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May 21, 1993

HAND DELIVERED

Michael E. Stogner
Oil Conservation Division
310 Old Santa Fe Trail
Santa Fe, New Mexico 87501

Re: Meridian Oil Inc.
DHC cases

Dear Mike:

I have enclosed a 5.25 floppy disk which contains the DHC allocation formula for NMOCD Cases 10721 through 10725. In addition, I have enclosed a hard copy of that formula for each case and printed such that it can be attached to the respective order as an exhibit. Please call me if you need anything else.

Tom

WHITLEY A #100

MONTHLY GAS PRODUCTION ALLOCATION FORMULA

GENERAL EQUATION

Q = Qftc + Qpc

WHERE: Qt = TOTAL MONTHLY PRODUCTION (MCF/MONTH)

Qftc = FRUITLAND COAL (FTC) MONTHLY PRODUCTION
Qpc = PICTURED CLIFFS (PC) MONTHLY PRODUCTION (MCF/MONTH)

REARRANGING THE EQUATION TO SOLVE FOR Qftc:

Qftc = Qt - Qpc

ANY PRODUCTION RATE OVER WHAT IS CALCULATED FOR THE PICTURED CLIFFS (PC) USING THE APPLIED FORMULA IS FRUITLAND COAL (FTC) PRODUCTION.

PICTURED CLIFFS (PC) FORMATION PRODUCTION FORMULA IS:

Qpc = Qpci * e^{-(Dpc)*(t)}

WHERE: Qpci = INITIAL PC MONTHLY FLOW RATE (CALCULATED FROM FLOW TEST)

Dpc = PICTURED CLIFFS MONTHLY DECLINE DATE DETERMINED FROM:

MATERIAL BALANCE (FIELD ANALOGY):
VOLUMETRIC RESERVES (LOG ANALYSIS)
G f(P*) = 1.34 MMCF/PSI x P* X Rf

P* = INITIAL RESERVOIR PRESSURE (7 DAY SIBHP)
RF = RECOVERY (FIELD ANALOGY): = 0.85

THUS: **Qftc = Qt - Qpci * e^{-(Dpc)*(T)}**

WHERE: (t) IS IN MONTHS

REFERENCE: Thompson, R. S., and Wright, J. D., "Oil Property Evaluation", pages 5-2, 5-3.

WHITLEY A #100

DETERMINATION OF Qpci:
(INITIAL PICTURED CLIFFS MONTHLY PRODUCTION)

Qpci = Qt(1) * Qpc(p) \ {Qpc(p) + Qftc (p)}

WHERE:

Qt(1) = FIRST MONTH TOTAL PRODUCTION (MCF)

Qpc(p) = FINAL PICTURED CLIFFS FLOW TEST (MCFPD)

Qftc(p) = FINAL FRUITLAND COAL FLOW TEST (MCFPD)

WHITLEY A #100

EXAMPLE DETERMINATION OF:

(a) Np(pc)	PC EUR
(b) Qpci	INITIAL PC MONTHLY FLOW RATE
(c) Dpc	PC MONTHLY DECLINE RATE

(a) DETERMINATION OF Np(pc)

Np(pc) = 1.34 (MMCF/PSI) X P*(PSI) X Rf

P* = 300 PSI (FROM 7 DAY SIBHP)

Np(pc) = 1.34 MMCF/PSI X 300 PSI X 0.85

Np(pc) = 341.7 MMCF

(b) DETERMINATION OF Qpci

Qpci = Qt(1) X {Qpc(p)/(Qpc(p) + Qftc(p))}

Qt(1) =	15,000 MCF	1ST MONTH TOTAL PRODUCTION
Qpc(p) =	500 MCF/D	PC FLOW TEST
Qftc(p) =	400 MCF/D	FTC FLOW TEST

Qpci = 15,000 MCF/M X {500 MCF/D/(500 MCF/D + 400 MCF/D)}

Qpci = 8,333 MCF/M

(c) DETERMINATION OF Dpc

Dpc = (Qpci - Qpcabd)/Npc

Qpcabd = 300 MCF/M

Dpc =(8,333MCF/M - 300MCF/M)/(341,700MCF)

Dpc = 0.024/M

THUS: Qftc = Qt(MCF/M) - 8,333(MCF/M) X e^{-(0.052(1/M)) X t(M)}

WHITLEY A #100

DETERMINATION OF Qpci:
(INITIAL PICTURED CLIFFS MONTHLY PRODUCTION)

<u>**Qpci = Qt(1) X Qpc(p) / {Qpc(p) + Qftc (p)}**</u>

WHERE:

Qt(1) = FIRST MONTH TOTAL PRODUCTION (MCF)

Qpc(p) = FINAL PICTURED CLIFFS FLOW TEST (MCFPD)

Qftc(p) = FINAL FRUITLAND COAL FLOW TEST (MCFPD)

WHITLEY A #100

MONTHLY GAS PRODUCTION ALLOCATION FORMULA

GENERAL EQUATION

Qt = Qftc + Qpc

WHERE: Qt = TOTAL MONTHLY PRODUCTION (MCF/MONTH)

Qftc = FRUITLAND COAL (FTC) MONTHLY PRODUCTION
Qpc = PICTURED CLIFFS (PC) MONTHLY PRODUCTION (MCF/MONTH)

REARRANGING THE EQUATION TO SOLVE FOR Qftc:

Qftc = Qt - Qpc

ANY PRODUCTION RATE OVER WHAT IS CALCULATED FOR THE PICTURED CLIFFS (PC) USING THE APPLIED FORMULA IS FRUITLAND COAL (FTC) PRODUCTION.

PICTURED CLIFFS (PC) FORMATION PRODUCTION FORMULA IS:

Qpc = Qpci * e^{-(Dpc)*(t)}

WHERE: **Qpci** = INITIAL PC MONTHLY FLOW RATE (CALCULATED FROM FLOW TEST)

Dpc = PICTURED CLIFFS MONTHLY DECLINE RATE CALCULATED FROM:
Dpc = **(Qpci-Qpcabd)/Np(pc)**
See Determination of Qpci and PC Estimated Ultimate Recovery (EUR)
Qpcabd = 300 MCF/M

WHERE: **Np(pc)** = PICTURED CLIFFS ESTIMATED ULTIMATE RECOVERY (EUR)
P*x 1.34 MMCF/PSI x Rf**
P* = INITIAL RESERVOIR PRESSURE (7 DAY SIBHP)
RF = RECOVERY (FIELD ANALOGY): = 0.85
** DETERMINED FROM MATERIAL BALANCE (FIELD ANALOGY) AND VOLUMETRIC RESERVES (LOG ANALYSIS)

By calculating PC EUR FROM SIBHP and determining PC initial flow rate, Dpc can then be estimated utilizing the previously described parameters

THUS: **Qftc = Qt - Qpci * e^{-(Dpc)*(t)}**

WHERE: **(t) IS IN MONTHS**

REFERENCE: Thompson, R. S., and Wright, J. D., "Oil Property Evaluation", pages 5-2, 5-3, 5-4.

TELECOPIER FORM

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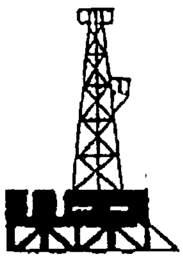

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TO: Tom Kellahin

COMPANY: Kellahin & Kellahin

TELECOPIER NUMBER:

FROM: Alan Alexander

DATE: 6-15-93

TOTAL NUMBER OF PAGES (Including this one): 10

SPECIAL INSTRUCTIONS:

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HUERFANO UNIT #549

In order to facilitate an economic Pictured Cliffs completion three requirements must be met. It is the combination of these three requirements that determines the economic status and completion method (PC single completion, PC-FTC Dual, PC-FTC commingle) utilized. These three requirements are as follows:

RESERVES Np(pc)

FLOW RATE (Qpcl)

COSTS (Investment and Operating)

Shown in the following example are the parameters and calculations used to determine Pictured Cliffs initial rate (Qpci), Pictured Cliffs Estimated Ultimate Recovery (Np(pc)), and Pictured Cliffs decline rate (Dpc). Additionally, estimated costs associated with each completion method and economic sensitivities (figures 1-3) are attached to show the effects of PC reserves (Np(pc)), initial PC rates (Qpci), and completion method (costs).

This example is for the Huerfano Unit #549, but the methodology is applicable for each of the commingle applications submitted (Rhodes C #'s 101 & 102, Whitley A #100, McAdams #500, and the Rowley Com #500). The variations in the Np(pc)'s are due to the specific drill block parameters (thickness, porosity, water saturation). Costs will be similar and the economic sensitivities are applicable for each case.

HUERFANO UNIT #549

MONTHLY GAS PRODUCTION ALLOCATION FORMULA

GENERAL EQUATION

Qt = Qftc + Qpc

WHERE: Qt = TOTAL MONTHLY PRODUCTION (MCF/MONTH)

Qftc = FRUITLAND COAL (ftc) MONTHLY PRODUCTION
Qpc = PICTURED CLIFFS (pc) MONTHLY PRODUCTION (MCF/MONTH)

REARRANGING THE EQUATION TO SOLVE FOR Qftc:

Qftc = Qt - Qpc

ANY PRODUCTION RATE OVER WHAT IS CALCULATED FOR THE PICTURED CLIFFS (PC) USING THE APPLIED FORMULA IS FRUITLAND COAL (FTC) PRODUCTION.

PICTURED CLIFFS (PC) FORMATION PRODUCTION FORMULA IS:

Qpc = Qpci X e^{-(Dpc) X (t)}

WHERE: **Qpci** = INITIAL PC MONTHLY FLOW RATE (CALCULATED FROM FLOW TEST)

Dpc = PICTURED CLIFFS MONTHLY DECLINE RATE CALCULATED FROM:
Dpc = (Qpci-Qpcabd)/Np(pc)
See Determination of Qpci and PC Estimated Ultimate Recovery (Np(pc))
Qpcabd = 300 MCF/M

WHERE: Np(pc) = PICTURED CLIFFS ESTIMATED ULTIMATE RECOVERY (EUR)
Np(pc) = **P X 1.08 MMCF/PSI** X Rf**
P* = INITIAL RESERVOIR PRESSURE (SIBHP)
RF = RECOVERY (FIELD ANALOGY): = 0.85
** DETERMINED FROM MATERIAL BALANCE (FIELD ANALOGY) AND VOLUMETRIC RESERVES (LOG ANALYSIS)

By calculating Np(pc) from SIBHP and determining Qpci, Dpc can then be calculated utilizing the previously described parameters. See derivation of Dpc, item (c) on page 4.

THUS: **Qftc = Qt - Qpci X e^{-(Dpc) X (t)}**
WHERE: **(t) IS IN MONTHS**

REFERENCE: Thompson, R. S., and Wright, J. D., "Oil Property Evaluation", pages 5-2, 5-3, 5-4.

HUERFANO UNIT #549

DETERMINATION OF Qpci:
(INITIAL PICTURED CLIFFS MONTHLY PRODUCTION)

$$Qpci = Qt(1) \times Qpc(p) / \{Qpc(p) + Qftc(p)\}$$

WHERE:

Qt(1) = FIRST MONTH TOTAL PRODUCTION (MCF)

Qpc(p) = FINAL PICTURED CLIFFS FLOW TEST (MCFPD)

Qftc(p) = FINAL FRUITLAND COAL FLOW TEST (MCFPD)

HUERFANO UNIT #549

EXAMPLE DETERMINATION OF:

(a) Np(pc)	PC EUR
(b) Qpci	INITIAL PC MONTHLY FLOW RATE
(c) Dpc	PC MONTHLY DECLINE RATE

(a) DETERMINATION OF Np(pc)

(see page 5 for Np(pc) derivation)

Np(pc) = 1.08 (MMCF/PSI) X P*(PSI) X Rf

P* = 300 PSI (FROM SIBHP)

Np(pc) = 1.08 MMCF/PSI X 300 PSI X 0.85

Np(pc) = 275.4 MMCF

(b) DETERMINATION OF Qpci

Qpci = Qt(1) X {Qpc(p)/(Qpc(p) + Qftc(p))}

Qt(1) =	15,000 MCF	1ST MONTH TOTAL PRODUCTION
Qpc(p) =	500 MCF/D	PC FLOW TEST
Qftc(p) =	400 MCF/D	FTC FLOW TEST

Qpci = 15,000 MCF/M X {500 MCF/D/(500 MCF/D + 400 MCF/D)}

Qpci = 8,333 MCF/M

(c) DETERMINATION OF Dpc

Dpc = (Qpci - Qpcabd)/Np(pc)

Qpcabd = 300 MCF/M

Dpc =(8,333MCF/M - 300MCF/M)/(275,400MCF)

Dpc = 0.029/M

THUS: Qftc = Qt(MCF/M) - 8,333(MCF/M) X e^{-(0.029(1/M)) X t(M)}

HUERFANO UNIT #549

A. DETERMINATION OF PC RESERVES Np(pc)= (HCPV X Bg X Rf)
Volumetric Evaluation (averages are for subject 160 acre drill block)

a.	(t)	thickness	=	35.0	ft
b.	(phi)	porosity	=	15.0	%
c.	(Sw)	H2O saturation	=	55.0	%
d.	(Rf)	Recovery Factor	=	85.0	%
e.	(rcf)	Reservoir Cubic Feet	@ reservoir conditions		
f.	(scf)	Standard Cubic Feet	@standard conditions		

1. HCPV = HYDROCARBON PORE VOLUME (rcf)

= t (ft) X a (ft^2) X phi X (1-Sw)
= 35 (ft) X 160 (acres) X 43,560 (ft^2/acre) X 0.15 X (1-0.55)
= 16,465,680 ft^3   1mmrcf = 1,000,000 ft^3

HCPV = 16.466 mmrcf

2. Bg = FORMATION VOLUME FACTOR (scf/rcf)

UTILIZING THE REAL GAS LAW TO DETERMINE THE FORMATION VOLUME FACTOR (Bg):
REAL GAS LAW states: P V = Z n R T
Rearranging to solve for n: n = P V / Z R T

assuming: nr = ns

WHERE: nr = NUMBER OF MOLES OF GAS AT RESERVOIR CONDITION
ns = NUMBER OF MOLES OF GAS AT SURFACE CONDITIONS

THUS: Pr Vr/ Zr Tr R = Ps Vs / Zs Ts R
Rearranging: Vs/Vr = Bg = Zs Ts Pr / Zr Tr Ps
assuming:

Zs	=	1.00		
Zr	=	0.94		
Ts	=	60	°F	or 520 °R
Tr	=	100	°F	or 560 °R
Ps	=	15.025 psia		
Pr	=	Determined from build-up test		

Bg = FORMATION VOLUME FACTOR (scf/rcf)= Zs Ts Pr / Zr Tr Ps
= (scf/rcf) {1.00 X 520 (°R) X Pr (psia)}/ {0.94 X 560 (°R) X 15.025 (psia)}

Bg = 0.0657 {scf/ (rcf psia)} X Pr (psia)

3. EUR = HCPV X Bg X Rf
= 16.466 (mmrcf) X 0.0657 {scf/(rcf psia)} X Pr (psia) X 0.85

Np(pc) = 1.08 (mmscf/psia) X Pr (psia) X 0.85

HUERFANO UNIT #549

B. PICTURED CLIFFS DRILLING /COMPLETION COST SUMMARY

1. STAND ALONE SINGLE PC COMPLETION

ESTIMATED COSTS:	TANGIBLE (M$)	INTANGIBLE (M$)	TOTAL (M$)
	183.39	136.12	319.51

2. FTC/PC DUAL COMPLETION*

ESTIMATED COSTS:	TANGIBLE (M$)	INTANGIBLE (M$)	TOTAL (M$)
	173.49	93.67	267.16

3. FTC/PC COMMINGLE COMPLETION*

ESTIMATED COSTS:	TANGIBLE (M$)	INTANGIBLE (M$)	TOTAL (M$)
	91.69	93.67	185.36

*PICTURED CLIFFS COSTS ONLY

C. ECONOMIC SUMMARY

FIGURES 1-3 PICTURED CLIFFS RESERVES VS RATE OF RETURN (%)

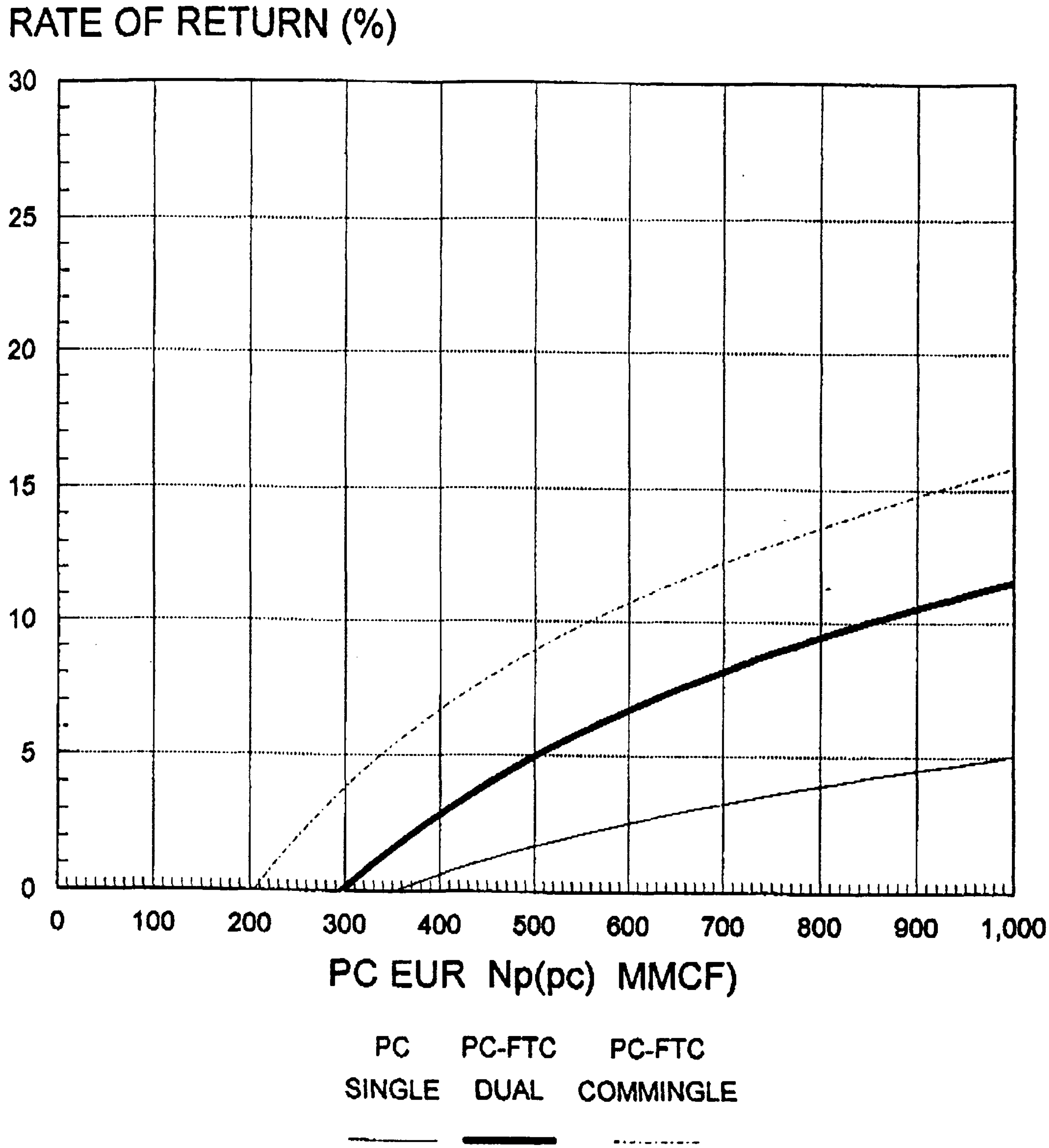
THREE CASES PER FIGURE (FTC/PC COMMINGLE, FTC/PC DUAL, PC SINGLE)

FIGURE 1 INITIAL RATE = 100 MCF/D
FIGURE 2 INITIAL RATE = 200 MCF/D
FIGURE 3 INITIAL RATE = 300 MCF/D

PICTURED CLIFFS

ECONOMIC EVALUATION

COMPLETION TECHNIQUE SENSITIVITY



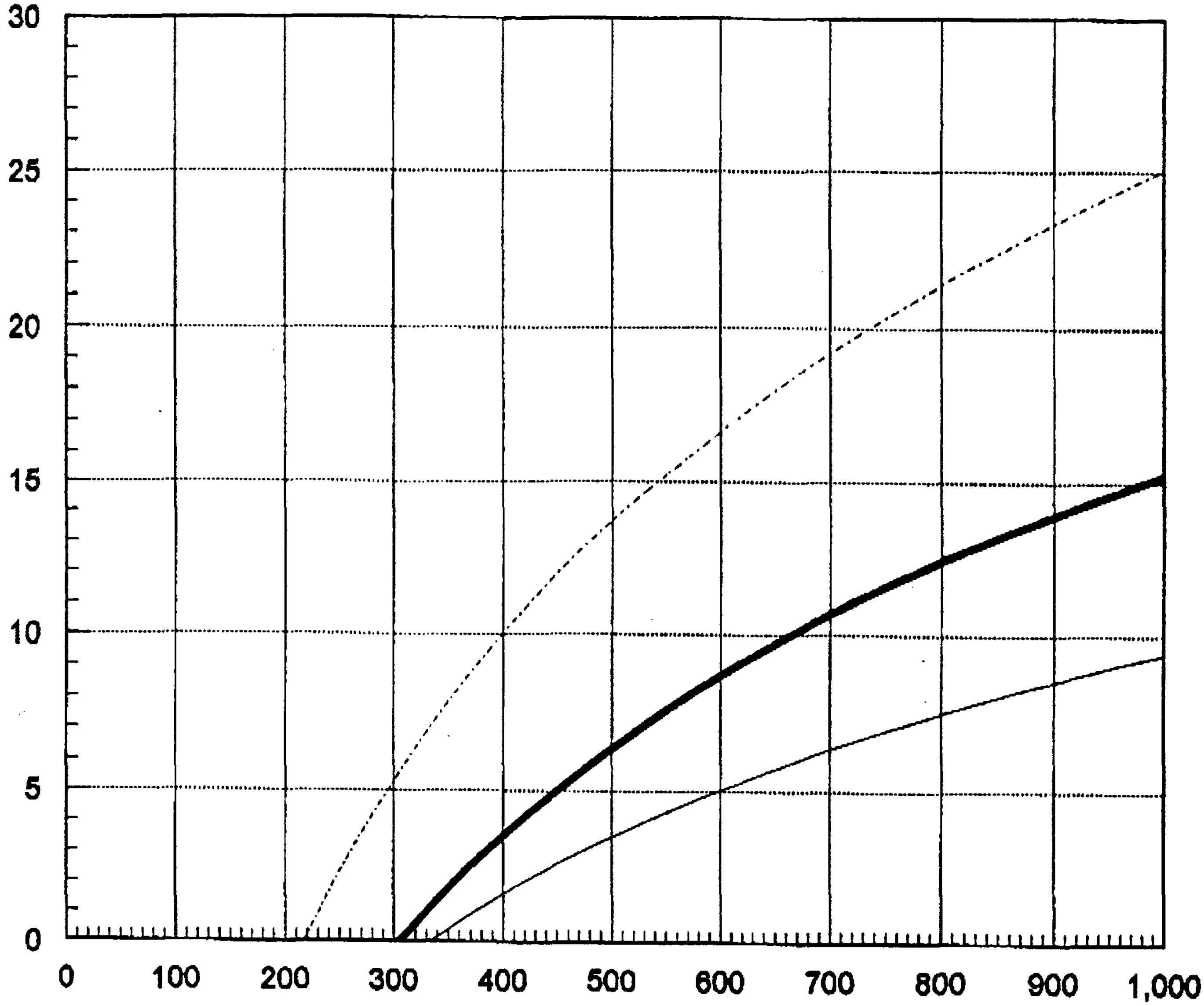
INITIAL RATE (Qpci) = 100 MCF/D
OR 3,000 MCF/M
FIGURE 1

PICTURED CLIFFS

ECONOMIC EVALUATION

COMPLETION TECHNIQUE SENSITIVITY

RATE OF RETURN (%)



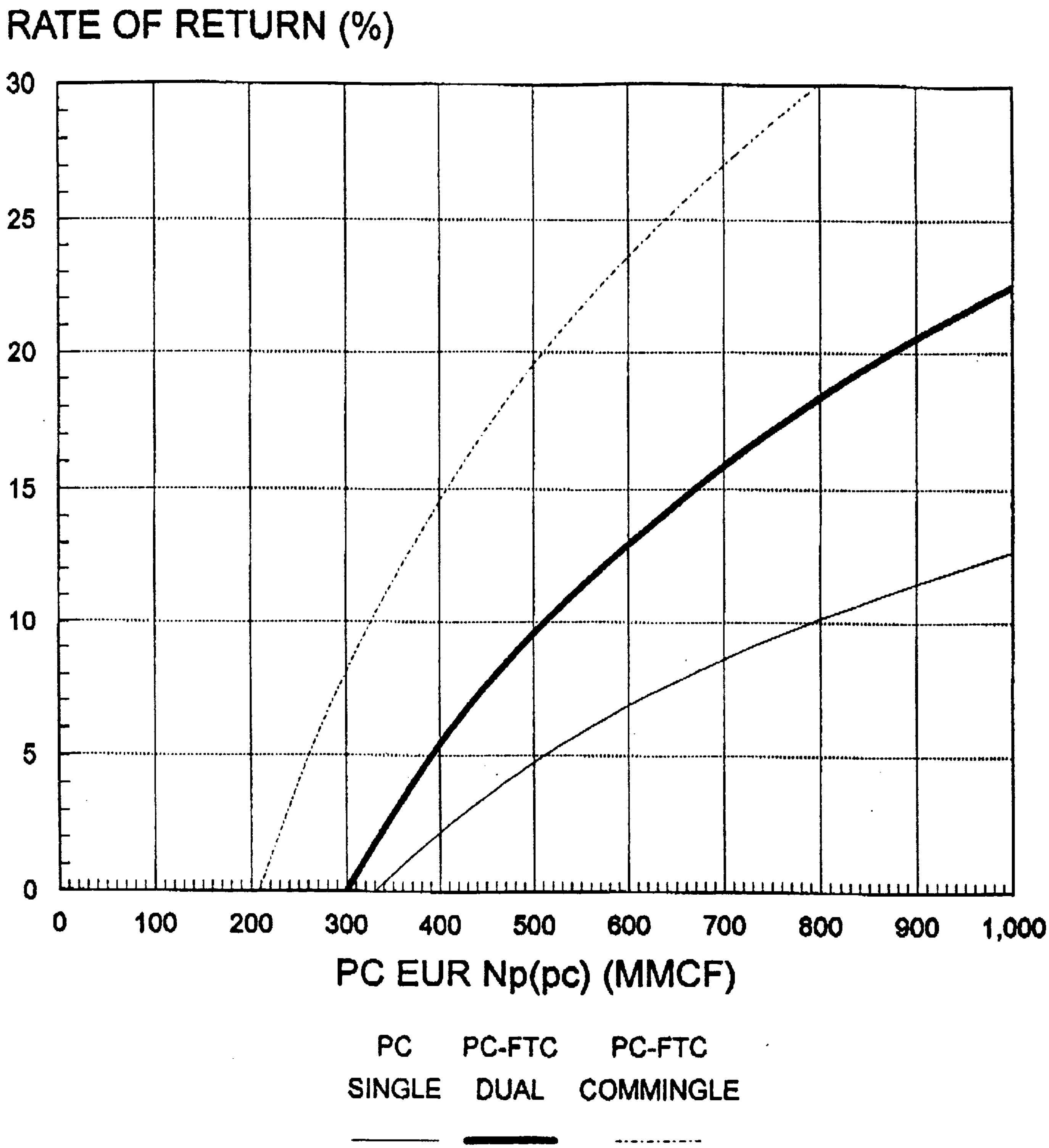
PC EUR Np(pc) (MMCF)

PC SINGLE	PC-FTC DUAL	PC-FTC COMMINGLE
———— (thin solid)	━━━━ (thick solid)	- - - - - (dashed)

INITIAL RATE (Qpcl) = 200 MCF/D
OR 6,000 MCF/M
FIGURE 2

ECONOMIC EVALUATION

COMPLETION TECHNIQUE SENSITIVITY



INITIAL RATE (Qpcl) = 300 MCF/D
OR 9,000 MCF/M
FIGURE 3

	WELL	POOL		OWNERSHIP		NSL		ECONOMICS
		FTC	PC	FTC	PC	FTC	PC	SUB ECON
1.	Rhodes C#101	BFTC	W-K	Comm	Comm	NSL	NSL	FTC - PC
2.	Rhodes C#102	BFTC	W-K	Comm	Comm	OK	NSL	FTC - PC
3.	Whitley A#100	BFTC	W-K	Comm	Comm	OK	NSL	FTC - PC
4.	Rowley Com#500	BFTC	FK	Diff	Diff	OK	NSL	PC -Margin
5.	McAdams #500	BFTC	FK	Diff	Diff	OK	OK	PC

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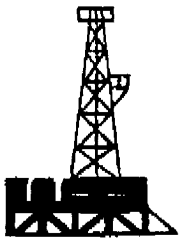

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TO: M.E. Stogner

COMPANY: NMOCD

TELECOPIER NUMBER: 827-5741

FROM: Scott Daves

DATE: 5-26-93

TOTAL NUMBER OF PAGES (Including this one): 3

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to plot, they yield results on a time basis, and they're deceptively easy to analyze. Decline curves are also one of the oldest methods of predicting reserves.

Decline curves, as used today, are simply a plot of production rate versus time on semilog, log-log, or specially scaled paper. The most common plot is semilog. When the logarithm of producing rate is plotted versus linear time, a straight line often results. This phenomenon is referred to as "exponential decline" and is similar to the decay of a radioactive element. Exponential decline is also referred to as constant percentage decline because of terminology used in the early 1900's. Occasionally, someone will state that exponential decline and constant percentage decline are different. This is not true; they are synonyms for decline curves which plot as a straight line on semi-log paper.

Often the data will not plot as a straight line on semi-log paper, but instead will "curve up" or be concave upwards. This situation, in which the decline rate continuously decreases with time, can usually be modeled with a hyperbolic equation. In cases of this type, the well is said to be experiencing "hyperbolic decline." A special case of hyperbolic decline is known as "harmonic decline."

5.1 DECLINE CURVE EQUATIONS

5.1.1 *Exponential Decline*

The equation of a straight line on semilog paper can be written as

$$q = q_i \, e^{-Dt} \qquad (5\text{-}1)$$

where

- q = producing rate at time t, vol/unit time
- q_i = producing rate at time 0, vol/unit time
- D = nominal exponential decline rate, 1/time
- t = time
- e = base of natural logarithms, (2.718....)

Any system of units can be used as long as the product **Dt** is unitless and q and q_i are expressed in the same units. Equation 5-1 can be "derived" by stating that the decline rate at any time is proportional to the production rate, but there is no theoretical foundation for this "derivation." The theoretical foundation for exponential decline will be discussed later.

5.1.1.1 *Nominal and Effective Decline Rates*

Equation (5-1) *defines* the nominal decline rate (D). In dealing with production data, we intuitively think in terms of "effective" decline rate. For example, if we are told that a well produced 100 BOPD one year ago and now produces 50 BOPD, we naturally feel that the well declined at a rate of 50% per year. Imagine our surprise when the engineer says it is declining at 69.3% per year! Which one of the these is correct? Both of them are. Effective decline is defined as

$$D_e = \frac{q_i - q}{q_i} \qquad (5\text{-}2)$$

for a given time period. The relationship between **D** and $\mathbf{D_e}$ can be derived as follows. We take **t** to be one time period (a year, perhaps). Since $\mathbf{q_i}$ and **q** are the same for both definitions of decline rate we can solve equations 5-1 and 5-2 for q and set the results equal:

$$q = q$$

$$q_i \, e^{-D} = q_i - q_i D_e$$

(t has been set to 1)

factor out q_i

$$q_i \, e^{-D} = q_i(1 - D_e)$$

Nominal decline as a function of effective decline is

$$D = -\ln(1 - D_e) \qquad (5\text{-}3)$$

or

Effective decline as a function of nominal decline is

$$D_e = 1 - e^{-D} \quad (5\text{-}4)$$

The authors strongly prefer the use of nominal decline rather than effective decline for reasons which will be discussed throughout the rest of the chapter.

One of the major reasons for using nominal decline has to do with changing the time units on decline rate. With nominal decline, a yearly rate can be changed to a monthly rate simply by dividing by 12. *This is not possible with effective decline!* In order to convert yearly effective rate to monthly effective rate, the *twelfth root* of $1 - D_e$ must be taken. Taking the twelfth root or raising a number to the twelfth power is not difficult, but it is not intuitive. An example will illustrate the above ideas.

Example 5-1
Nominal and Effective Decline Rates

Given that a well has declined from 100 BOPD to 96 BOPD during a one month period.

A) Predict the rate after 11 more months using nominal exponential decline.

B) Same as A using effective decline.

A) Using Nominal Decline

$q_i = 100$ BOPD

$q = 96$ BOPD

$t = 1$ month

$$D = \left[\ln\left(\frac{q_i}{q}\right)\right]/t \quad (5\text{-}1)$$

$D = .04082$/mo

Find rate at end of 1 year.

$q = q_i e^{-Dt}$ PRIMARY EQ

$q = 100e^{-.04082\,(12)}$

$q = 61.27$ BOPD

B) Using Effective Decline

$$D_e = \frac{q_i - q}{q_i} \quad (5\text{-}2)$$

$$D_e = \frac{100 - 96}{100}$$

$D_e = .04$/month

Convert to yearly

$1 - D_{ey} = (1 - D_{em})^{12}$

$1 - D_{ey} = (1 - .04)^{12}$

$D_{ey} = .3875$/year

Find rate at end of 1 year

$q = q_i (1 - D_e)$

$q = 100(1 - .3873)$

$q = 61.27$ BOPD

The authors find it much easier to use nominal decline. No matter what the units on **D** and **t**, it is only necessary to multiply by the appropriate time factor to cause the product **Dt** to be unitless. Try to predict the rate 22½ months from now using effective decline — it's not worth the effort.

5.1.1.2 *Cumulative Production*

In oil property evaluation, we are more interested in the amount of oil produced each year than the rate at any given time. In order to determine the cumulative oil production (N_p) at any

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

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GOVERNOR

ANITA LOCKWOOD
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July 9, 1993

KELLAHIN AND KELLAHIN
Attorneys at Law
P. O. Drawer 2265
Santa Fe, New Mexico 87504

RE: CASE NOS. 10721, 10722, 10723, 10724, 10725
ORDER NO. R-9920

Dear Sir:

Enclosed herewith are two copies of the above-referenced Division order recently entered in the subject cases.

Sincerely,

Sally Leichtle

Sally E. Leichtle
Administrative Secretary

cc: BLM - Farmington
Steve Keene - TRD
Donna McDonald - OCD
Aztec OCD Office