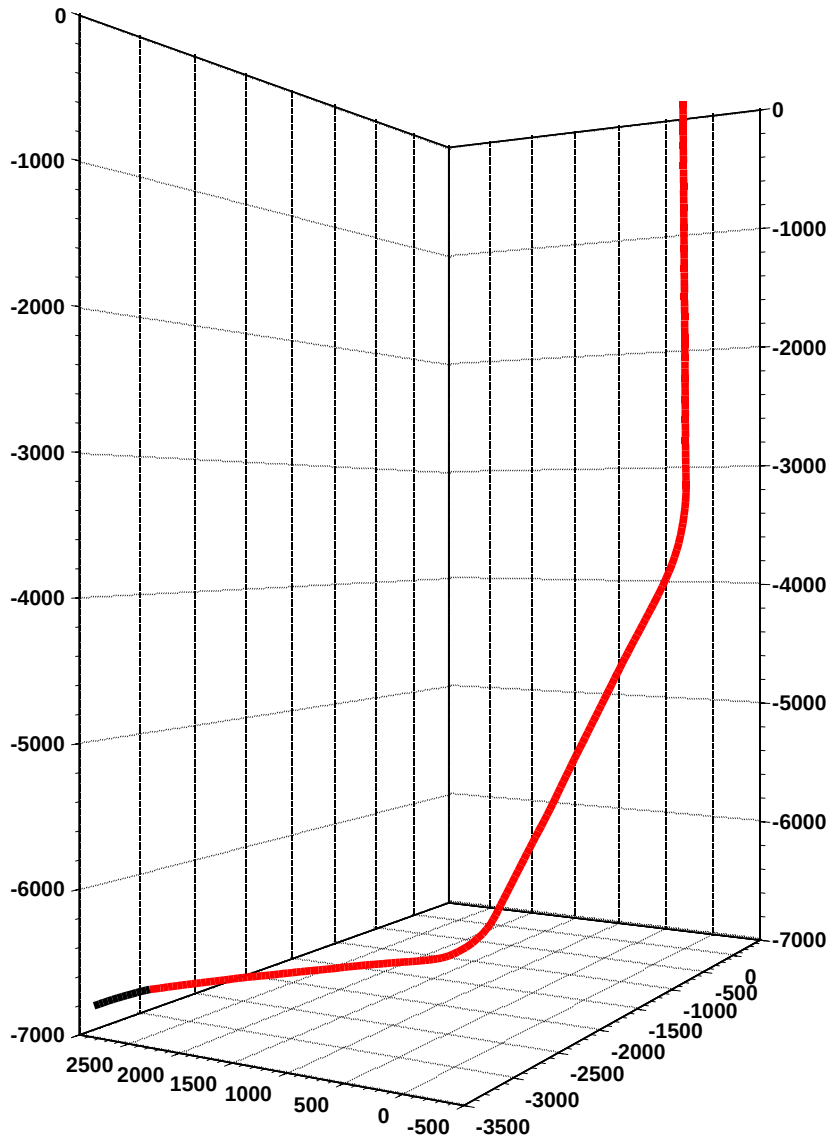

Fig. 1. Nash Draw #33 well path with extension.

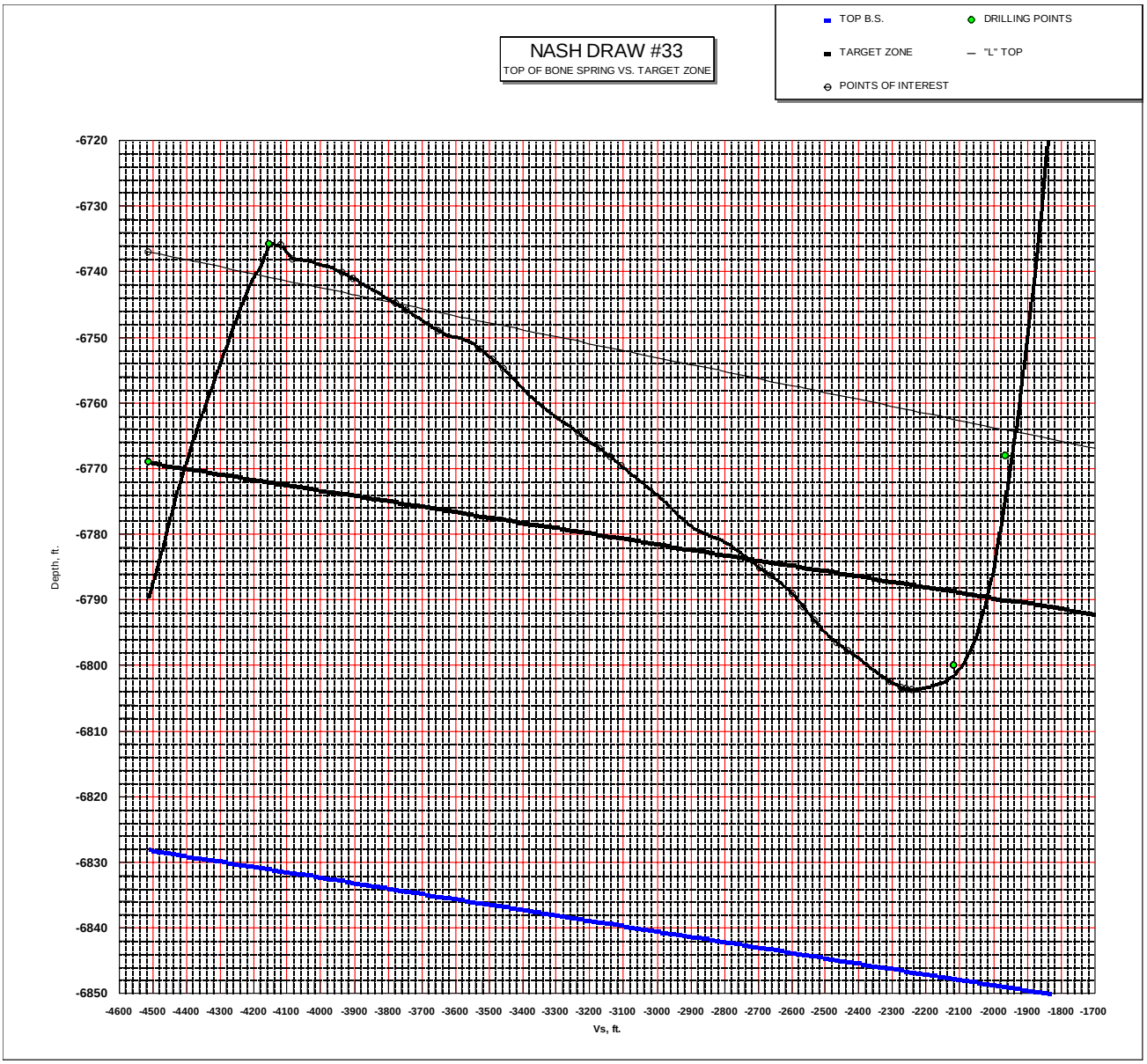

Fig. 2. ND #33 wellbore path relative to the “L” Zone.

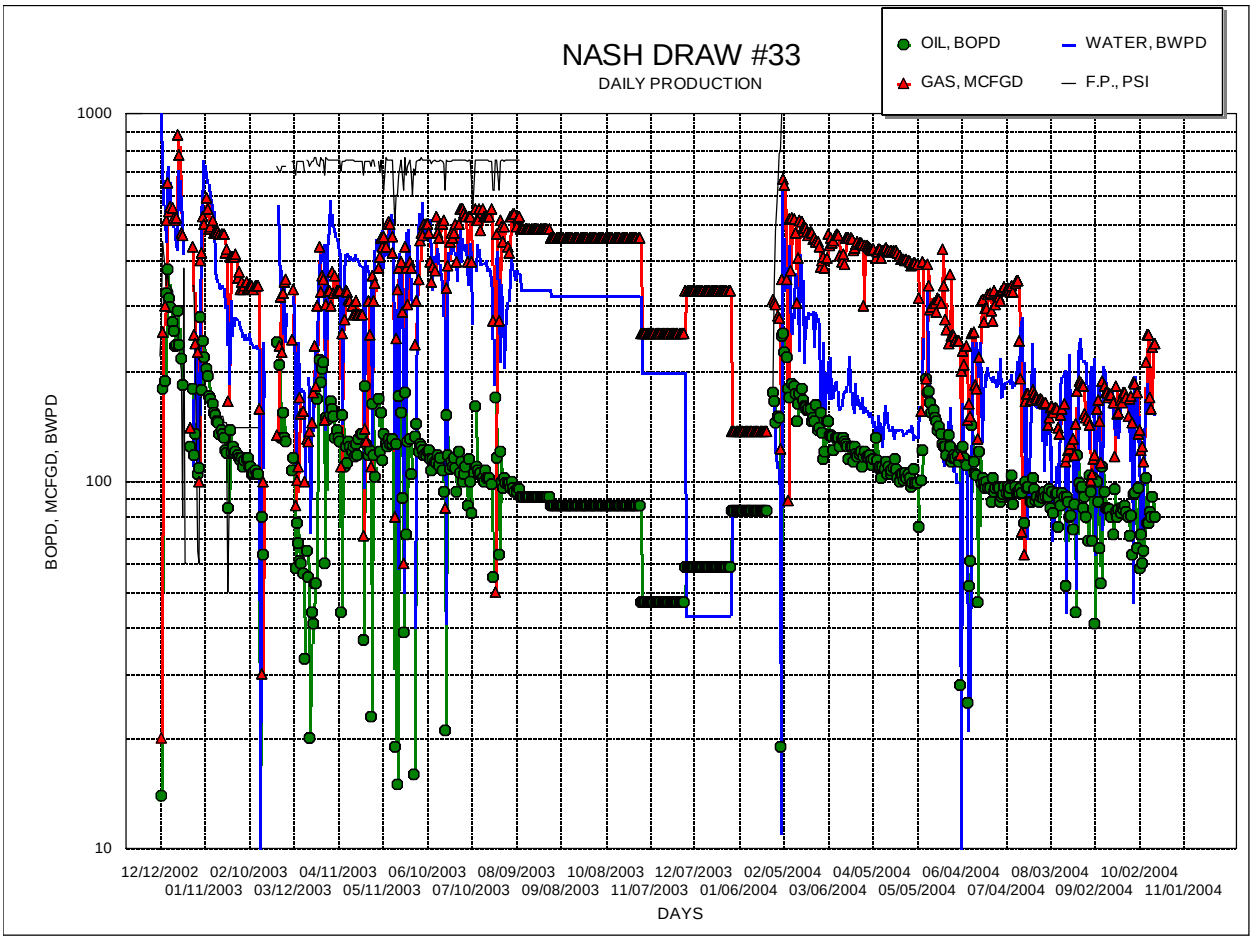

Fig. 3. ND #33 daily production plot.

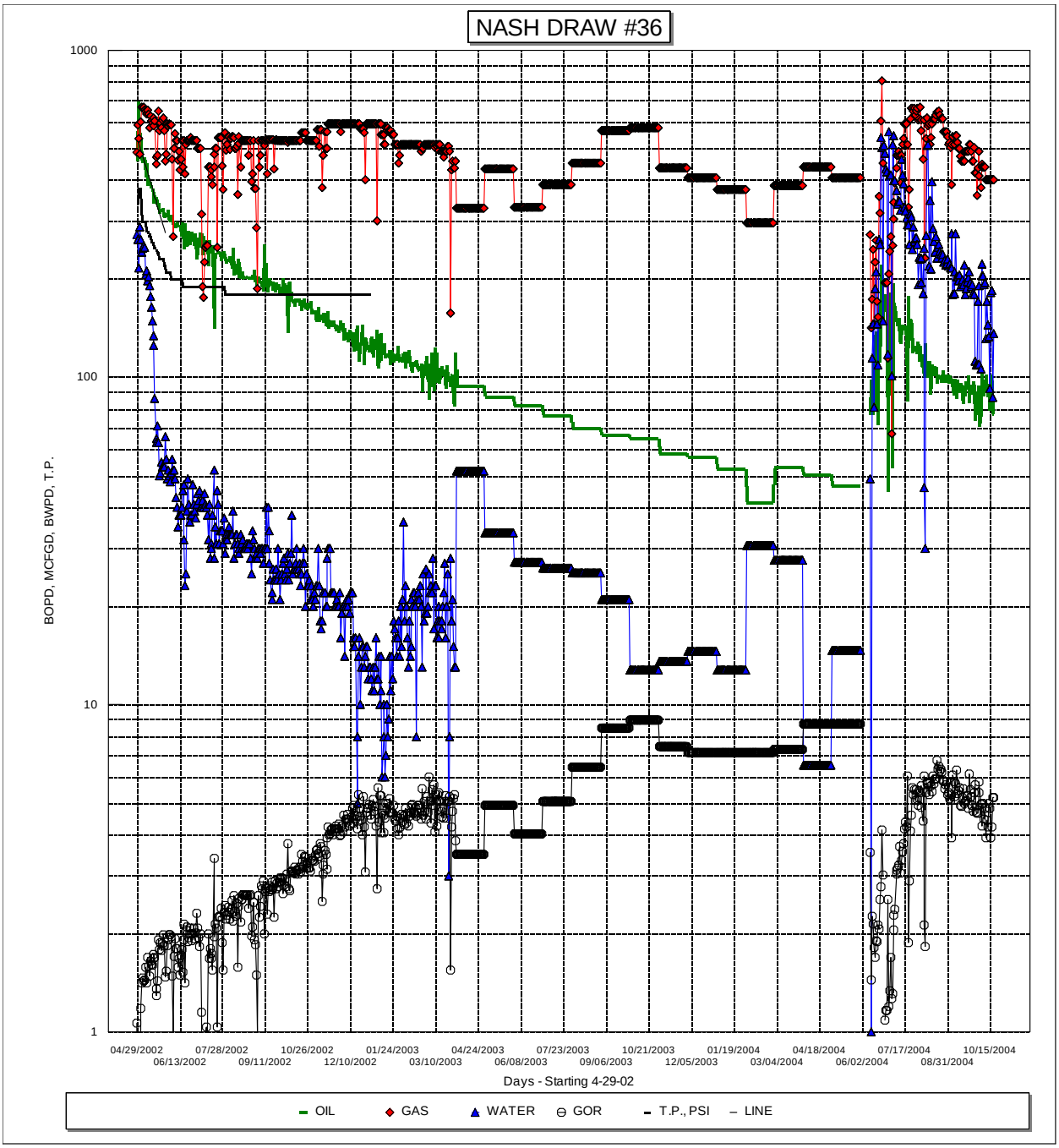

Fig. 4. ND #36 daily production plot.

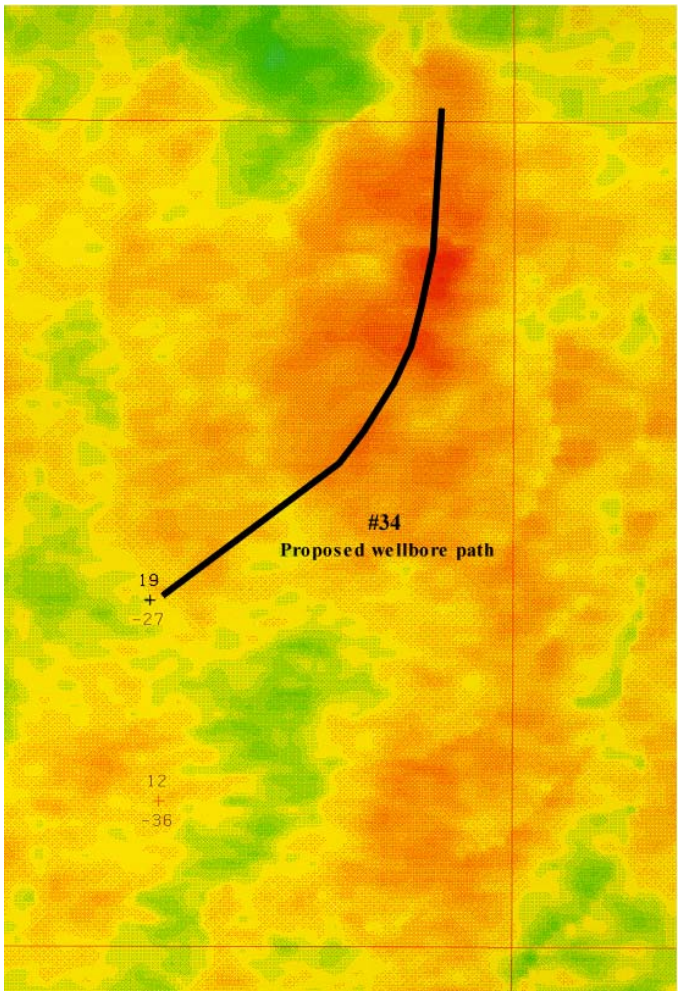

Fig. 5. Nash Draw #34 proposed wellbore path and seismic target.

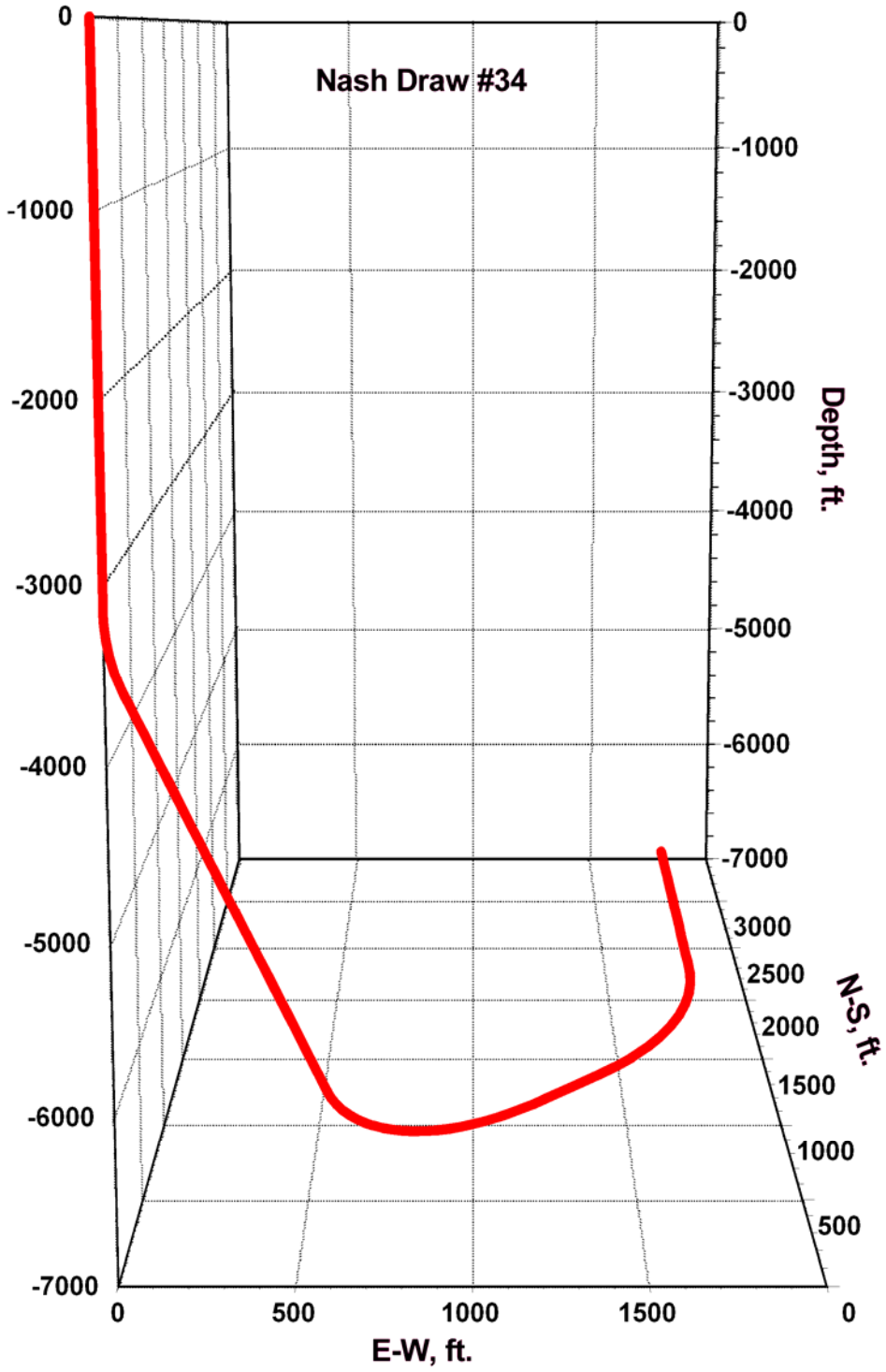

Fig. 6. ND #34 proposed wellbore path.

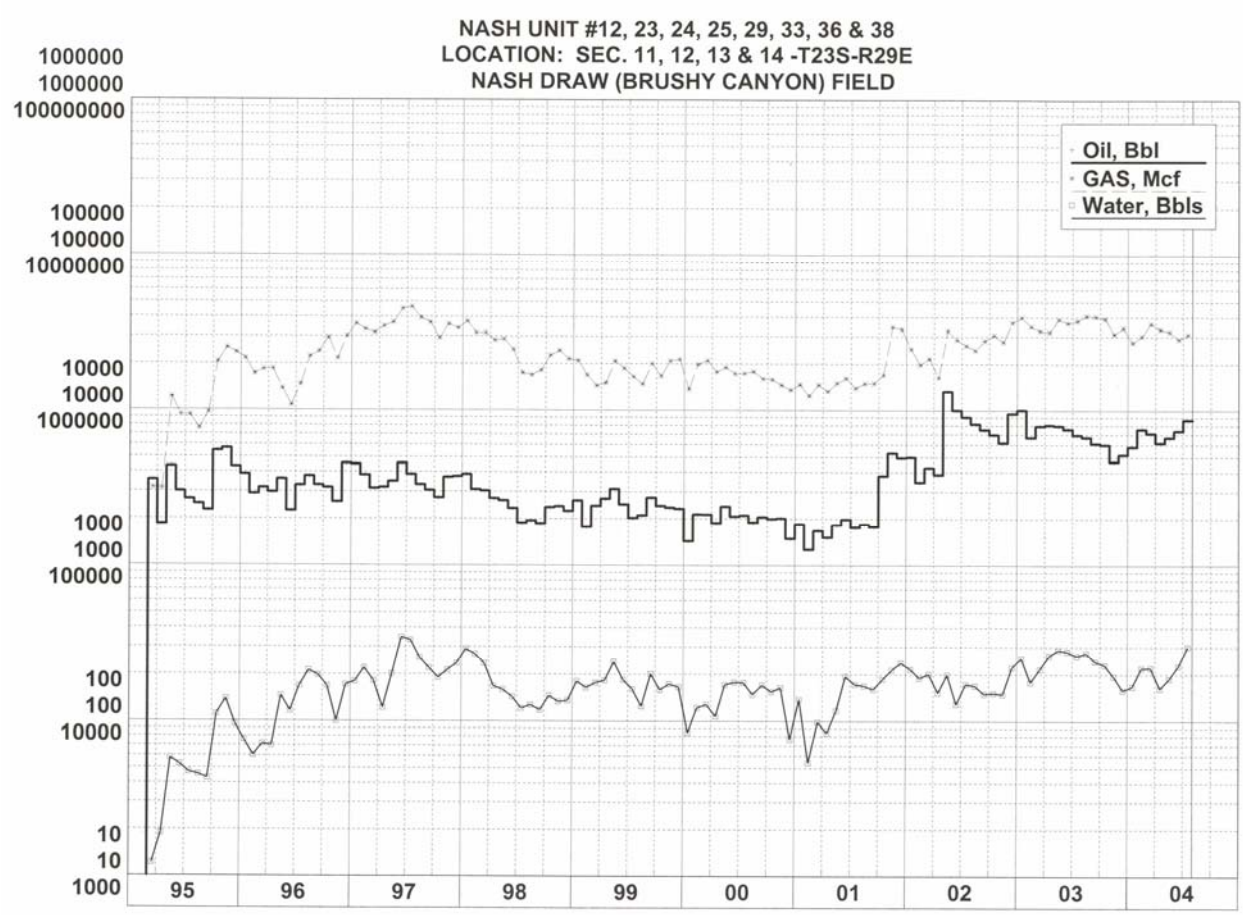

Fig. 7. Nash Draw D.O.E. wells cumulative production through 7-1-04.