North Dakota Law Review

Volume 58 | Number 3 Article 5

1982

# Microbes, Simulators, and Satellites: The Prudent Operator Pursues Enhanced Recovery Under the Implied Covenants

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# MICROBES, SIMULATORS, AND SATELLITES: THE PRUDENT OPERATOR PURSUES ENHANCED RECOVERY UNDER THE IMPLIED COVENANTS

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## I. INTRODUCTION

Over the course of this century, the oil and gas industry in the United States has had as its "prime mover"[1] the well-known figure of the prudent operator. In 1905 in the case of *Brewster v. Lanyon Zinc Co.*,[2] then Judge Van Devanter of the Court of Appeals for the Eighth Circuit enunciated the durable standard governing performance in the industry, which to this day, remarkably, still holds sway: "Whatever, in the circumstances, would be reasonably expected of operators of ordinary prudence, having regard to the interests of both lessor and lessee, is what is required."[3] This standard is to oil and gas law what that venerable fellow, the reasonable man, is to the law of torts.[4] Despite the remarkable changes in the industry over the decades, the prudent operator has

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1. In oil field slang "prime mover" is the chief source of power on a drilling rig.

2. 140 F. 801 (8th Cir. 1905).

3. Brewster v. Lanyon Zinc Co., 140 F. 801, 814 (8th Cir. 1905).

4. *See* 5 H. WILLIAMS & C. MEYERS, OIL AND GAS LAW § 806.3, at 40-42 (1981) [hereinafter cited as WILLIAMS & MEYERS]. Williams and Meyers offer the following definition of a prudent operator: "He is a hypothetical oil operator who does what he ought to do and does not do what he ought not to do with respect to operations on the leasehold." *Id.* at 41.

persisted to the present, although not without recent criticism.[5]

In our estimation, the standard has served the lessors, lessees, their advocates, and the courts well, and if the present is sage for the future, will continue to do so. The purpose of this Article is, first, to examine the prudent operator's performance in three recent cases[6] concerning the implied covenants of development, diligent operations, protection, and exploration[7] as they pertain to enhanced recovery;[8] second, to examine various current industry efforts at enhanced recovery and, to a lesser extent, modern exploratory methods; and finally, to tentatively draw conclusions and formulate predictions about past industry performance and future directions.

## II. THE IMPLIED COVENANTS OF DEVELOPMENT, DILIGENT OPERATIONS, AND PROTECTION

The implied covenant of development has traditionally involved a duty to diligently drill additional wells under an oil and gas lease that is held by production in paying quantities.[9] The

5. *See* Martin, *A Modern Look at Implied Covenants to Explore, Develop, and Market Under Mineral Leases,* 27 INST. ON OIL & GAS L. & TAX'N 177, 177-78, 212-13 (1976); Williams, *Implied Covenants in Oil and Gas Leases: Some General Principles,* 29 U. KAN. L. REV. 153, 153-54 (1981); 40 LA. L. REV. 974, 985 (1980).

6. Waseco Chem. & Supply Co. v. Bayou State Oil Corp., 371 So. 2d 305 (La. Ct. App.), *cert. denied,* 374 So. 2d 656 (La. 1979); Mitchell v. Amerada Hess Corp., 638 P.2d 441 (Okla. 1981); Amoco Prod. Co. v. Alexander, 622 S.W.2d 563 (Tex. 1981).

7. In 1956 Professor Charles J. Meyers suggested an implied covenant of further exploration, which required exploratory activities by the operator upon a leasehold held by production obtained in the primary term of the oil and gas lease. *See* Meyers, *The Implied Covenant of Further Exploration,* 34 TEX. L. REV. 553 (1956). The covenant of further exploration has been discussed, challenged, and defended in a notable display of rhetoric and conceptual acuity. *See, e.g.,* 5 WILLIAMS & MEYERS, *supra* note 4, §§ 841-847 (note especially the articles cited at pp. 261-62 n.6); Pickerill, *Is There a New Implied Covenant of Explorvelopment?,* 31 INST. ON OIL & GAS L. & TAX'N 245 (1980).

8. Enhanced recovery has been defined as "any method used to recover more oil from a petroleum reservoir than would be obtained by primary recovery." NATIONAL PETROLEUM COUNCIL, ENHANCED OIL RECOVERY 3 (1976). The term "enhanced recovery" is used herein in a broader context to mean any reasonable method a prudent operator would employ to maximize the recovery of oil and gas under his leasehold consistent with an economic application of advancing technology. Thus, enhanced recovery includes not only secondary or tertiary recovery, but also the most modern prudent use of equipment and technique in the primary recovery phases, infill drilling, fieldwide administrative relief in the form of pressure maintenance or an adjustment of allowables, unitization before fully developing the common source of supply, and application of secondary and tertiary recovery techniques before the primary energy drive is depleted.

Enhanced recovery includes, in an even broader sense, the use of reasonable exploratory methods by a prudent operator to maximize the discovery of reserves in an area of exploratory operations. This would include the use of reciprocal exploration agreements and the disciplines of economics and decision analysis, in addition to the use of advancing exploratory technology. *See generally* R. MEGILL, AN INTRODUCTION TO EXPLORATION ECONOMICS (2d ed. 1979); P. NEWENDORP, DECISION ANALYSIS FOR PETROLEUM EXPLORATION (1975); Williams, *Implied Covenants for Development and Exploration in Oil and Gas Leases — The Determination of Profitability,* 27 U. KAN. L. REV. 443 (1979); Williams, *supra* note 5.

9. Different formulations of the covenant of development have been posited. *See, e.g.,* 5 E. KUNTZ, A TREATISE ON THE LAW OF OIL AND GAS § 58.1, at 58 (1978) (duty to maintain active interest in developing the lease, in determining whether further development is feasible, and in drilling further development wells if drilling is feasible); M. MERRILL, COVENANTS IMPLIED IN OIL AND GAS LEASES 23-25 (2d ed. 1940) (implied covenant to drill additional wells); 2 W. SUMMERS, THE

covenant to carry on operations with due diligence has been described as a "catchall" obligation concerning situations not covered by the other more specific implied covenants. It reiterates the duty of the lessee to act in a manner consistent with the purposes of the lease.[10] The covenant to protect the leasehold from drainage requires the drilling of offset wells when the lessor establishes that substantial drainage has occurred and that an offset well would produce oil and gas in commercial quantities.[11] Our concern is with these covenants as recently applied to a lessee's duties in carrying out enhanced recovery activities, including engaging in secondary recovery[12] and operating in the context of fieldwide development.

### A. SECONDARY RECOVERY

In 1979 the Louisiana Court of Appeals decided the case of *Waseco Chemical & Supply Co. v. Bayou State Oil Corp.*[13] The decision involved an action by Waseco to cancel an eighty acre oil and gas lease held by the lessee-operator, Bayou State, in the Bellevue Field, Bossier Parish, Louisiana.[14] The field was initially discovered in 1921, and by the time Bayou State acquired the lease, known as the Scanland lease, in 1953, production was reaching the end of its primary phase.[15] The appellate court affirmed the lower court's judgment cancelling the lease for failure to diligently develop the premises as a reasonably prudent operator.[16]

When Bayou State acquired the lease, approximately 50 wells had been drilled to the Nacatoch Sand at a depth of 350-500 feet below the surface. The average leasehold production in 1955 was about 46 barrels of oil per day. Between 1953 and 1976 Bayou State expended no capital on the lease by drilling additional wells, reworking existing wells, or otherwise. By 1976 production had declined to six barrels per day from the only nine wells producing on the leasehold.[17]

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LAW OF OIL AND GAS § 395, at 535 (1959) (a covenant, if oil or gas be found in paying quantities, to proceed with reasonable diligence in drilling a sufficient number of wells to reasonably develop the premises).

10. 5 WILLIAMS & MEYERS, *supra* note 4, § 861, at 424.

11. 5 WILLIAMS & MEYERS, *supra* note 4, §§ 822-832, at 78-80.

12. Secondary recovery is defined broadly as "methods of oil extraction in which energy sources extrinsic to the reservoir are utilized in the extraction." H. WILLIAMS & C. MEYERS, OIL AND GAS TERMS 681-82 (5th ed. 1981) [hereinafter cited as WILLIAMS & MEYERS, TERMS].

13. 371 So. 2d 305 (La. Ct. App.), *cert. denied*, 374 So. 2d 656 (La. 1979). For analyses of the *Waseco* case, see 40 LA. L. REV. 974 (1980) and 15 TULSA L. J. 597 (1980).

14. Waseco Chem. & Supply Co. v. Bayou State Oil, 371 So. 2d 305, 306, 310 (La. Ct. App.), *cert. denied*, 374 So. 2d 656 (La. 1979).

15. 371 So. 2d at 310-11.

16. *Id.* at 306, 313.

17. *Id.* at 310-11.

The court found that the extensive drilling and testing activities of the operators in the field had resulted in a clear understanding of its subsurface strata, including the quality and thickness of the Nacatoch Sand, its heavy, viscous oil, and its lack of reservoir pressure and amenability to waterflooding. The Scanland property was comparable to other adjoining properties in the field and contained an estimated 3,000,000 barrels of additional recoverable oil.[18]

The evidence before the court further showed that Getty, a major operator in the field, had begun a fireflood project[19] in 1963, had drilled more than 500 wells on its leases and planned to drill 200 more, had produced from one of its 40 acre leases more than 2,000,000 barrels of oil, and had produced more than 2,500,000 barrels of oil from an 80 to 90 acre lease which had been fireflooded since 1967.[20] Getty's pilot fireflood program on a mere 2.8 acres had increased production within an 18 month period from 4 barrels to 100 barrels per day.[21] Another major operator, Cities Service, had drilled hundreds of wells since it commenced its fireflood operations in 1971. Even Bayou State had initiated a fireflood program on another of its leases, the Wyche lease, but had not carried on active development operations since 1975.[22]

Finally, the court found that the Bellevue fireflood projects had been well publicized, that the knowledge of Getty's increased production was available to Bayou State, and that fireflooding would successfully produce sixty percent of the oil in place compared to the stripper method's recovery of five percent.[23] In fact, several years before the filing of the lawsuit, Waseco had requested that Bayou State initiate a fireflood project to further develop the lease, but Bayou State refused to undertake any feasibility studies or plans for fireflooding the lease.[24]

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18. *Id.* at 311.

19. Fireflooding is also called in-situ combustion and is defined as follows:

> An experimental means of recovery of oil of low gravity and high viscosity which is unrecoverable by other methods. The essence of the method is to heat the oil in the horizon to increase its mobility by decreasing its viscosity. Heat is applied by igniting the oil sand and keeping the fire alive by the injection of air. The heat breaks the oil down into coke and lighter oils and the coke catches fire. As the combustion front advances, the lighter oils move ahead of the fire into the bore of a producing well.

WILLIAMS & MEYERS, TERMS, *supra* note 12, at 365. *See infra* notes 140-50 and accompanying text for a discussion of fireflooding and other thermal processes.

20. Waseco Chem. & Supply Co. v. Bayou State Oil, 371 So. 2d at 311.

21. *Id.*

22. *Id.* at 312.

23. *Id.* at 311-12. The court of appeals noted that while fireflooding is a technique of *secondary* recovery, it is the only efficient method of producing the type of residual oil in the Bellevue Field. *Id.* at 312.

24. *Id.* at 312-13.

For more than thirty years commentators have recognized that in an oil and gas lease there exists an obligation to employ secondary recovery methods for the extraction of hydrocarbons if it is reasonably prudent to do so. In 1951 the preeminent Professor Merrill stated:

> To the extent that secondary recovery methods are capable of application to a leased tract as an independent unit, the implied covenant obligations seem to present no serious obstacle to their adoption. In fact, since they afford a means of increasing the return to the lessor from oil which would be left in the ground if operations were confined to primary methods, they constitute a part of the general duty of diligent operation of the premises, imposed upon the lessee as an implied covenant.[25]

The primary cases on which various authors rely to support the principle of an obligation to use secondary recovery methods were decided around midcentury.[26] For example, in 1954 the Oklahoma Supreme Court stated: "There is respectable authority to the effect that there is an implied covenant in oil and gas leases that a lessee should resort to a secondary recovery method shown to be practical and presumably profitable as a means of getting additional return from the lease."[27] However, that statement and all the other early assertions of such a duty rested on dicta.

Despite this early recognition of the duty, it is significant that the *Waseco* decision almost thirty years later is the first to squarely

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25. Merrill, *Implied Covenants and Secondary Recovery*, 4 OKLA. L. REV. 177, 181 (1951) (footnotes omitted). As Merrill and others indicate, the duty of secondary recovery is traditionally considered a part of the implied covenant of diligent operation. *See, e.g.*, 5 E. KUNTZ, *supra* note 9, § 59.1, at 102; 5 WILLIAMS & MEYERS, *supra* note 4, § 861.3, at 430. For additional discussion of this issue, see Hughes, *Legal Problems of Water Flooding, Recycling and Other Secondary Operations*, 9 INST. ON OIL & GAS L. AND TAX'N 105, 116-20 (1958); Walker, *Problems Incident to the Acquisition, Use and Disposal of Repressuring Substances Used in Secondary Recovery Operations*, 6 ROCKY MTN. MIN. L. INST. 273, 285-88 (1961). Conceptually, treatise writers have placed the duty to apply enhanced recovery techniques, such as waterflooding, fireflooding, and other secondary recovery methods, as coming under the implied covenant of diligent operation. *See, e.g.*, 5 E. KUNTZ, *supra* note 9, § 59.1, at 102. *Cf.* Waseco Chem. & Supply Co. v. Bayou State Oil, 371 So. 2d 305, 307 (La. Ct. App.), *cert. denied*, 374 So. 2d 656 (La. 1979) (duty to fireflood considered within context of duty of diligent development); 40 LA. L. REV. 974, 980 (1980) (*Waseco* extends obligation of reasonable development to encompass the duty to use enhanced methods of oil recovery). It would seem that the duty partakes of elements of diligent operations *and* developmental drilling, and in any event, proof of such a duty in any given context would no doubt tend to take on a hybrid quality, borrowing from both covenants.

26. Ramsey v. Carter Oil Co., 74 F. Supp. 481 (E.D. Ill.), *aff'd*, 172 F.2d 622 (7th Cir.), *cert. denied*, 337 U.S. 958 (1947); Carter Oil Co. v. Dees, 340 Ill. App. 449, 92 N.E.2d 519 (1950); *In re* Shailer's Estate, 266 P.2d 613 (Okla. 1954).

27. *In re* Shailer's Estate, 266 P.2d 613, 616-17 (Okla. 1954). *See* Merrill, *The Modern Image of the Prudent Operator*, 10 ROCKY MTN. MIN. L. INST. 107 (1965). Professor Merrill notes that the principle of law articulated in *In re Shailer's Estate* found support in his own treatise. *Id.* at 117. *See* M. MERRILL, *supra* note 9, § 77, at 192-94.

hold that a lessor can enforce upon a lessee a duty to employ secondary recovery techniques.[28] In doing so, the *Waseco* court considered a variety of factors including geological data, the number and location of wells drilled on leased lands and adjoining property, the productive capacity of producing wells, the costs of drilling operations compared with profits, the time between completion of the last well and the demand for additional operations, and the amount of disputed acreage.[29] For our purposes, the question arises whether this analytical framework, as applied to the facts, serves sufficiently to resolve the overriding issues of technological feasibility and profitability of the proposed method of recovery, issues likely to be critical in any litigation of this nature.

The *Waseco* court considered the first factor, geological data, in detail and concluded that the properties of the producing sands under the lease in question were essentially the same as those underlying adjacent leases and, therefore, were amenable to fireflooding. Moreover, reserve estimates indicated a quantity of oil sufficient to indicate a degree of profitability.[30]

Considering the second factor, the number and location of wells, the court found that Bayou State was not drilling any new wells, whereas other operators had drilled hundreds of wells on their leases.[31] While there was no indication that the plaintiff desired the drilling of developmental wells to recover additional primary reserves, the lack of developmental activity of any type is significant, especially in the context of the relatively feverish drilling activity on nearby leases.

Third, regarding the productive capacity of the wells, the evidence showed that the Scanland lease had declined from forty-six barrels of oil per day in 1953 to six barrels of oil per day in 1976. Other operators in the field had, by fireflooding, recovered millions of barrels during the same period.[32]

As to the fourth factor, a cost and profit comparison, the court observed, "Bellevue wells are shallow, closely spread (one or more wells per acre), and are capable of being drilled with little risk, inexpensively, in about 12 hours."[33] The court also indicated that one of Bayou State's own fireflood projects had recouped its capital

28. Waseco Chem. & Supply Co. v. Bayou State Oil Corp., 371 So. 2d 305, 306-07, 312 (La. Ct. App.), *cert. denied*, 374 So. 2d 656 (La. 1979). *See* WILLIAMS & MEYERS, *supra* note 4, § 869, at 469; MERRILL, *supra* note 27, at 119; 40 LA. L. REV. 974, 977 (1980); 15 TULSA L. J. 597, 597-98 (1980).
29. 371 So. 2d at 312.
30. *Id.* at 311.
31. *Id.*
32. *Id.*
33. *Id.*

expenditures and operating expenses within a five year period and had since remained profitable.[34]

With respect to the fifth factor considered by the court, the time interval between wells, the evidence showed that Bayou State had drilled no wells on the Scanland lease since its acquisition in 1953, although the lessor had made its demand for additional wells several years before filing the lawsuit.[35] Although the plaintiff did not seek the drilling of traditional development wells,[36] the total absence of development activity was, again, important.

Finally, as to the amount of acreage involved on the leasehold, the court may have considered the evidence showing increased producing capacity of leases not only comparable in size, but even much smaller than Bayou State's lease.[37] In both development and exploration situations the size of the tract is a factor in the determination of potential profit.[38]

Following its review of the facts, the Louisiana appellate court upheld cancellation of the lease.[39] It is difficult to imagine a case more suitable for the application of the principle that a reasonably prudent operator has the duty to employ enhanced recovery methods. The *Waseco* court, however, could have utilized its framework of analysis to resolve more explicitly the central issues of technological feasibility and profitability. It is clear that the court considered fireflooding feasible, although the minimum sufficiency of proof to require fireflooding is still uncertain. In a like manner, the court did not succinctly state what degree of profitability must ultimately be demonstrated. Given the current sophistication of analysis by an operator of the profit potential of such a project, it is perhaps disappointing that profitability was not addressed more directly. In any event, the court's six part approach to the facts was at the least a workable one in this case.[40]

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34. *Id.* at 312. The court's opinion reflected only the additional barrels of oil recovered on other firefloods, but did not discuss the costs of recovery or an acceptable rate of return. The five year payout on Bayou State's Wyche fireflood may or may not have been reasonable, assuming a similar length of payout on the Scanland lease. It would have been helpful if the court had addressed the assumptions made about the present and future price of the product and operating costs. *See* 40 LA. L. REV. 974, 983 (1980) (uncertainty surrounding federal price controls).

35. 371 So. 2d at 311-13.

36. The fireflood would entail workover of some of the existing wells, abandonment of others, and in all probability, drilling of additional wells. Thus, the covenants of development and diligent operation are both applicable. *See supra* note 25.

37. 371 So. 2d at 311.

38. In *Waseco* Bayou State had several other tracts under lease in the field. *Id.* at 310-11.

39. *Id.* at 312. In addition to the facts discussed above, equitable notions almost certainly influenced the court. The fact that Bayou State's expert testified to its financial limitations and the admission by the company that its production in the field was geared to its refinery capacity were probably persuasive. *Id.* at 311-12.

40. Although the court's approach was workable, this does not mean that outright lease cancellation was the appropriate remedy. A general discussion of the subject of remedies in this context is outside the scope of this Article.

### B. FIELDWIDE OPERATIONS

Recently, the Texas Supreme Court handed down a decision that undoubtedly will materially impact the judicial realm in which the prudent operator must function. *Amoco Production Co. v. Alexander*[41] was an action for damages by the Alexanders, royalty owners in the Hastings West Field, Brazoria County, Texas, against Amoco, the lessee-operator, because of fieldwide drainage.[42] The field is a nonhorizontal water drive reservoir.[43] The leases located in the higher part of the reservoir are known as "updip leases"[44] and, conversely, those located in the lower part, as were the Alexanders' leases, are "downdip leases."[45] The natural conditions inherent in such a field, once the production of oil commences, operate to the disadvantage of the downdip leases because the oil-water contact rises updip as the reservoir is produced. Water being heavier than oil, the downdip wells are the first to water out.[46] Amoco held eighty percent of the field production. Exxon, Amoco's chief competitor in the field, held leases that lay between Amoco's updip leases and the downdip Alexander leases.[47]

The Hastings West Field began producing in 1934 and as of 1979 was producing 75,000 barrels of oil daily.[48] In 1969 Amoco commenced a large-scale "plug-back"[49] program, which resulted in greater production from the field's higher producing sands and greater acceleration of the updip migration of oil.[50] In the same year the Alexanders contacted Amoco to complain about the decline in production on their leases and to suggest that offset operators were doing a better job of producing their leases. Amoco responded that they could do nothing about the situation.[51] Four

41. 622 S.W.2d 563 (Tex. 1981).

42. Amoco Prod. Co. v. Alexander, 622 S.W.2d 563, 565 (Tex. 1981).

43. *Id.* at 566. The field "is highest (closer to the surface) in the southeast part. It is lowest in the northwest. Hence, the reservoir dips downward gradually from the southeast to the northwest." *Id.*

44. An updip well is a "well located high on the structure where the oil is nearest the surface of the field." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 805.

45. A downdip well is a "well located low on the structure where the oil is furtherest from the surface of the field." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 201.

46. Amoco Prod. Co. v. Alexander, 622 S.W.2d at 566.

47. *Id.* It may be significant to note that the Alexander leases were burdened with a one-sixth royalty whereas Amoco's updip leases were only subject to a one-eighth royalty. *Id.* at 566, 569.

48. *See* Amoco Prod. Co. v. Alexander, 594 S.W.2d 467, 472 (Tex. Civ. App. 1979), *aff'd as modified,* 622 S.W.2d 563 (Tex. 1981). *See* 12 ST. MARY'S L. J. 600 (1980) (an analysis of *Amoco*).

49. Plugging is the "sealing off of the fluids in the strata penetrated by a well, so that the fluid from one stratum will not escape into another or to the surface." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 552.

Amoco's "plug-back" program was " 'the standard practice' of producing from the lowermost sand in the reservoir first and then 'plugging-back' to successively higher sands as the portion of the well bore penetrating the lower sand became watered out." Amoco Prod. Co. v. Alexander, 594 S.W.2d at 472.

50. 594 S.W.2d at 472.

51. *Id.* at 479.

years later the Alexanders again contacted Amoco complaining that their leases had suffered a dramatic drop in production from 9000 barrels to 1900 barrels per month. They also drew attention to the fact that Exxon's leases had improved their production. Amoco again stated that it intended to take no corrective action.[52]

Subsequently, the Alexanders filed suit alleging damages from Amoco's failure to rework existing wells and failure to drill replacement wells on the extreme updip portion of their leases.[53] Drilling the replacement wells would have required Amoco to obtain an exception from the Texas Railroad Commission to the well spacing rules applicable to the field. Such an exception is traditionally granted upon a showing that it is necessary to prevent waste or to protect the applicant's property from confiscation.[54] The Commission had previously granted Exxon and Amoco twenty-two exceptions for the field.[55] Amoco had never applied for any such exceptions on the Alexander leases.[56]

In a case of first impression, the Texas Supreme Court, affirming the judgment of the district court and the court of civil appeals,[57] held that Amoco had the duty as a reasonably prudent operator to protect the Alexander leases against fieldwide drainage.[58] The court stated: "The duties of a reasonably prudent operator to protect from field-wide drainage may include (1) drilling replacement wells, (2) re-working existing wells, (3) drilling additional wells, (4) seeking field-wide regulatory action, (5) seeking Rule 37 exceptions from the Railroad Commission, (6) seeking voluntary unitization, and (7) seeking other available administrative relief."[59]

Amoco's unsuccessful position in the litigation was, generally, that no fieldwide duty to protect against drainage exists. While admitting an obligation to protect against local drainage, Amoco understandably argued that any broader duty would affect all leases in the field, requiring each operator to drill fieldwide protection

52. *Id.*

53. *Id.* at 470.

54. *Id.* at 475; 622 S.W.2d at 569.

55. 622 S.W.2d at 570. An "exception well" is a "well authorized or drilled as an exception under the applicable well spacing rule." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 246. In Texas the "statewide well spacing rule of the Texas Railroad Commission" is rule 37. *Id.* at 668. "Rule 37 itself provides for two exceptions: (1) to prevent the confiscation of property, and (2) to prevent waste." *Id.* at 669.

56. 622 S.W.2d at 569.

57. Actually, the supreme court reversed the grant of exemplary damages to the Alexanders, but in all other material respects it affirmed the judgment below. *Id.* at 572.

58. *Id.* at 568.

59. *Id.* While the case seems chiefly to have arisen under the implied covenant to protect against drainage, the nature of the duties listed by the Texas Supreme Court also implicates the development covenant. As in *Waseco,* the proof of prudent operations is a mixture of elements from more than one implied covenant.

wells.[60] Amoco concluded that a chain reaction would ensue, resulting in the acceleration of fieldwide drainage.[61] The argument appears to have merit. If each lessee drilled the offset wells to which he was entitled or which he was obligated to drill, the result would be accelerated production at a greater cost. Yet this scenario would do nothing to prevent the natural water drive of the oil updip; updip wells would still obtain the structural advantage.[62]

Amoco also argued that the only feasible method of mitigating fieldwide drainage is through fieldwide regulation by the Railroad Commission.[63]

> [T]he imposition of implied covenants in leases on a case by case basis is an inefficient and unjust way to go about it. The more orderly and only valid way is through the regulatory authority of the Texas Railroad Commission in regulating rates of production for the purpose of protecting correlative rights in a field.[64]

Amoco denied that any duty existed under Texas law to seek administrative relief by applying to the Railroad Commission for exceptions to the well-spacing regulations.[65] If such a duty were imposed on Amoco, it would be placed in an inherent conflict between its updip and downdip lessors, with each demanding further inefficient and uneconomical drilling.[66]

Finally, it appears from the opinion of the court of appeals that Amoco also argued that even if the duty to prevent fieldwide drainage existed as a general principle, the particular replacement wells sought would not be "economically worthwhile" because allowables on the updip wells would be transferred, in part, to the new downdip wells.[67] This, in effect, was an argument tied to fieldwide profitability.

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60. *Id.* at 567-68.

61. *Id.* at 568.

62. *Id.* The opposite situation would occur if one allowed downdip operators and lessors to recover all their oil in place prior to any of it migrating updip. After such recovery, the other operators would produce their leases progressively updip. This method does not appear feasible since updip operators would be required to shut-in their production until the oil-water contact had risen to the downdip boundary of their lease. This method would do away with the Rule of Capture, along with depriving updip lessees and lessors a timely return on their capital. *Cf.* 5 WILLIAMS & MEYERS, *supra* note 4, § 822.4, at 102-03 (profit incentive in Rule of Capture assumes drainage of other leaseholds).

63. 622 S.W.2d at 568.

64. Application for Writ of Error of Amoco Prod. Co. at 27, Amoco Prod. Co. v. Alexander, 622 S.W.2d 563 (Tex. 1981).

65. 622 S.W.2d at 569-70.

66. *Cf.* 12 ST. MARY'S L. J. 600, 608 (1980) (prudent operation of updip leases could require Amoco to challenge any application for exception well).

67. 594 S.W.2d at 479.

In finding such arguments unpersuasive, the Texas Supreme Court properly "began at the beginning" by positing the prudent operator standard as the touchstone and reasoning as follows: "[B]ecause of the complexity of the oil and gas industry and changes in technology, the courts cannot list each obligation of a reasonably prudent operator which may arise. The lessee must perform any act which a reasonably prudent operator would perform to protect from substantial drainage."[68] "Oil lost by field-wide drainage is just as lost as local drainage oil."[69] The prudent operator would prevent such a loss by drilling replacement wells if it could be demonstrated that such wells probably would be profitable under the traditional standard of proof.[70] The Alexanders were able to prove that an operator could have drilled replacement wells and reworked existing wells at a "handsome profit."[71]

In the same fashion the court looked to the prudent operator standard in finding a duty to seek an exception to the well-spacing requirements for the replacement wells to be drilled on the Alexander leases.[72] The court upheld the jury's determination that a prudent operator, under the circumstances, would have applied for the exceptions.[73] Perhaps the court and jury further reasoned that this *duty* to seek administrative relief only balanced Amoco's *right* to such relief,[74] particularly given the evidence that since 1975 Exxon and Amoco had been granted twenty-two rule 37 permits in the same fault block section of the field.[75]

In an equitable vein, the court indicated concern over Amoco's inherent conflict of interest as common lessee:

> The Alexander leases provided for 1/6th royalty while Amoco's updip leases provided for 1/8th royalty. There is no economic incentive for Amoco to increase production on the Alexander lease because it will eventually recover the Alexander's oil updip. Money invested in the Hastings, West Field, will have a longer productive life if invested updip. The greater the updip production the sooner Amoco's competitor Exxon will water out. Money

68. 622 S.W.2d at 568.
69. *Id.*
70. *Id.* (citing Clifton v. Koontz, 160 Tex. 82, 96-97, 325 S.W.2d 684, 695-96 (1959)).
71. 594 S.W.2d at 479.
72. 622 S.W.2d at 569-70.
73. *Id.* at 570.
74. *Cf.* Ramsey v. Carter Oil Co., 74 F. Supp. 481, 482 (E.D. Ill. 1947), *aff'd*, 172 F.2d 622 (7th Cir. 1949) (discussion of right and duty to adopt proper gas repressuring systems).
75. 622 S.W.2d at 570.

> spent updip will yield greater returns than money spent downdip because of higher daily production. With downdip operators out of production Amoco can produce its upper sands without competition and can begin production from its lower sands where it does not have significant production competition.[76]

The court, in effect, found that Amoco had placed itself in an untenable position by having to play both ends against the middle.

Perhaps more interesting are the aspects of the court's opinion relating to the duties to seek voluntary unitization and available fieldwide regulatory action.[77] Although pronouncements of such duties are clearly dicta, the prudent operator would be well served to bear them in mind. In fact, as to the situation in *Amoco* itself, one writer has observed:

> [T]he plaintiffs might even have enhanced their entitlement to damages by proof that the field could and should have been unitized (if in fact that had been possible), since a unitized participation in the field production would have endured as long as oil was produced from the reservoir through wells on any lease in the field, not merely the plaintiffs' leases.[78]

Does the Amoco case stand for the principle that a reasonably prudent operator has the duty to unitize to develop and protect his leasehold? Again, over thirty years ago, Professor Merrill stated with his customary vision:

> The extraction process in a unitized field is not foreign to the development and operative processes. All are parts of a unified scheme of development, designed to promote the efficient, economic and conservative exploitation of the resources in the pool or field. The unitization merely undertakes to make possible the sort of exploitation which would have been possible if the land, or the subsurface rights, had been in single ownership from the beginning of the oil and gas industry.[79]

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76. *Id.* at 569.

77. *Id.* at 568.

78. Hoffman, *Pooling and Unitization,* in ADVANCED OIL GAS & MINERAL LAW COURSE D-1½ (State Bar of Texas Course, Oct. 1981). *See* 12 ST. MARY'S L. J. 600, 605, 608-10 (1980).

79. Merrill, *Unitization Problems: The Position of the Lessor,* 1 OKLA. L. REV. 119, 126 (1948). *See* 6 WILLIAMS & MEYERS, *supra* note 4, § 935; Eckman, *Statutory Fieldwide Oil and Gas Units: A Review for*

As indicated previously, Amoco argued that the only plausible solution to its dilemma was a fieldwide approach.[80] At first glance and as the court recognized in dicta, one fieldwide approach would be voluntary unitization in the primary phase of recovery.[81] Because of the natural structural advantage of the updip leases, however, any unitization allocation formula would be doomed to fail without crediting this advantage. Downdip leases would presumably have to be credited for the additional reserves that would have been recovered by drilling replacement wells. All parties would have to be convinced that recovery of additional reserves at additional profits could be assured. While the possibility for achieving such a result might seem doubtful, the number of unitization agreements that have been successfully negotiated suggests that this approach is plausible in many circumstances, or at the least, that a prudent operator will have the occasion to investigate the feasibility of unitization.[82]

Another idea implicit in the court's mention of fieldwide regulatory relief[83] would entail petitioning the regulatory body for fieldwide allowable adjustments. Any such approach would necessitate a formula that essentially would aim at the same allocation and rate of production as the unitization formula, although without the same complexities.

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*Future Agreements,* 6 NAT. RESOURCES LAW. 339 (1973); Hardy, *Drainage of Oil and Gas from Adjoining Tracts — A Further Development,* 6 NAT. RESOURCES J. 45, 48-49, 51 (1966); McDonald, *Unit Operation of Oil Reservoirs as an Instrument of Conservation,* 49 NOTRE DAME LAW. 305 (1973); Merrill, *Implied Covenants, Conservation and Unitization,* 2 OKLA L. REV. 469, 478 (1949); Merrill, *The Modern Image of the Prudent Operator,* 10 ROCKY MTN. MIN. L. INST. 107, 124-25 (1965); Comment, *Prospects for Compulsory Fieldwide Unitization in Texas,* 44 TEX. L. REV. 510 (1966).

Professor Merrill's observation in 1948 was simultaneously echoed by an American Bar Association Committee of the Section of Mineral Law:

> It is only through unit operation that the logical and complete application of present technical knowledge of oil and gas conservation can be accomplished. It is only through unit operation of a common source of supply that individual property rights can be fully protected. It is only through unit operation that the maximum recovery can be achieved and the maximum rate of daily production maintained.

CONSERVATION OF OIL AND GAS, A LEGAL HISTORY (B. Murphy ed. 1948), *quoted in* 1 R. MYERS, THE LAW OF POOLING AND UNITIZATION § 2.06, at 58 (2d ed. 1967).

80. It is interesting to note that while Amoco claimed the only solution to the problem was fieldwide regulatory action, at the same time it argued that it had no duty to pursue administrative relief from well-spacing requirements. 622 S.W.2d at 569-70. The court apparently saw the contradiction when it set out a duty to seek fieldwide relief. *Id.* at 568.

81. 622 S.W.2d at 568.

82. Of course statutory unitization, which Texas lacks, would greatly increase the likelihood of unitization in this instance. Amoco did not hesitate to remind the court of this fact:

> The difficulty is compounded by the fact that any solution to the problem must necessarily be of field-wide application. Further difficulty is added by the fact that Texas has no statute authorizing compulsory field-wide unitization. . . . Thus the Commission lacks the necessary authority to even begin to resolve the problem properly.

Motion for Rehearing of Petitioner Amoco Prod. Co. at 9, Amoco Prod. Co. v. Alexander, 622 S.W.2d 563 (Tex. 1981).

83. 622 S.W.2d at 568.

Within the context of fieldwide operations, then, the prudent operator must take into consideration the development of the field. This includes protecting leaseholds from substantial fieldwide drainage, which may entail seeking exceptions to spacing regulations, petitioning for fieldwide regulatory relief, or initiating unitization.

## III. THE IMPLIED COVENANT TO EXPLORE FURTHER

One of the most interesting and much debated of the covenants implied in oil and gas leases is the covenant of further exploration. This covenant imposes a duty of additional drilling on a leasehold in potentially productive strata that have not yet been proved, when, under the circumstances, the failure to so drill is unreasonable.[84] Professors Williams and Meyers, the leading proponents of the covenant of further exploration, list the following as among the relevant circumstances for inquiry:

> (1) the period of time that has elapsed since the last well was drilled;
>
> (2) the size of the tract and the number and location of existing wells in relation thereto;
>
> (3) the existence on the land of untested geological formations favorable to the accumulation of hydrocarbon substances;
>
> (4) the attitude of the lessee toward further testing of the land, and his operations on the land and elsewhere in the vicinity in this regard;
>
> (5) the feasibility of further exploratory drilling, including the cost of drilling, the market for the product, and the size of the block needed to justify a test well;
>
> (6) whether part of the leasehold is excluded from a production unit so that the lease is being preserved thereon without the payment of royalty for such acreage or the conducting of operations thereon.[85]

The lessor claiming breach of the covenant need not show that the proposed additional exploratory well[86] probably would produce oil

84. 5 WILLIAMS & MEYERS, *supra* note 4, § 841, at 258-59.

85. 5 WILLIAMS & MEYERS, *supra* note 4, § 841, at 259-60.

86. An exploratory well is a "well drilled in unproven or semi-proven territory for the purpose of ascertaining the presence underground of a commercial petroleum deposit." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 256.

or gas in commercial quantities,[87] unlike the lessor demanding that a development well[88] be drilled in a proven formation.[89]

The covenant to explore further, originally formulated by Professor Charles J. Meyers in 1956,[90] is "segregated from the covenant of reasonable development and separately labelled."[91] It has not been accepted by all courts and commentators.[92] Recently, the Oklahoma Supreme Court considered a proposal to adopt the covenant in Oklahoma in an important case, *Mitchell v. Amerada Hess Corp.*[93]

*Amerada Hess* involved consolidation of eighteen cases brought to cancel several twenty-three year old oil and gas leases situated in two townships in Ellis County, Oklahoma.[94] Plaintiffs alleged that exploration in the general area indicated the presence of numerous potentially productive formations under the leaseholds, that defendants had failed to explore the formations, and that the leases were being held by marginal production for speculation.[95] The trial court found that twelve years had lapsed without further drilling to explore deeper formations.[96] The trial court ruled that all but one of the defendants had breached an implied covenant to explore after first production.[97] It also decreed that the leases would be cancelled as to all strata below the base of the producing formation unless the defendants in breach commenced or participated in the drilling of a single well to test the deeper Hunton Formation by July 1, 1979,[98] approximately nine and one-half months from the date of the trial court's judgment.[99]

On direct appeal to the Oklahoma Supreme Court, the issue was stated and restated as follows:

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87. 5 WILLIAMS & MEYERS, *supra* note 4, § 841, at 259, 263.

88. A development well is a "well drilled to a known producing formation in a previously discovered field as distinguished from a wildcat, or exploratory, well and from an offset well." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 186. *See infra* note 115 for the definition of a wildcat well.

89. *See* 5 WILLIAMS & MEYERS, *supra* note 4, §§ 843.3, 843.5, at 307-08. The authors state that "[t]he party having the burden of proving that a well will produce in paying quantities must show that drilling is more likely than not to result in commercial production." *Id.* § 843.5, at 307-08.

90. *See* Meyers, *The Implied Covenant of Further Exploration*, 34 TEX. L. REV. 553 (1956). *See also* Meyers, *The Covenant of Further Exploration: A Comment*, 37 TEX. L. REV. 179 (1958).

91. 5 WILLIAMS & MEYERS, *supra* note 4, § 841, at 263.

92. *See, e.g.*, Clifton v. Koontz, 160 Tex. 82, ____, 325 S.W.2d 684, 696 (1959); 2 E. BROWN, THE LAW OF OIL AND GAS LEASES § 16.05 (2d ed. 1973); Merrill, *The Implied Covenant for Further Exploration*, 4 ROCKY MTN. MIN. L. INST. 205 (1958). For further articles on the covenant of further exploration, see the authorities cited in 5 WILLIAMS & MEYERS, *supra* note 4, § 841, at 261 n.6.

93. 638 P.2d 441 (Okla. 1981). *See* Pickerill, *Is There a New Implied Covenant of Explorvelopment?*, 31 INST. ON OIL & GAS L. & TAX'N 245, 279-81 (1980) (discussion of the trial court's decision in *Amerada Hess*).

94. Mitchell v. Amerada Hess Corp., 638 P.2d 441, 442 (Okla. 1981).

95. *Id.* at 443.

96. Pickerill, *supra* note 93, at 279.

97. Mitchell v. Amerada Hess Corp., 638 P.2d at 443.

98. *Id.*

99. Pickerill, *supra* note 93, at 279 n.99.

> [I]s an action maintainable in this jurisdiction to cancel a lease for failure to further explore a lease premises during a period in which paying production is had from the lease premises.
> . . . The ultimate issue resolving these appeals is the question of the existence of an implied covenant to further explore.
> . . . The issue is: would a prudent operator, having due consideration for the interest of both the lessee and lessor, considering all factors, including what is known about the market, the geology and adjoining activity, drill the proposed well.[100]

The court rejected the proposed covenant, holding that "there is no implied covenant to further explore after paying production is obtained, as distinguished from the implied covenant to further develop."[101] Unfortunately, some passages of the case are ambiguous and contain faulty reasoning, leaving doubt as to the precedential effect of the decision.

First, the opinion demonstrates confusion as to the analysis of potential profit under the covenant of further exploration. The court accurately states that Professor Meyers "proposes that the profit motive is to be deemphasized in determining whether a reasonably prudent operator would drill a well to previously unknown sources. . . ."[102] Then, however, the court repeatedly appears to claim that Professor Meyers' formulation not only deemphasizes, but ignores, the issue of profit:

> Failure to recognize the profit motive as an instrumental force in oil and gas leases on behalf of both lessee and lessor is to ignore the very essence of the contract. . . . Meyers' formulation of the proposed implied covenant ignores the potential for profit. . . . Can the duties of the lessee be judged apart from the spectre of profit where the activity is judged exploration rather than development? To do so is unwise and unnecessary. . . . It is simply not realistic to ignore profit as a consideration of the standard of a prudent operator simply because the lessor demands a wildcat be drilled on a productive lease rather than an additional well to a productive formation.[103]

100. 638 P.2d at 444, 446-47.
101. *Id.* at 449.
102. *Id.* at 446. The *Amerada Hess* court's statement is accurate if, by deemphasizing the profit motive, the court means that Meyers proposes not to require proof of a *likelihood* of profit.
103. *Id.* at 447. The Oklahoma Supreme Court is not the only authority to overstate Professors

These excerpts from *Amerada Hess* do not accurately capture the approach taken by Professors Williams and Meyers on the profitability issue. Profitability is not ignored and at least is implicit in the evidence they suggest should be offered concerning the demanded drilling; that is, evidence going to the size of the leasehold, the favorable nature of any untested geological formations, the lessee's exploratory testing operations on the leasehold and in the area, the cost of drilling, the market for the product, and the size of the lease block needed to justify a test well.[104]

While evidence of favorable geological prospects "falls far short of proof that a well will probably produce oil or gas in commercial quantities . . . it does show that there is some degree of possibility that an exploratory well will be successful."[105] Continuing this analysis, Professors Williams and Meyers state:

> The difference is one of probabilities. The party having the burden of proving that a well will produce in paying quantities must show that drilling is more likely than not to result in commercial production. In order to establish breach of exploration covenant, this degree of probability is not required. Taken together with other circumstances showing that further delay in exploratory drilling is unreasonable, it is enough that some possibility of securing commercial production exists.[106]

The other factors also point in varying degrees of probability to the chances for a successful well. Of course, the size of the leasehold and the size of a lease block needed to justify a test well relate principally to developmental drilling in the event the

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Williams and Meyers' position on profitability. *See* Williams, *Implied Covenants in Oil and Gas Leases: Some General Principles*, 29 U. KAN. L. REV. 153 (1981). Williams states that "[i]t is paradoxical that the covenant of further exploration is governed by the prudent operator standard but, purportedly, dispenses with any requirement of profitability." *Id.* at 174. Nevertheless, Williams' article is an excellent analysis of implied covenants from the perspective of the discipline of economics. *See also* Williams, *Implied Covenants for Development and Exploration in Oil and Gas Leases — The Determination of Profitability*, 27 U. KAN. L. REV. 443 (1979).

104. 5 WILLIAMS & MEYERS, *supra* note 4, § 841, at 259-60.

105. 5 WILLIAMS & MEYERS, *supra* note 4, § 843.5, at 305.

106. 5 WILLIAMS & MEYERS, *supra* note 4, § 843.5, at 307-08. In a similar vein, the same authors discussed a standard frequently seen in further exploration cases:

> The standard of "a reasonable expectation of profit to the lessee" is one that lessors can meet in exploration cases if "reasonable expectation" is defined in light of the fact that the wells the lessor seeks are exploratory wells. In short, a prudent operator could have a reasonable expectation of profit from a test well where the geological prospects for discovering new production were favorable.

*Id.* § 845.6, at 358. *See id.* § 847, at 383 (a discussion of probabilities of success).

exploratory well proves successful. The degree of exploratory prospecting also is concerned, in part, with potential for a profitable test. Cost of drilling and market demand are clearly factors in assessing payout. Thus, the element of profit has not been ignored by Professors Williams and Meyers.[107]

A more serious problem in the *Amerada Hess* decision concerns its lack of clarity in stating what degree of profitability *is* required. In lieu of the covenant of further exploration, the Oklahoma court states firmly that the covenant to further develop is sufficiently flexible to resolve issues such as those raised in *Amerada Hess:*

> The machinery to adjudicate an "exploration" controversy exists presently in the form of the covenant to diligently develop. The element of chance in achieving a profit from any given drilling project is invariably present and varies from a development situation to an exploration only in its magnitude. The probability of a productive well is a consideration presently existing in actions to further develop, and the need for a new rule to supplant further development litigation in cases where the odds of profitability are low is to apply two rules of law to the same legal issue. . . . *To say as Meyers does that the covenant to further develop requires the operator to drill only those wells which must pay for themselves and pay a profit to boot is thus overly restrictive.*[108]

Had the *Amerada Hess* court stopped there, it would be tempting to say that form had triumphed over substance; that what was sought by way of postulating a covenant of further exploration was given in the name of the covenant of further development. The above language clearly incorporates Williams and Meyers' previously quoted thesis that the "difference is one of probabilities."[109] Moreover, the *Amerada Hess* admonition that "all factors" must be considered, including "the market, the geology, and adjoining activity"[110] is consistent with Williams and Meyers' inquiry into the reasonableness of the actions of the operator in all the circumstances.

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107. Professor Stephen Williams' explanation of an operator's reason for undertaking a wildcat well that is more likely than not to be a dry hole incorporates risk-weighting, that is, weighing possible outcomes by their probabilities. Included is the premise that a producing well will produce income from itself and from wells drilled upon the basis of its success. *See* Williams, *Implied Covenants in Oil and Gas Leases: Some General Principles,* 29 U. KAN. L. REV. 153, 174 (1981). Williams and Meyers' factors would seem to implicitly point toward such a risk-weighted analysis.

108. 638 P.2d at 447 (footnote omitted) (emphasis added).

109. 5 WILLIAMS & MEYERS, *supra* note 4, § 843.5, at 307.

110. 638 P.2d at 447.

Yet the *Amerada Hess* court did not hesitate to reject the further exploration covenant, and in doing so raised questions by contradicting its earlier statements: "[T]he covenant . . . [of further exploration] is substantially served by the covenant for further development as it is interpreted in this jurisdiction while limiting the duty to drill additional wells to those instances where a prudent operator would expect a probability of potential profit from the well contemplated."[111] The court then added a cryptic footnote reading as follows: "In this regard it is necessary to distinguish between probable expectations regarding this well and the statistical figures for the industry."[112]

The effect of the above pronouncements is that those claiming that an exploratory well need not be drilled, as well as those demanding it be drilled, now can argue either that, under the covenant for further development, proof of profitability is or is not required. On the one hand, the opinion rejects the covenant of further exploration, ignoring the element of profitability, and relies instead upon the covenant of further development and its traditional requirement of probable profit.[113] On the other hand, the court suggests that one should not interpret the covenant of further development in an "overly restrictive" fashion requiring that the operator drill only those wells proven capable of commercial production.[114]

Placing the decision's ambiguities in the context of the further exploration doctrine, including the case law and the extensive commentary, we believe that *Amerada Hess* should be read as a rejection of the covenant for further exploration in favor of a covenant for further development. This covenant, in Oklahoma, takes into account the fact that exploratory wells, from wildcats[115] to step-outs[116] to development wells in "spotty" fields, are

111. *Id.* at 449 (footnote omitted).

112. *Id.* at 449 n.3. The *Amerada Hess* court "decline[d] to state that the issue of probable profit is not a relevant consideration in an action to cancel a lease for failure to further develop thus creating an action to cancel for failure to further explore." *Id.* at 448. This statement can be read to mean one of at least three things, all in the context of a covenant of further development. First, that a requirement of proof of probable profit is retained in all exploratory drilling requests. Second, that the issue of probable profit, while relevant, is not a mandatory component of the showing required in exploratory drilling requests, and third, that probable profit is an element in further development actions and there is, therefore, no action to cancel for failure to further explore. The last option is clearly a *non sequitur.*

113. *Id.* at 447, 449.

114. *Id.* at 447.

115. A wildcat well is an "exploratory well being drilled in unproven territory, that is, in a horizon from which there is no production in the general area. Since the meaning is vague, it should be observed that some wells are more wildcat than others." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 834.

116. A step-out well is a "well drilled adjacent to a proven well but located in an unproven area; a well drilled 'step-out' from proven territory in an effort to ascertain the extent and boundaries of a producing formation." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 724.

traditionally less than "probably profitable," yet are promising enough to require testing. Testing includes, as it did in *Amerada Hess,*[117] use of modern exploratory methods with time enough to plan, budget, implement, and evaluate the results.[118] Based upon those test results, the covenant for further development under *Amerada Hess* may require drilling a prospect, either a single test well or a series of exploratory wells.[119] In the event it is determined that a prospect well should be drilled, the court should give due regard for the investment decision of the current lessee in fashioning the decree. For example, the period of time in which the lessee must drill or lose the lease should be long enough to accommodate corporate budgets and personnel deployments.[120]

Despite the confusing nature of the *Amerada Hess* opinion, the above reading would accommodate the facts and the court's emphasis on the predominant analytical inquiry, the question of profitability. It would also be consistent with the court's result, and yet factor in worthwhile components of the Williams and Meyers' approach.[121] Nevertheless, until the Oklahoma Supreme Court construes its most recent addition to the large body of case law on further exploration efforts, there will be no comfortable degree of certainty in the minds of lessors and lessees facing similar factual circumstances.

## IV. SCOPE OF THE COVENANTS AS REFLECTED IN INDUSTRY PRACTICES TODAY

*Waseco, Amoco,* and *Amerada Hess* are interesting reminders of the continued use of implied covenants in disputes between lessors

117. One participant in the *Amerada Hess* litigation described evidence of exploratory activities offered by the defendants as "voluminous and uncontested showing sizeable expenditures by various parties as recently as within one year prior to the litigation and at varying intervals for many years prior." Pickerill, *supra* note 93, at 280 n.100.

118. Presumably because of the rejection of the covenant of further exploration, the *Amerada Hess* court accepted what was apparently an invitation by plaintiffs' counsel to treat their petition and the record on appeal as urging cancellation of the leases under the traditional covenant to further develop. The court found that the defendants were justified in continuing to test the deeper prospects, particularly in light of the fact that the plaintiffs themselves would require further testing and because the plaintiffs were not able to demonstrate that immediate drilling would take place if the leases were cancelled. 638 P.2d at 450.

119. In *Amerada Hess* the trial court required the drilling of a single test well only. *Id.* at 443. On cross-appeal, plaintiffs argued that a well should be drilled on each lease premises. *Id.* The issue became moot because of reversal of the trial court's holding that any well should be drilled. *Id. Cf.* Sinclair Oil & Gas Co. v. Masterson, 271 F.2d 310, 323, 325 (5th Cir. 1959), *cert. denied,* 362 U.S. 952 (1960) (appellate court affirmed the trial court's conditional decree ordering a five year drilling program requiring six wells to be drilled per year for failure to exercise reasonable diligence in exploring 90,000 acres under lease).

120. *See generally* Williams, *supra* note 107, at 167-68 (discussion of "entrepreneurial capacity" of lessee and capital acquisition costs in the context of the lessee's failure to adopt the lessor's likely profitable proposal).

121. Note Williams and Meyers' opinion of Clifton v. Koontz, 160 Tex. 82, 325 S.W.2d 684 (1959), which rejected, at least in name, the covenant for further exploration. "It thus appears that

and lessees over the prudence of the latter's actions.[122] They are good examples, too, of the increasingly sophisticated nature of the prudent operator's world today. The variety, complexity, and magnitude of industry operations will undoubtedly create further litigation of a novel or pressing nature. A brief examination of current and future industry activities, particularly in the realm of onshore enhanced recovery as defined herein, should assist interested observers and practitioners in understanding the state of the art as practiced by the prudent operator.[123]

### A. WATERFLOODING

Waterflooding[124] is the most widely used method of enhanced recovery, which, one source claims, had its origins in the 1870s.[125] By 1973 approximately one-half the production of our domestic oil came from reservoirs affected by waterflooding.[126] Continued use of waterflooding is assured. The prudent operator has been alert to its use and will continue to be so. Moreover, given the experience gained over the years, the advancements in field and laboratory technology, increasing use of computer simulation, and improved economics, fields never before considered for waterflooding are now candidates for this method of secondary recovery.

One recent example is the formation of the North Hobbs Unit in Lea County, New Mexico.[127] The Hobbs Grayburg - San Andres Pool underlies a substantial part of the city of Hobbs, New Mexico. It is one of the state's oldest producing pools and is a

an exploration obligation may exist in Texas law but that it must . . . be denominated as an implied covenant to reasonably develop. . . . [A]t least the case does not preclude the granting of relief for failure to explore under the proper circumstances." 5 WILLIAMS & MEYERS, *supra* note 4, § 845.6, at 358. The *Amerada Hess* court cited the *Koontz* decision as support for its rejection of the covenant of further exploration on the ground that Texas, like itself, found that the covenant of further exploration rejected an expectation of profit as an essential element in the exploratory drilling analysis. 638 P.2d at 447, 449 (citing Clifton v. Koontz, 160 Tex. 82, 325 S.W.2d 684 (1959)).

122. *See generally* M. MERRILL, COVENANTS IMPLIED IN OIL AND GAS LEASES (2d ed. 1940). *See also* 5 WILLIAMS & MEYERS, *supra* note 4, § 801, at 1 (continued vitality of law of implied covenants is reflected in "a steady flow of litigation and a rising tide of legal literature").

123. For previous comment in this area, see Merrill, *The Modern Image of the Prudent Operator,* 10 ROCKY MTN. MIN. L. INST. 107 (1965); Pickerill, *Is There a New Implied Covenant of Explorvelopment?,* 31 INST. ON OIL & GAS L. & TAX'N 245, 288-89 (1980); Roark, *Advancing Technology and the Relationship Between the Lawyer and the Engineer,* 19 INST. ON OIL & GAS L. & TAX'N 143 (1968); Comment, *Secondary Recovery of Oil & Gas — The Rule of Positive Dominion,* 9 LAND & WATER L. REV. 457 (1974).

For histories of petroleum technology, see EXECUTIVE COMM. ON DRILLING & PROD. PRACTICE, DIV. OF PROD., AM. PETROLEUM INST., HISTORY OF PETROLEUM ENGINEERING (1961); 1946-1965 NAT'L PETROLEUM COUNCIL, IMPACT OF NEW TECHNOLOGY ON THE U.S. PETROLEUM INDUSTRY (1967).

124. Waterflooding is "[o]ne method of secondary recovery in which water is injected into an oil reservoir for the purpose of washing the oil out of the reservoir rock and into the bore of a producing well." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 821.

125. NOYES DATA CORP., ENHANCED OIL RECOVERY: SECONDARY AND TERTIARY METHODS 19 (1978) [hereinafter cited as NOYES DATA CORP.].

126. *Id.*

127. New Mexico Oil Conservation Comm'n Case Nos. 6652, 6653 (1979).

northwest-southeast trending anticline about eight miles long and three and one-half miles wide. Discovered in 1928, the pool was producing by 1930 about 1,000,000 barrels of oil per month from 135 wells. As a result of continuing operations, the producing capacity of most wells tapered off. By 1975, bottom-hole pressures for most wells had declined, in many cases to as little as one-third of their initial bottom-hole pressures.

In 1970 Amoco initiated efforts to unitize the entire pool for the purpose of instituting a waterflood, but had to abandon its efforts in 1973 when working interest owners could not agree on a participation formula.[128] When Amoco abandoned its efforts, Shell undertook the effort to unitize the northern portion of the pool (the North Hobbs Pool or the pool). All operators in the North Hobbs Pool were invited to a meeting in 1973 at which time a Working Interest Owners' Committee and a Technical Committee were formed. The Technical Committee was comprised of engineering representatives from all the working interest owners. The committee undertook the task of determining the feasibility and profitability of instituting a pressure maintenance project and concluded that such a project would result in enhancing the recovery of the pool by fifty-five million barrels of oil, in addition to the remaining primary recovery of more than thirty-three million barrels. The committee proceeded deliberately in completing its study, not going forward until there was a substantial majority consensus on each issue before it. Otherwise, the committee feared there might be no more opportunities to unitize the field due to its depleted state.

The pool was exceedingly complex, consisting of various oil producing horizons overlain by a gas cap. The pool covered more than 10,000 acres and had 88 separate tracts with 905 royalty owners and 80 working interest owners sharing interests in the pool. Moreover, the pool was old and, therefore, contained many open hole completions. The completion and production histories of many wells were lacking or incomplete.[129] Furthermore, the upper portion of the San Andres formation had experienced water influx, which made estimating its reserves nearly impossible.

After numerous meetings over a span of four years, the

128. Nevertheless, Amoco succeeded in forming a voluntary unit which comprised the southern third of the pool and which became effective January 1, 1975. Certain lessees refused to join, which left some "windows" in the unit, but waterflood operations were nevertheless undertaken with respect to the participating leases. A "window" is a "term used to describe an unsigned interest affecting a pooled or unitized area." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 835.

129. For example, logs, core samples, and other technical data were missing on many of the wells in the pool.

committee came to substantial agreement and completed its Technical Report, which set forth estimates of remaining primary and secondary oil and gas reserves on a tract by tract basis. In establishing these estimates, the committee divided the pool into six different study zones corresponding to the various producing horizons, each possessing different structural characteristics and production data. Because of the complexity, customary engineering approaches were deemed inadequate to meet the task. With the consent of the Working Interest Owners' Committee, the Technical Committee proceeded to employ a computerized reservoir simulation model developed by Shell. Each working interest owner was afforded the opportunity to participate in the application of the model to the reservoir data, projected waterflood development, and respective ownership interests. The results of the computer simulation were accepted by over eighty percent of the members of the Technical Committee. The Technical Report also contained estimates of the total investment required for the water injection project and the total expected profit on a discounted basis with and without unitization.

In May 1977 the committee submitted the Technical Report to the Working Interest Owners' Committee, which accepted the report as accurate and as a basis for unitization negotiations. The Working Interest Owners' Committee then undertook the task of developing a participation formula for the approximately 1,000 mineral interest owners in the pool. At least seventy-five percent of the mineral owners had to approve the formula before an application for statutory unitization of the pool could be made to the New Mexico Oil Conservation Commission. Various formulas were proposed by several of the participants.

The participation formula, which included cost sharing, divided primary and secondary recovery into three phases. The first phase encompassed the period of time until acceleration of the primary recovery by the waterflood. The second phase covered accelerated recovery of the primary reserves, and the third phase covered the recovery of the remaining reserves. Benefits to be gained by those owners who mainly had primary reserves were equitably weighted with those owners whose remaining reserves were principally secondary. The participation formula adopted eventually received eighty-five percent approval of the working interest owners.

A major operator in the field remained doggedly recalcitrant, thereby forcing Shell to bring the matter to a hearing before the

New Mexico Oil Conservation Commission. The operator complained that the participation formula did not allocate its fair share of oil reserves in the pool and unjustly burdened it with the costs of the project. Evidence showed that this operator had placed submersible pumps on some of its wells in the field, thereby accelerating its primary production in the pool. This action was undoubtedly a legitimate course of action until unitization was effectuated, but it provided an unconvincing challenge to the validity of the computer simulation's reserve estimates. Nine years after first efforts at unitization, the entire Hobbs Grayburg-San Andres was unitized.[130]

### B. PRESSURE MAINTENANCE

Pressure maintenance refers to the injection of gas, water, or other fluids into reservoirs to maintain or bolster reservoir pressure to enhance the recovery of the hydrocarbons.[131] Substantial increases in primary recovery of the original oil in place can be achieved with a program of pressure maintenance, which is implemented prior to the loss of the natural or formation pressure.[132] For years, prudent operators have been alert to the need for such programs.

### C. INFILL DRILLING

Infill drilling in the context of enhanced recovery is drilling a well or wells within a standard spacing unit in addition to the original well drilled on that unit.[133] Regulatory approval is generally required and, when obtained, permits the operator to escape the handicap of a reduced allowable.[134] Some sources indicate that infill drilling will play an increasingly important role in production of domestic reserves.[135] In any event, the prudent

130. *See* New Mexico Oil Conservation Comm'n Case Nos. 6652, 6653 (1979).

131. WILLIAMS & MEYERS, TERMS, *supra* note 12, at 567.

132. NOYES DATA CORP., *supra* note 125, at 18.

133. An infill well has also been defined as a "well drilled on an irregular pattern disregarding normal target and spacing requirements." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 362.

134. An allowable is the "amount of oil (or gas) which a well, leasehold, field, or state is permitted to produce under production orders of a state regulatory commission." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 26-27.

In secondary recovery projects operators may apply for infill drilling orders to permit the drilling of an infill well. *Id.* at 362. "The IW order [infill well drilling order] will specify one minimum allowance for each developed drilling spacing unit irrespective of the number of wells that are drilled in it." *Id.*

135. One authority estimates that recovery from infill drilling in the Gulf and West Texas Basins will approximately equal the ultimate conventional recovery of 51 billion barrels. Fisher, *Oil in Texas Yesterday Today,* TIPRO REP., Fall 1981, at 10, 13. Other experts postulate that if infill drilling is properly done, it will produce at least as much oil as has been produced by primary

operator will seek out answers to the feasibility of infill drilling and, when justified, obtain the necessary regulatory approval.

Illustrative are the two infill drilling programs initiated by the El Paso Natural Gas Company in the Blanco Mesaverde and Basin Dakota Pools in San Juan and Rio Arriba Counties, New Mexico.[136] When the New Mexico Oil Conservation Commission considered El Paso's request for permission to drill infill wells in the Blanco Mesaverde Pool, there were already approximately 2,055 wells under production on 900,000 acres. The pool was operated on spacing units of 320 acres. Original proven reserves for the existing wells were estimated to be 8.665 trillion cubic feet. Cumulative production at the time of the hearing was approximately 3.723 trillion cubic feet.

El Paso, based upon its experience with the pool, had concluded that one well would not adequately drain a 320 acre unit. Specifically, it believed the pool to be more heterogeneous than it was originally understood to be.[137] To test drainage three test wells were drilled, shut-in, and not allowed to produce. Through these wells El Paso could make a determination of any decline in pressures, which would indicate probable drainage by offsetting wells. While some drainage apparently did occur, its relative insignificance convinced El Paso of the soundness of its preliminary conclusions. El Paso was also encouraged by developments in completion techniques over the years, particularly advances in well fracturing.[138]

Some of the other operators in the pool were less convinced of the merits of El Paso's proposal. El Paso's dual status as producer and purchaser complicated the matter, but the strongest disagreement concerned whether additional wells would increase estimated reserves in place. If the reserves could not be increased, additional wells could possibly drain offsetting premises and accelerate recovery of the reserves at a substantial and unwarranted cost. A shortage of tubular goods and a relative unavailability of

methods. Van Everdingen & Kriss, *A Proposal to Improve Recovery Efficiency*, 32 J. OF PETROLEUM TECH. 1164, 1164 (July 1980). The latter authorities claim that the combination of infill drilling and waterflooding for pressure maintenance can increase average recovery efficiency to at least 50%. Van Everdingen & Kriss, *Why Can't We Get More Oil From the Ground?*, DRILL BIT, May 1981, at 102, 110.

136. New Mexico Oil Conservation Comm'n Cases 5264, 6533 (1974, 1979).

137. El Paso believed that the pool had a good degree of lensing, including variation in the areal extent of the lenses, and that it had significant variations in permeability and porosity.

Lensing is the "thinning out of a stratum in one or more directions." U.S. DEP'T OF THE INTERIOR, A DICTIONARY OF MINING, MINERAL AND RELATED TERMS 636 (P. Thursh ed. 1968) [hereinafter cited as U.S. DEP'T OF THE INTERIOR]. A lens is a "relatively porous, permeable, irregularly shaped, sedimentary deposit surrounded by impervious rock. The lens may serve as a local center of concentration of oil in the formation." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 396.

138. Fracturing is a "process of breaking a fluid-bearing strata by injecting a fluid under such pressure as to cause partings in the strata rock." U.S. DEP'T OF THE INTERIOR, *supra* note 137, at 460.

drilling rigs heightened the operators' fears that those who could drill the fastest would obtain an unfair advantage. Moreover, the infill program might subject the offset operators to burdensome demands by lessors, under the implied and express covenants of their leases, for drilling protection wells unjustified by prudent operation or for payment of unjustified compensatory royalties. There was also disagreement over regulatory treatment of prices on gas from the new wells to be drilled, the amount of a discount factor, if any, to be applied to the projected returns, cost of drilling and operating the new wells, the estimation of a reasonable rate of return in the face of the cost of capital, and the effect of deploying that capital and equipment inventory in this pool rather than on other projects.

The New Mexico Conservation Commission heard the evidence, decided in favor of El Paso, and infill drilling commenced. Five years later, El Paso again returned to the Commission with another application for infill drilling, this time in the deeper Basin Dakota Pool, which was located in the same basin as the Blanco Mesaverde Pool. Uncontested expert testimony on El Paso's behalf established, to the Commission's satisfaction, the viability of the proposed drilling. Estimated original recoverable reserves had been placed at five trillion cubic feet. Projected additional recoverable reserves were set at four to four and one-half trillion cubic feet. El Paso supported its position, in part, by preliminary indications of successful infill drilling in the Blanco Mesaverde Pool, increased sophistication in reservoir analysis from the earlier infill drilling experience, and an improved economic climate for natural gas.

Another operator joined in supporting El Paso's request based upon its own analysis, including sophisticated computer simulation and test drilling. The computer analysis included use of log and core data and net pay, water saturation, and porosity and permeability figures from seventy-eight existing wells chosen from throughout the pool. The analysis yielded projections of future performance, including calculations showing the time and rates of production, cumulative production, and reservoir pressure. It demonstrated that the drainage pattern for wells with a fifty year life was approximately 163 acres. This sophisticated generation of technical data persuasively argued in favor of infill drilling. What originally seemed farfetched to many operators proved to be quite prudent upon close examination.[139]

139. While the examples of Shell's waterflood and El Paso's infill drilling programs are somewhat dramatic owing to the scope of the projects and the magnitude of effort put into them, the principle remains the same for a project of any size: if data and technology are developed which

## D. THERMAL PROCESSES

Thermal processes involve methods of increasing recovery of low gravity crude oil by heat application.[140] Heat is applied to the reservoir to reduce the viscosity of the oil, activate a solution gas drive in certain circumstances, create increased relative permeability by thermal expansion of the oil, create distillation and, in certain cases, induce thermal cracking of the oil.[141] Two basic methods are used, steam injection and combustion methods. Steam injection is the most advanced and widely used of the tertiary recovery methods.[142] It can be either cyclic, when the steam is injected and the reservoir is allowed to "soak" before the heated oil flows back (the "huff and puff" method), or steam drive, with continuous injection of steam by injection wells and withdrawal of the displaced oil by production wells (steamflooding).[143] Combustion methods, or fireflooding, as exemplified in the *Waseco* case,[144] involve injecting hot air into the reservoirs to cause ignition of the hydrocarbons with heat and gases, which move the oil to the production wells.[145]

Steamflooding was responsible for recovering 300,000 barrels of oil per day from over 40,000 acres in 1980 and it is projected to recover 1 to 1.5 million barrels per day from 110,000 to 180,000 acres in 1991.[146] Projected additions to domestic recoverable reserves by use of steamflooding have been estimated at approximately nine to ten billion barrels.[147] While fireflooding is not expected to produce nearly as much otherwise unrecoverable hydrocarbons as steamflooding,[148] developments still continue. For example, Texaco recently announced a pilot fireflood project in Louisiana, which, it was estimated, could lead to an additional ultimate recovery of ten to fifty million barrels of heavy oil from its Louisiana acreage in the next ten years.[149] Given an estimated 150 thermal projects underway in 1980,[150] there is no doubt this area of

indicate feasibility and profitability, then the prudent operator must proceed or risk being held accountable by the lessor.

140. WILLIAMS & MEYERS, TERMS, *supra* note 12, at 769.

141. NOYES DATA CORP., *supra* note 125, at 65.

142. OFFICE OF TECHNOLOGY ASSESSMENT, CONGRESS OF THE U.S., ENHANCED OIL RECOVERY POTENTIAL IN THE U.S. 27 (1978) [hereinafter cited as OFFICE OF TECHNOLOGY ASSESSMENT].

143. *Id.*

144. Waseco Chem. & Supply Co. v. Bayou State Oil Corp., 371 So. 2d 305 (La. Ct. App.), *cert. denied,* 374 So. 2d 656 (La. 1979).

145. OFFICE OF TECHNOLOGY ASSESSMENT, *supra* note 142, at 28-29.

146. *See Big EOR Production Hike Seen From Chemicals,* 79 OIL & GAS J., Aug. 17, 1981, at 74-75. *See also* INTERNATIONAL PETROLEUM ENCYCLOPEDIA 246 (1981).

147. NOYES DATA CORP., *supra* note 125, at 76.

148. *See* NOYES DATA CORP., *supra* note 125, at 80-81; OFFICE OF TECHNOLOGY ASSESSMENT, *supra* note 142, at 27, 45.

149. *Texaco Plans Louisiana Fireflood,* 79 OIL & GAS J., Mar. 9, 1981, at 59.

150. *See* INTERNATIONAL PETROLEUM ENCYCLOPEDIA 251 (1981).

enhanced recovery will receive further attention by the prudent operator.

### E. CARBON DIOXIDE MISCIBLE FLOODING

One of the most promising new techniques in the field of enhanced recovery is carbon dioxide miscible flooding. "Miscible processes are those in which an injected fluid dissolves in the oil it contacts, forming a single oil-like liquid that can flow through the reservoir more easily then [sic] the original crude."[151] Because of the likelihood of extensive use of carbon dioxide in future enhanced recovery, a more elaborate summary follows.[152]

Carbon dioxide that has been compressed enough for injection into the tiny pore spaces of the rock where oil remains trapped is often nearly as dense as the oil itself. At such conditions, the carbon dioxide dissolves well in the oil. For instance, at pressures (2,000 pounds per square inch) and temperatures (100 degrees Fahrenheit) typical of oilfields in New Mexico and west Texas, carbon dioxide will occupy a third of the volume of a mixture of oil saturated with dissolved carbon dioxide. In other words, dissolved carbon dioxide swells the oil, expanding its volume by about fifty percent. Thus, tiny droplets of trapped oil expand as carbon dioxide dissolves in them, and they become easier to displace to a producing well. Oil that contains dissolved carbon dioxide moves more easily through the porous rock because it is much less viscous than the same oil containing no carbon dioxide.

Furthermore, when carbon dioxide mixes with oil, it not only dissolves efficiently, it also extracts hydrocarbons from the oil into the remaining carbon dioxide. The resulting mixture of carbon dioxide and hydrocarbons does a better job of displacing oil than carbon dioxide alone. On a laboratory scale, the displacement process can be very efficient. If the pressure is high enough, carbon dioxide can recover all but three to five percent of the oil remaining after a waterflood.

In actual oilfields recoveries will be lower, because it is more difficult to control large scale movements of fluids in the multilayered reservoir rocks than it is in small laboratory size rock samples. Also, low viscosity carbon dioxide may not sweep all the reservoir rocks because it is difficult to push a thick fluid with a thin

151. OFFICE OF TECHNOLOGY ASSESSMENT, *supra* note 142, at 29.

152. The textual information concerning carbon dioxide miscible flooding is based chiefly upon materials supplied to the authors by Dr. F.M. Orr, Head, Miscible Flood Research, Petroleum Recovery Research Center, New Mexico Institute of Mining and Technology.

one. Indeed, the principal technical problem with carbon dioxide flooding is the prevention of early breakthrough of carbon dioxide into the producing wells, an indication that only part of the oil reservoir was swept. Because of these difficulties, typical estimates are that approximately twenty-five percent of the oil remaining after waterflooding can be recovered. In any event, oil companies are betting billions of dollars that enough oil can be recovered by carbon dioxide flooding to justify pipelines to carry carbon dioxide from natural reservoirs in southwest and southeast Colorado and in northeast New Mexico to the large oilfields of the Permian Basin in western Texas and southeastern New Mexico. Another pipeline is scheduled to be constructed from Big Piney, Wyoming over 500 miles to the Powder River and Williston Basin fields of Wyoming, Montana, and North Dakota. Countless smaller projects are also underway or in the planning stages, including many whose source of carbon dioxide is the industrial smokestack.

Detailed assessments of the economics involved in carbon dioxide flooding are difficult to make because prices of carbon dioxide and the amounts required are still uncertain. Estimates of the amount of carbon dioxide required to produce a barrel of oil vary widely, from four to twenty thousand cubic feet at standard surface conditions, which is equivalent to about two to nine barrels of carbon dioxide at reservoir conditions. Estimates of the cost of carbon dioxide also vary widely, though most fall into the range of $1.00 to $3.50 per thousand cubic feet. Thus, the cost of carbon dioxide alone will be large.

In 1980 approximately 79,000 barrels per day of domestic crude oil were attributable to the use of carbon dioxide and other gases in the miscible flooding process.[153] Naturally, projections of ultimate recoveries vary. One study, using a 1978 assumption of $22 per barrel of crude oil, concluded that 8.5 to 16.3 billion barrels would be recovered by the year 2000.[154] It is clear, then, that in certain fields prudent operations may dictate that carbon dioxide pilot projects be implemented, to be followed, when justified, by full scale operations.[155]

### F. SURFACTANT-POLYMER FLOODING; MICELLAR OR MICROEMULSION FLOODING

The newest and most complex of the enhanced recovery

153. *See* INTERNATIONAL PETROLEUM ENCYCLOPEDIA 246 (1981).

154. OFFICE OF TECHNOLOGY ASSESSMENT, *supra* note 142, at 42.

155. Some cautious operators in the Permian Basin have in fact been negotiating for commitments of carbon dioxide reserves for eventual use on their wells.

processes is surfactant-polymer flooding, also known as microemulsion or micellar flooding.[156] Some consider the technique to possess the greatest long-term potential for recovering significant amounts of tertiary oil.[157] This type of flooding relies on detergent-like chemicals or surfactants (surface active agents) to reduce the surface tension between the water and the oil. These chemicals are comprised of molecules which, on one end, are repelled by water, and on the other, attracted to it. The oil is thus organized into droplets called micells, which are much smaller than normal oil particles, and therefore move much more easily through the formation. The oil and surfactant slug is then driven toward production wells by injected water which has been treated by polymers to effectively match the water to the slug.[158] Because of the present experimental nature of surfactant-polymer flooding, estimates of recovery capability vary widely. One source predicts 1.4 million barrels per day by 1996[159] and another predicts from 1.3 to 2.5 million barrels per day by 2000.[160] The first source predicts that nine billion barrels of tertiary oil will be recovered through surfactant-polymer flooding over a thirty year period.[161]

### G. MASSIVE HYDRAULIC FRACTURING OF TIGHT GAS BASINS

Massive hydraulic fracturing is "a newly developing, large-scale application of fracturing techniques"[162] that, where applied successfully, converts otherwise noncommercial tight gas formations[163] into profitable production.[164] One report estimates that up to 7.7 trillion cubic feet of gas could be produced annually by 1990 at prices of $4.50 per million cubic feet.[165] Another government report states boldly that "[e]nhanced gas recovery, primarily by massive fracturing of tight sands, is projected to be the

156. OFFICE OF TECHNOLOGY ASSESSMENT, *supra* note 142, at 31.
157. NOYES DATA CORP., *supra* note 125, at 56.
158. OFFICE OF TECHNOLOGY ASSESSMENT, *supra* note 142, at 31.
159. NOYES DATA CORP., *supra* note 125, at 63 (Lewin and Assocs., Inc. prediction).
160. OFFICE OF TECHNOLOGY ASSESSMENT, *supra* note 142, at 41.
161. NOYES DATA CORP., *supra* note 125, at 63 (Lewin and Assocs., Inc. forecast).
162. NOYES DATA CORP., UNCONVENTIONAL NATURAL GAS 35 (1980).
163. Tight gas is gas found in sands of such low permeability that commercial production has not generally been possible without extensive formation stimulation. *Id.* at 4-5. The low permeability, or resistance to flow, is 5 to 2,000 times greater than typical oil and gas producing formations. *Id.* at 6. Tight gas sands also vary from single, thin gas-bearing beds of generally uniform thickness to multiple, lens-shaped sands interbedded with clays and shales. *Id.* The San Juan Basin, which includes the Basin Dakota and Blanco Mesaverde reservoirs, contains tight, blanket gas sands. *Id.* at 57.
164. *See id.* at 4-7, 23-97 (discussion of tight gas basins).
165. *Id.* at 5 (noting Lewin and Assocs. 1978 Report of Enhanced Recovery). A large portion of such production would likely be from blanket sands formations where, owing to more favorable reservoir conditions, industry has already achieved considerable production. *Id.*

major source of natural gas in 2020."[166] As technology develops and natural gas prices increase, the prudent operator will be in the forefront of enhanced gas recovery.

### H. EXOTICS

Brief reference should be made to certain potentially viable techniques that indicate the space-age possibility of enhanced recovery. One such technique, not proven successful, utilizes underground nuclear explosions to fracture the formation, thereby increasing recovery of hydrocarbons.[167] Another possible method employs microorganisms, particularly bacteria, to bring about beneficial reactions in a petroleum reservoir. These reactions include gas production and a possible repressurizing of the reservoir, production of substances that act on the surface of the formation rock to release hydrocarbons, production of solvents to alter the oil's viscosity and raise its gravity, selective plugging of portions of a formation by microorganism growth and cell division, production of polymers by microorganisms to provide a polymer drive, and production of acids to favorably alter formation characteristics.[168]

### I. ADVANCING EXPLORATORY TECHNOLOGY

Several years ago one successful independent pithily described the predicament of the prudent operator as an explorationist in modern times: "Economic necessity has precluded the shotgun and demanded the rifle."[169] The same individual also identified the techniques that he had come to use as his ammunition: seismic geophysical prospecting, geochemical prospecting, microgravity analysis, electromagnetics, aerial and satellite photography, infrared photography using various color techniques, and airborne radiation surveys.[170] Moreover, once drilling has commenced,

166. 3 ENERGY INFORMATION ADMIN., DEP'T OF ENERGY, 1980 ANNUAL REPORT TO CONGRESS 172.

167. *See* NOYES DATA CORP., *supra* note 125, at 82-85. *See also* Roark, *supra* note 123, at 159 (noting joint El Paso Natural Gas Co. and federal government "Gasbuggy" project utilizing 26 kiloton nuclear device).

168. *See* DEP'T OF ENERGY, CONTRACTS FOR FIELD PROJECTS AND SUPPORTING RESEARCH ON ENHANCED OIL RECOVERY AND IMPROVED DRILLING TECHNOLOGY, PROGRESS REVIEW NO. 27, 127 (1981) (entitled "Development of a Procedure for the Microbiological Evaluation of a Petroleum Reservoir"). *See also* Wall Street J., Sept. 2, 1981, at 39, cols. 3-4, in which the optimistic prediction is made by Edward Lanphier, director of International Resources Development, Inc., Norwalk, Connecticut, that microbial oil recovery may achieve four billion barrels per year, or over ten million barrels per day, with tangible results seen in the 1990s. *Id.*

169. Kidd, *An Independent's Experience With Various Exploration Techniques,* 13 EXPLORATION & ECON. OF THE PETROLEUM INDUS. 99, 108 (1975).

170. *Id.* at 100-08.

exploration does not end. Standard of Indiana has developed a camera three inches in diameter and twelve feet long, which films formations for photographic examination on the surface.[171] Also, Arco is experimenting with an oil rig capable of curving the drill pipe at five degrees per foot drilled. Horizontal drilling is thereby achieved within eighteen feet and, it is hoped, can be continued for some distance.[172] The list of techniques is seemingly endless and continues to grow.[173] To the extent an implied covenant of further exploration exists in any jurisdiction, the examination of a lessee's actions will include an analysis of his good faith and sophistication in pursuing modern exploratory methods.

## V. CONCLUSION

For many years, conflicts surrounding the oil and gas lease have been discussed, debated, and litigated. Implied covenants, unwritten promises by the lessee, have been involved in their share of these disputes. Because every lessee, by entering the lease contract, will be held to a promise to act in accordance with the standards of the industry, the prudent operator will continue to be the measure of a lessee's performance in any such dispute.[174]

Given an industry that has been a stimulus for change in this century, the propagation of a large number of cases and a good deal of commentary comes as no surprise. *Waseco,*[175] *Amoco,*[176] and *Amerada Hess*[177] are recent examples of the vitality of the implied covenants and the prudent operator. Without claiming to be hallmarks, they demonstrate that the prudent operator continues to adapt to changing circumstances. In each case a workable result was attained. In each case a problem of enhancing gain from natural resources was brought forth and resolved.

It is interesting, perhaps instructive, to draw some further conclusions from the common elements of these three factually different disputes. In *Waseco* the issue of profitability was not explicitly resolved. Yet, as discussed previously, the approach of

171. Wall Street J., Feb. 12, 1982, at 29, col. 4.

172. *Id.*

173. *See generally* NOYES DATA CORP., GEOPHYSICAL AND GEOCHEMICAL TECHNIQUES FOR EXPLORATION OF HYDROCARBONS AND MINERALS (1980) (description of exploratory techniques based on United States patent literature).

174. *See* Merrill, *Implied Covenants and Secondary Recovery,* 4 OKLA. L. REV. 177, 193 (1951). *See also* M. MERRILL, COVENANTS IMPLIED IN OIL AND GAS LEASES §§ 221-223, at 464-74 (2d ed. 1940). In 1940 Professor Merrill predicted that the implied covenants would retain their vitality because of the relation between the parties to an oil and gas lease. *Id.* § 227, at 480-81.

175. Waseco Chem. & Supply Co. v. Bayou State Oil Corp., 371 So. 2d 305 (La. Ct. App.), *cert. denied,* 374 So. 2d 656 (La. 1979).

176. Amoco Prod. Co. v. Alexander, 622 S.W.2d 563 (Tex. 1981).

177. Mitchell v. Amerada Hess Corp., 638 P.2d 441 (Okla. 1981).

the court in resolving the issue apparently produced the correct result.[178] *Waseco* did not foreclose further definition of an operator's ability to economically employ current technology in the enhanced recovery of hydrocarbons. At the same time, the case fulfilled a longstanding prophecy that a lessor can require the operator to carry out secondary recovery operations.[179] Paradoxically, the subject matter of the lawsuit was not waterflooding, which had been discussed and practiced as a means of prudent operation for many years. Instead, a comparatively exotic form of recovery, fireflooding, was required. Several other methods of enhanced recovery following original development of a reservoir have been utilized for years without one lawsuit culminating in a decree that any such method must be performed. This fact speaks well for the competitive nature of the oil and gas industry and its ability to confront and resolve disputes before they reach the judicial forum. In this regard also, the talent and expertise of the conservation regulators of the industry should not be overlooked.[180]

Although *Waseco* and *Amoco* were not factually concerned with unitization, both cases draw into question a duty to unitize.[181] Apart from the uncommon situation in *Waseco* in which secondary or tertiary recovery does not involve unitization, one who relies upon *Waseco* to require enhanced recovery will, as a practical matter, have to address the duty to unitize. *Amoco,* too, will be relied upon to address the same question. If a prudent operator attempts unitization, the Texas courts will probably enforce the unitization demand by the operator-lessor.

*Amoco* holds that an operator must protect leaseholds clearly defined as subject to fieldwide drainage.[182] The lessor bears the burden of proof that drainage is substantial and that the proposed additional operations would, more likely than not, be profitable.[183] A lessor can now obtain relief from an operator's refusal to seek exceptions to the general spacing regime when it can be demonstrated that a prudent operator would have sought such

178. *See supra* notes 39-40 and accompanying text.

179. Waseco Chem. & Supply Co. v. Bayou State Oil Corp., 371 So. 2d at 306-07. *See supra* notes 25-28 and accompanying text.

180. Other reasons for the paucity of cases concerning secondary recovery are the sophisticated technical assistance which a lessor must obtain, the fact that the operator is in control of most of the critical data, and the obvious expense entailed in bringing such a lawsuit. *Cf.* 5 WILLIAMS & MEYERS, *supra* note 4, § 861.3, at 431 (litigation rare due to the crushing burden of proof). On the other hand, lessors over the years have also developed sophistication and the means to apply it. Perhaps the conjunction of the three cases discussed herein in a short period of time is not coincidental.

181. *See* Amoco Prod. Co. v. Alexander, 622 S.W.2d at 568; Waseco Chem. & Supply Co. v. Bayou State Oil Corp., 371 So. 2d at 312-13.

182. 622 S.W.2d at 568.

183. *Id.*

exceptions.[184] Other forms of administrative relief undoubtedly will be required under appropriate circumstances if the attention of a court is called to the *Amoco* decision. Finally, the *Amoco* court's enumeration of possible actions required of a prudent operator[185] lends strength to the lessor who, faced with an apparently novel situation, believes that the lessee has not acted in a manner conducive to the interests of both.

A more difficult question arises when a lessor advocates requiring exploration of wildcat acreage, either lateral acreage, new depths, or a combination of the two. The issue of profitability is central in this type of *Amerada Hess*[186] situation. Lessors will have to be as sophisticated in their approach to this issue as a reasonable explorationist.[187] In *Amerada Hess* the absence in plaintiffs' proof of an operator ready, willing, and contractually bound to drill was significant.[188] Perhaps more important was the ability of the defendants to point to substantial exploratory activities undertaken by them in the area.[189] This evidence apparently included the use of computers and testimony regarding the price of the potential product.[190] Such good faith actions by the lessee indicate that the correct result was ultimately reached.

Although just another in a long line of cases concerning further exploration under leases held by production, *Amerada Hess* should be carefully scrutinized, given the increasing importance of exploring formations at greater depths. It was apparent to the Oklahoma Supreme Court that the existing lessees were intent on enhancing the recovery of yet to be discovered hydrocarbons. Presumably the hydrocarbons were there, although the precise location in which to commence discovery by drilling had not been ascertained. Although the *Amerada Hess* opinion lacks clarity, one can read the case to allow demands for further exploration in the future, without penalizing the prudent operator in the exploratory realm.

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184. *Id.* at 570.

185. *Id.* at 568.

186. *See* Mitchell v. Amerada Hess Corp., 638 P.2d 441 (Okla. 1981).

187. Such sophistication is shown in new leases by the increasing use of depth rights clauses, Pugh clauses, and continuous development commitments, but that is no consolation for the many lessors whose minerals have long been held by production. Nor is a legislative remedy likely to be of assistance. *See* 52 OKLA. STAT. ANN. § 87.1(b) (West Supp. 1981) (statutory Pugh clause).

A Pugh clause is "[t]he name given to a type of pooling clause which provides that drilling operations on or production from a pooled unit or units shall maintain the lease in force only as to lands included within such unit or units." WILLIAMS & MEYERS, TERMS, *supra* note 12, at 602. *See also* Kuntz, *Statutory Well Spacing and Drilling Units,* 31 OKLA. L. REV. 344, 349-51 (1978); Pickerill, *Is There a New Implied Covenant of Explorvelopment?,* 31 INST. ON OIL & GAS L. & TAX'N 245, 270-73 (1981).

188. 638 P.2d at 450.

189. *See* Pickerill, *supra* note 187, at 280.

190. *See* Pickerill, *supra* note 187, at 280.

As all three of these cases indicate, we are likely to see increasing sophistication by the lessor in requiring a lessee to carry out activities pursuant to the oil and gas lease. The issues of profitability and technological feasibility will undergo continued refinement. Yet words written over thirty years ago still hold true today:

> We shall be conscious of the fact that the lessors' income from the mineral wealth still is dependent upon the diligence and skill with which the operations are carried on. . . . We shall be mindful that the law wisely declines to let one be the final judge of his own rights and obligations. . . . [W]e shall expect that the implied covenant principle will continue to have vitality in the judicial disposition of the disputes which are bound to arise. We shall expect that the applications of this principle will be modified to suit the new and altered conditions upon which it operates. We shall be prepared to see some applications disappear entirely because the circumstances which evoked them no longer exist. We shall look for the development of the new law of implied covenants in the same way in which the old law developed, through the decision of controversies by the courts as they are presented in concrete litigation.[191]

The industry has performed well and, in the emerging context of enhanced recovery, will continue to do so. On the occasion that operations do not attain the level of reasonableness proved to be the industry standard, invocation of the implied covenants will be an important avenue of redress.

191. Merrill, *Implied Covenants and Secondary Recovery*, 4 OKLA. L. REV. 177, 193-94 (1951) (footnotes omitted) (discussing unitization and implied covenants).