Oil Exploration and Development in the North Dakota Williston Basin: 1996-1997 Update

By Thomas J. Heck

MISCELLANEOUS SERIES NO. 85
North Dakota Geological Survey
John P. Bluemle, State Geologist
1998

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Cover Photograph: **Marmath Gas Processing and Gathering Facility**

In June 1996, Bear Paw Energy Inc. contracted with Burlington Resources Oil and Gas Company to construct and operate a natural gas gathering, treating, and processing system in Bowman and Slope counties, North Dakota, to support its Red River "B" production.

The initial project was the construction of a gas gathering system comprised of sixteen miles of ten inch diameter pipe to gather natural gas from approximately 75 wells at four common points at a maximum delivery rate of approximately 3.5 MMcfd (million cubic feet per day). Also included in the gathering system was a dry gas return system designed to redeliver processed gas back to the well sites for lease equipment operations.

At the north end of the gathering system, a compression, treating, and processing facility was constructed in the NW/4NW/4 of Section 36, T131N-R106W, Slope County, North Dakota. It was operational in the fourth quarter of 1996. This facility is comprised of an inlet compressor, which compresses gas from 5 psig to 750 psig in four stages for treating and processing, as well as providing the energy to enter the gas sales pipeline which is owned and operated by Williston Basin Interstate Pipeline.

After compression, the gas is sweetened using a patented batch type process for selectively removing hydrogen sulfide gas (H_2S). The H_2S contaminated gas flows through the product and chemically reacts with the material converting the H_2S into iron pyrite or "fools gold." This leaves the resulting gas stream free of H_2S and it is termed "sweet" or "treated" and ready for further processing.

The gas is then routed through a processing plant to lower the temperature of the gas to approximately -10°F. By lowering the temperature, removable hydrocarbons (ethane, propane, butane, and gasoline) are condensed into a liquid state and sent to storage for further processing or fractionation at another site. The remaining gas stream is commonly called residue or dry gas (as the liquid has been removed), and is put into the sales pipeline or returned to the field for lease use.

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INTRODUCTION

This update summarizes oil exploration and development of the 1980s and 1990s, but focuses on the events of 1996 and 1997. The 1980s saw many changes in North Dakota's oil industry. The decade began with domestic oil industry activity at record highs in response to the Arab oil embargo and subsequent rapid price increases during the late 1970s. Record high crude oil prices were reached during the early 1980s, but crude oil prices began to decline. Exploration had increased during the 1970s, but began to decrease in response to the lower prices of the early 1980s. Many had thought that prices had hit bottom in 1985, but overproduction by OPEC caused oil prices to fall even further in 1986. By the end of 1997 the domestic oil industry had seemingly reached a stable condition with relatively constant oil prices, but drilling in North Dakota is currently far below the levels seen during 1980-1981. Many of the wells drilled over the last two years were in Cedar Hills Field in Bowman County where wells were drilled horizontally in the Red River "B" porosity. Without the activity in this field there would have been fewer wells drilled in the state during 1996 and 1997.

Data included in this report are primarily from the files of the North Dakota Industrial Commission Oil and Gas Division. Additional data were provided by the State Tax Department, the State Land Department, Amoco Oil Company, and Saskatchewan Energy and Mines. Help from these sources is gratefully acknowledged. Interpretations of the data, however, are my own. Following the precedent set in the 1988-1989 Update (Heck, 1990), the historical overview of exploration in North Dakota before 1980, included in many earlier updates, has been dropped. The reader is referred to Fischer and Bluemle (1988) for this information. For those readers unfamiliar with abbreviations used in this report (Table 1) lists those most commonly used in this report.

1980-1989

The oil-industry entered the 1980s with activity at record levels, both nationally and in North Dakota. Oil prices were high, averaging $28 per barrel in North Dakota (Fischer and Bluemle, 1988), and operators aggressively pursued new plays and prospects. State lease sales brought record revenues (*Figure 1*) and tax revenues doubled from 1979 (*Figure 2*). Of the nearly 600 wells drilled in North Dakota during 1980 (*Figure 3*), 182 (31%) were wildcats (*Figure 4*). There were 84 new-pools discovered (*Figure 5*) and production rose to 40,354,030 BO, a second consecutive annual record (*Figure 6*).

Table 1

BO	Barrel(s) of oil. One barrel equals 42 U.S. gallons
BOPD	Barrels of oil per day. Daily production rate of an oil well
BW	Barrel(s) of water
BWPD	Barrels of water per day
MCF	One thousand cubic feet of natural gas
MCFPD	Thousand(s) of cubic feet of gas per day
Oil Pool	One or more oil wells producing from a single zone
Oil Field	One or more wells producing oil from one or more pools
Wildcat	A well drilled more than one mile from existing oil production

The records set during 1980 fell in 1981 as the "oil boom" peaked in North Dakota. New records of 834 total wells drilled, 267 wildcats drilled, and 102 new-pools discovered were set. The

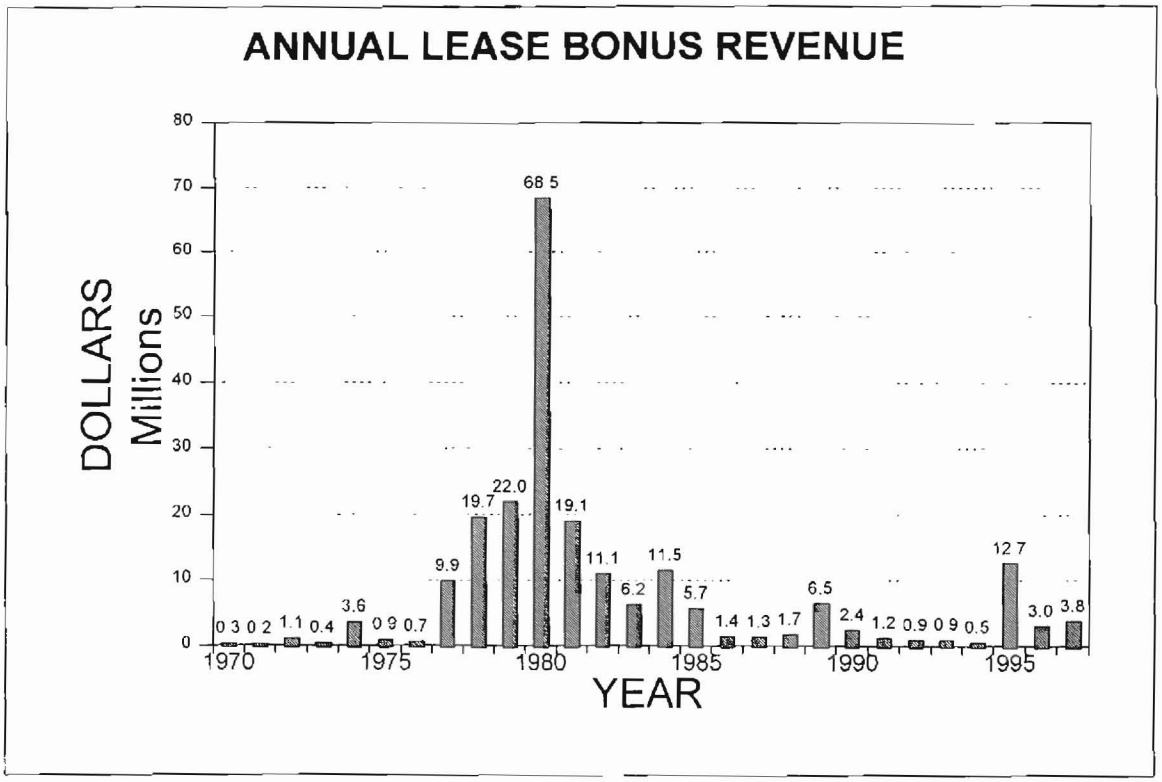

Figure 1. Bar diagram of annual state lease sale revenue in North Dakota for the period 1970 to 1997. (Source: N. D. State Land Dept.).

1980 annual production record was surpassed in 1981 with 45,706,999 BO produced, setting a third straight annual production record. State revenues increased as the new extraction tax began generating its first revenue (*Figure 2*). Together, the extraction and production taxes supplied more than 20 percent of the state's collections in 1981, the first year the extraction tax was in place (*Figure 7*).

The oil industry could not maintain a high level of activity after oil prices began to slip during 1982. However, oil production and tax revenues continued to climb despite reduced drilling because the drilling emphasis shifted toward developing existing fields and away from exploring. Another reason for the continued increase in tax revenue is that there is a one-to three-year lag between the discovery and peak production from an oil field. In general, the larger the field the longer the lag because the number of wells required to develop the field increases. Many fields discovered during 1980 and 1981 did not reach peak production until 1982 to 1984.

Oil prices continued to decline during 1983, further reducing drilling. Wildcat drilling (*Figure 4*) was one-third of 1981 levels, reflecting the lower oil prices, but development drilling remained high. Oil production continued to rise, as did tax revenues (*Figures 2 & 6*). Both wildcat and development well drilling rose slightly during 1984 (*Figures 3 & 4*) and oil production in North Dakota reached its all-time high of 52,654,336 barrels (*Figure 6*). Despite record production volumes, tax revenues declined for the first time since 1973 because of lower oil prices (*Figure 2*). Drilling resumed its decline during 1985 as oil prices slid further and began to fluctuate. Overproduction by OPEC caused a rapid price drop in early 1986 (*Figure 8*), with prices falling below $10 a barrel for certain types of crude oil. Drilling plummeted and oil companies began to downsize and reduce spending in response to lower crude oil prices and uncertainties about future prices. The impact on North Dakota's oil industry was a drop in

drilling and a decrease in the number and size of oilfield service companies. Many either went bankrupt and closed their doors or moved out of state to cut costs.

From mid-1986 through early 1987, crude oil prices rose gradually and a modest increase in drilling occurred between mid-1987 and early 1988. Although the number of wells spudded increased during the second half of 1987, activity during the first half was so low that only 190 wells were drilled during the year (*Figure 3*). In 1988, drilling jumped sharply to 255 wells. Part of the increase was the result of development drilling in Wabek Field, an important new oil field discovered along the Mississippian Sherwood subinterval shoreline. During 1989, another important field, Plaza Field, was discovered near Wabek Field and development of the field began. Plaza Field produces from the Bluell subinterval, which immediately overlies the Sherwood subinterval. Sperr, et al. (1993) estimate ultimate recoveries of six to eight million barrels from Wabek Field and 3.5 million barrels from Plaza Field. These two fields are the largest Madison fields discovered during the late 1980's.

From 1986 through 1991, between two and three hundred wells were usually drilled each year except during 1987 and 1989 when drilling dropped below 200 wells, recording the lowest numbers of wells drilled since 1974 (*Figure 3*). Between 35 and 67 of the wells drilled annually were wildcat wells during this period. For example, 67 of the 190 total wells drilled in 1987 and 35 of the 188 wells drilled in 1989 were wildcats. The number of wells drilled annually decreased steadily from 1990 until 1995 when a slight increase occurred. Wildcat drilling also decreased, declining to 20 and 17 wildcats during1994 and 1995, respectively. The 17 wildcats drilled during 1995 were the fewest wildcats drilled in North Dakota since oil was discovered in 1951.

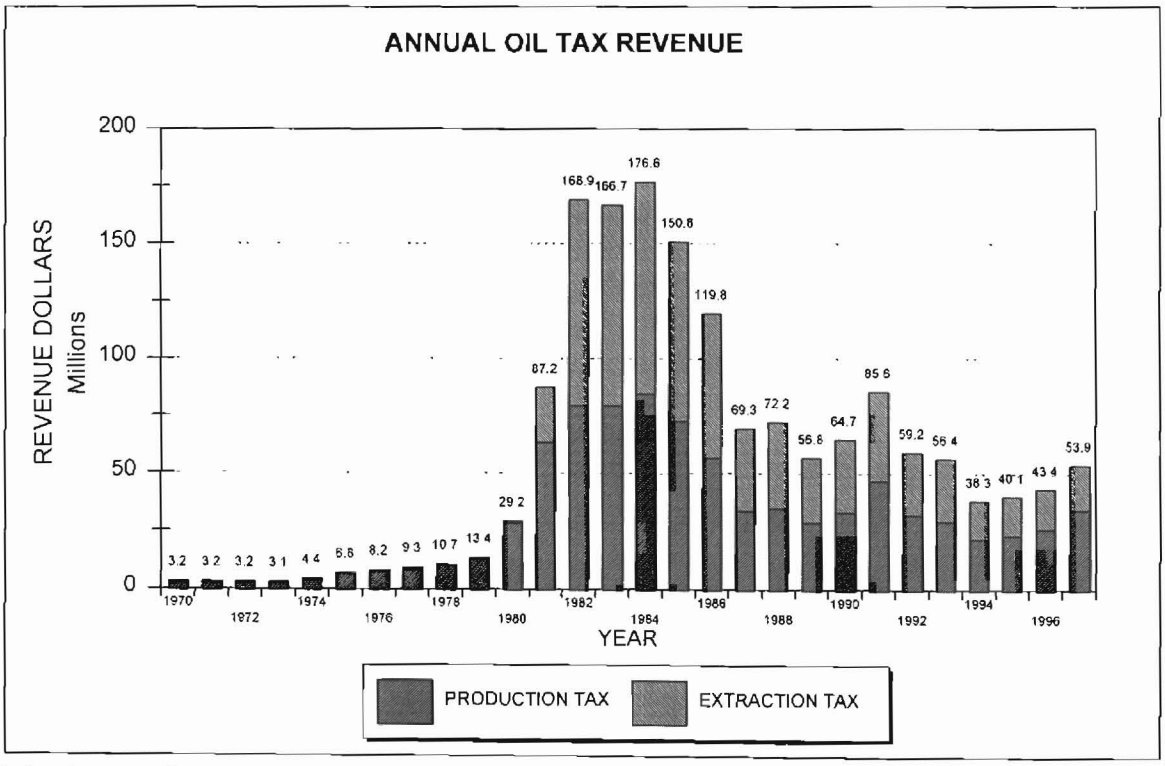

Figure 2. Bar diagram of annual production and extraction tax revenue from crude oil production in North Dakota for the period 1970 to 1997. The extraction tax took effect January 1, 1981. (Source: N.D. State Tax Commission).

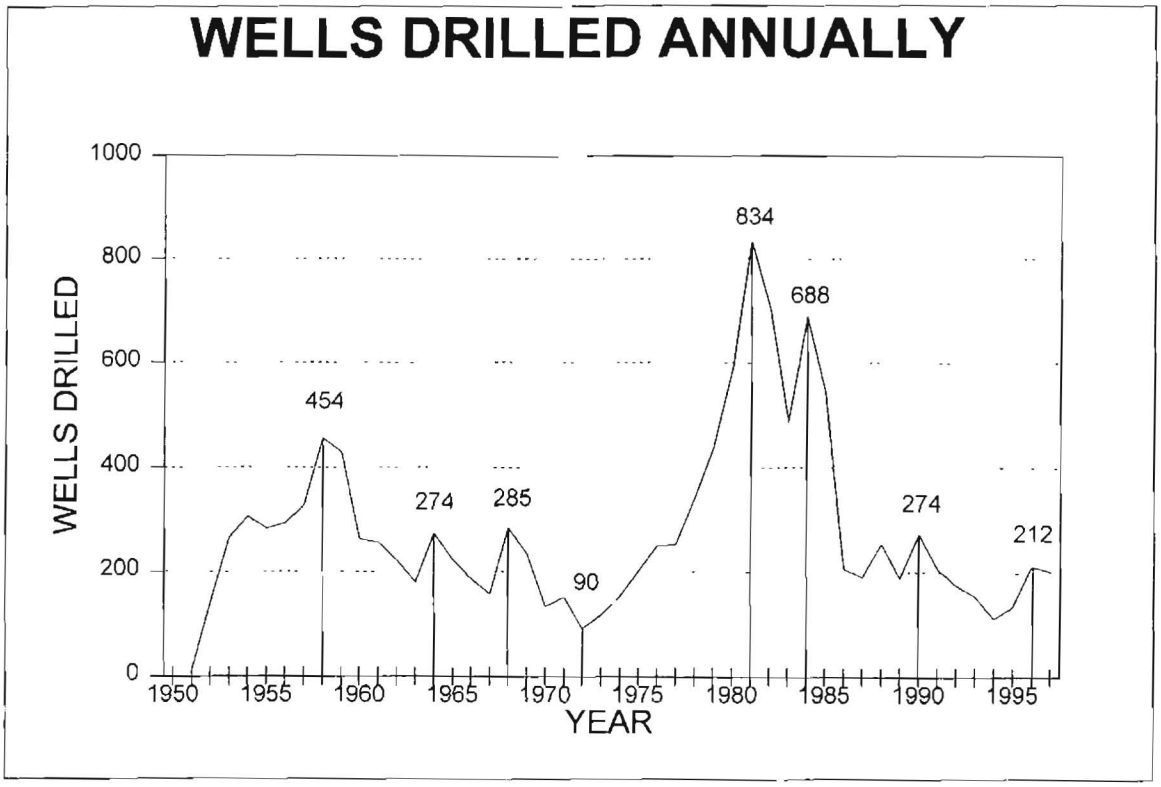

Figure 3. Line graph of the number of oil and gas wells drilled annually in North Dakota since 1951. (Source: N.D. Geogological Survey and N.D. Oil and Gas Division).

Horizontal drilling has become a major drilling method for the oil industry in North Dakota. Horizontal drilling in the Williston Basin began during 1987 when the first horizontal Bakken Shale wells were drilled in North Dakota and the first horizontal Madison wells were drilled in Saskatchewan. Horizontal drilling in these plays became commonplace during 1989. One result of the horizontal Bakken play was that state lease bonus revenue (*Figure 1*) jumped in 1989 as industry interest in the play continued to rise. Many state oil leases brought favorable per-acre bonuses at auctions during 1989 and 1990. In contrast, the U. S. Forest Service was unable to lease the Little Missouri National Grasslands (LMNG) at this time because of a court-imposed requirement for an environmental impact statement for the LMNG. As a result they lost both lease and production revenue that would have exceeded those of the State Land Department as the U. S. Forest Service owned much more acreage in the Bakken play.

The 1980's ended with the North Dakota oil industry in the best shape it had been in for several years. Oil production and drilling were up with new plays to raise industry interest and horizontal drilling technology was becoming important in North Dakota. In addition, oil prices were up slightly (*Figure 7*), increasing the positive effects at the end of the decade.

1990-1997

DRILLING

The 1990s began with many of the recently acquired leases in the horizontal Bakken Shale play being drilled as activity in the play peaked during 1990. The total number of wells drilled in the state rose significantly from 1989 to 1990, climbing 86 to a total 274 wells, the most wells drilled in any year

since 1985 (*Figure 3*). Seventy-seven of those wells drilled were Bakken tests. During 1991, 48 Bakken tests were completed, while during 1992 and 1993, 30 and 24 Bakken tests were completed, respectively. Success rates for Bakken tests, as judged solely by a well being completed as a producing oil well, remained high. The success rate during 1991 was 97% and the success rates during both 1992 and 1993 were 100%. Despite the appearance of success by this one measure, many of these wells were economic failures because the volume of hydrocarbons recovered was not sufficient to pay for the drilling and completion costs.

The viable extent of the horizontal Bakken play was defined between 1990 and 1993 and two drawbacks to the play became apparent in this same period. First, many Bakken wells declined faster than expected which meant that second, reserves were lower than expected. As a result, drilling activity decreased as companies re-evaluated the play. By 1994, the horizontal Bakken play was nearly over with only nine horizontal Bakken wells completed. In 1995, only three wells were completed, marking the end of the horizontal Bakken play.

A major factor in the 1990 drilling increase was Iraq's invasion of Kuwait in August 1990. World oil prices surged as uncertainties about the security of the Middle East oil supply rose. Oil prices in North Dakota also increased (*Figure 8*). Responding quickly to the price increase, oil companies nearly doubled the number of wells spudded each month in North Dakota (*Figure 8*). The rapid deployment of allied military forces during the fourth quarter of 1990 generated a downward pressure on oil prices and the number of wells spudded decreased as uncertainties lessened. The price of oil began to fall in late 1990 and continued to decline into 1991, but the price of oil remained $1 to $3 per barrel above

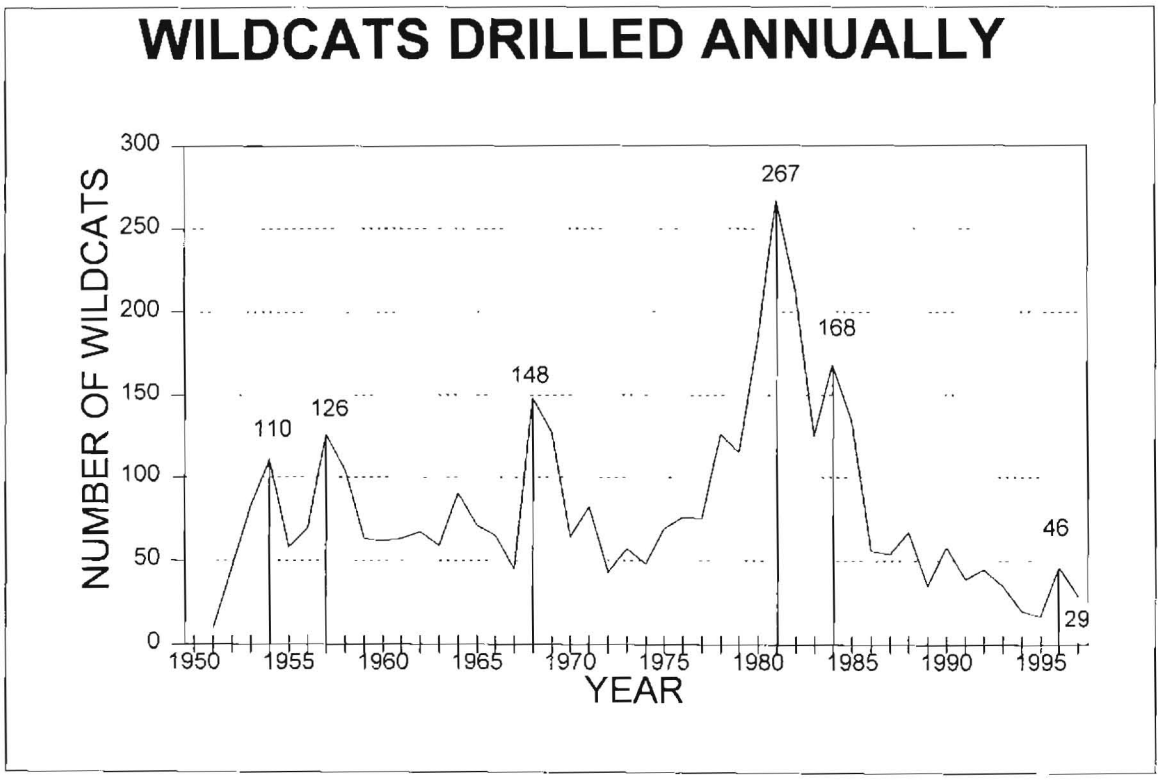

Figure 4. Line graph of the number of wildcat wells drilled annually in North Dakota since 1951. (Source: N.D. Geological Survey and N.D. Oil & Gas Division).

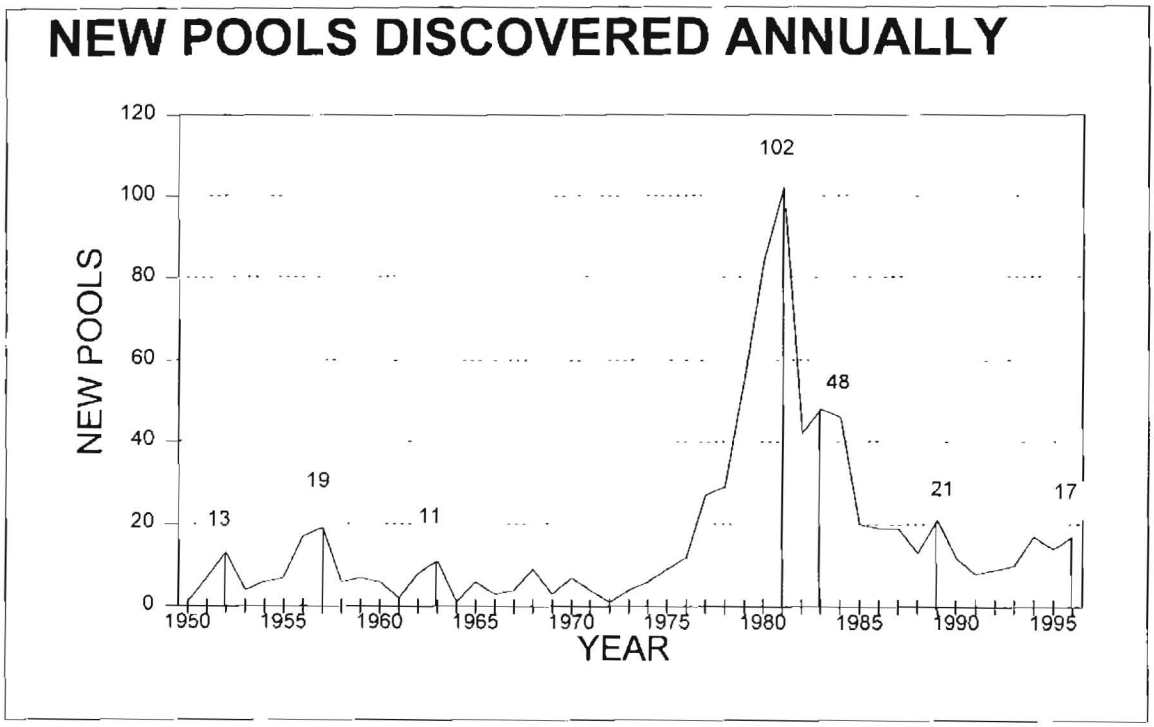

Figure 5. Line graph of the number of new oil pools discovered annually in North Dakota since 1951. (Source: N.D. Geological Survey and N.D. Oil & Gas Division).

the July 1990 price well into 1991. By late 1991, after Kuwait was liberated, prices had returned to pre-Gulf War levels.

Drilling during the 1990s has been irregular. From 1990 through 1994 the number of wells drilled annually in the state decreased from 274 to 111 more than 200 wells per year were drilled as drilling increased in two new plays and one older play. A small increase occurred during 1995 and then rose to 212 and 202 during 1996 and 1997, respectively (*Figure 3*). The 200-plus wells drilled per year were the result of activity in two new plays and one older play.

The first new play began when Conoco, Inc. discovered Waulsortian bioherms or Waulsortian-like mounds in the basal Lodgepole Formation while drilling a deep test in Dickinson Field during 1993 (Burke and Diehl, 1993). This well was the first economic Lodgepole production in North Dakota and the flow-rates of this and subsequent Lodgepole wells drew national attention. The hunt for similar features continues, though sporadically, in many parts of the Williston Basin.

The second new play is the horizontal Red River "B" zone play in Bowman and Slope counties, North Dakota and in adjacent parts of Montana and South Dakota. The first horizontally drilled Red River well in North Dakota was completed in 1994 by Meridian Oil, Inc. (now Burlington Resources Oil & Gas Co.). Meridian Oil, Inc. (MOI) began the horizontal Bakken play during 1987 and drilled the first horizontal Red River B zone wells in Montana near East Lookout Butte Field on the Cedar Creek anticline in 1988. Between the horizontal Bakken and Red River "B" plays, MOI has drilled more horizontal wells in the state than any other operator. The early horizontal Red River wells in Montana were disappointing, but the discovery of Bog Creek Field during 1994, later renamed Cedar Hills Field,

sparked a large land play and widespread drilling. The two main operators in the play are Burlington Resources Oil & Gas Co. and Continental Resources, Inc.

Although the horizontal Red River play did not immediately capture oil companies attention as did the discovery of the first Lodgepole well, it has proven to be economically attractive and has surpassed the Lodgepole play in oil production (*Figure 9*). By the end of 1997, 164 wells were producing in Cedar Hills Field and the field had produced 11,360,244 BO; 900,000 more barrels than all the Lodgepole fields and units had during the same period. At current production levels, primary production from the Cedar Hills Field will probably equal or exceed the total of primary and secondary production from all the presently known Lodgepole fields in Stark County.

An old play being revitalized is the horizontal Madison play. Operators have apparently evaluated the geological controls on horizontal Madison wells in Saskatchewan and North Dakota and are trying to drill those areas in North Dakota that they think best meet their geologic criteria. The number of horizontal Madison wells drilled in North Dakota increased from nine during 1996 to 27 during 1997.

Wildcat drilling decreased from 58 wells during 1990 to 17 wells during 1995 (*Figure 4*), the fewest wildcat wells drilled in North Dakota since 1951 when oil was discovered in the state. Wildcat drilling jumped to 46 in 1996 as the hunt for Lodgepole mounds peaked, but then dropped to 28 as the play was not extended outside of the Dickinson area.

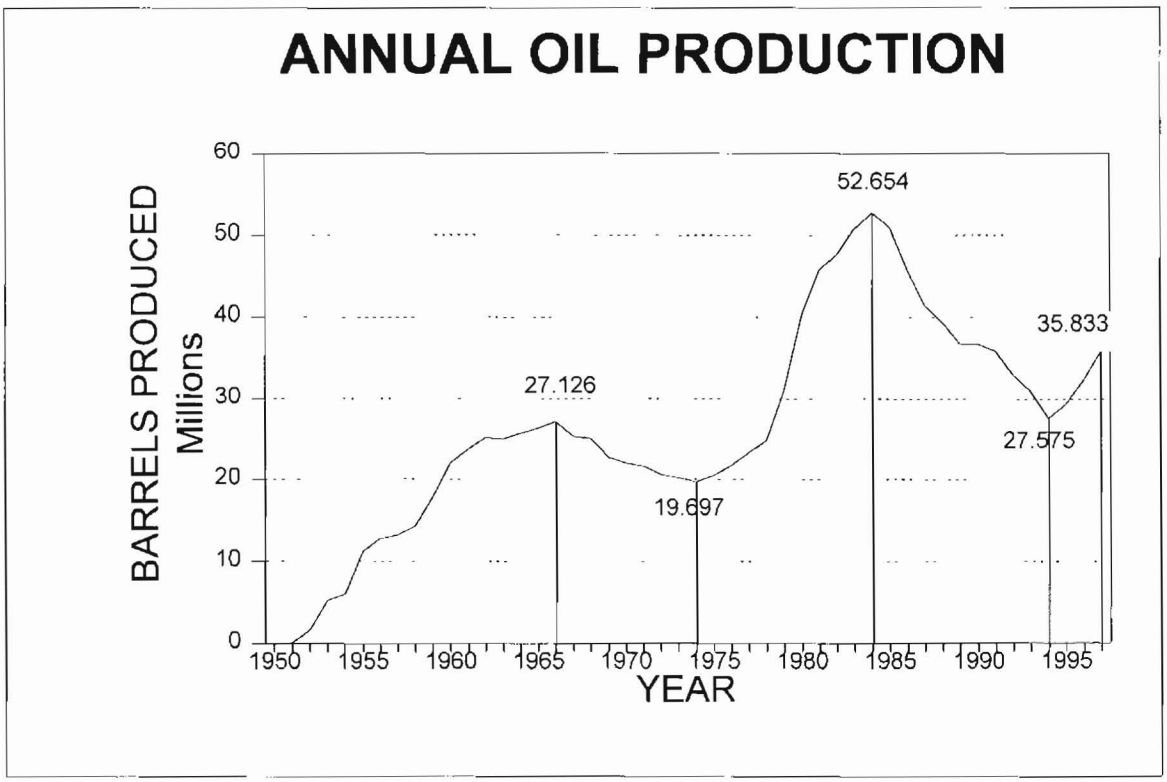

Figure 6. Line graph of annual oil production in North Dakota since 1951. Production is in U. S. barrels. (Source: N.D. Geological Survey and N. D. Oil & Gas Division).

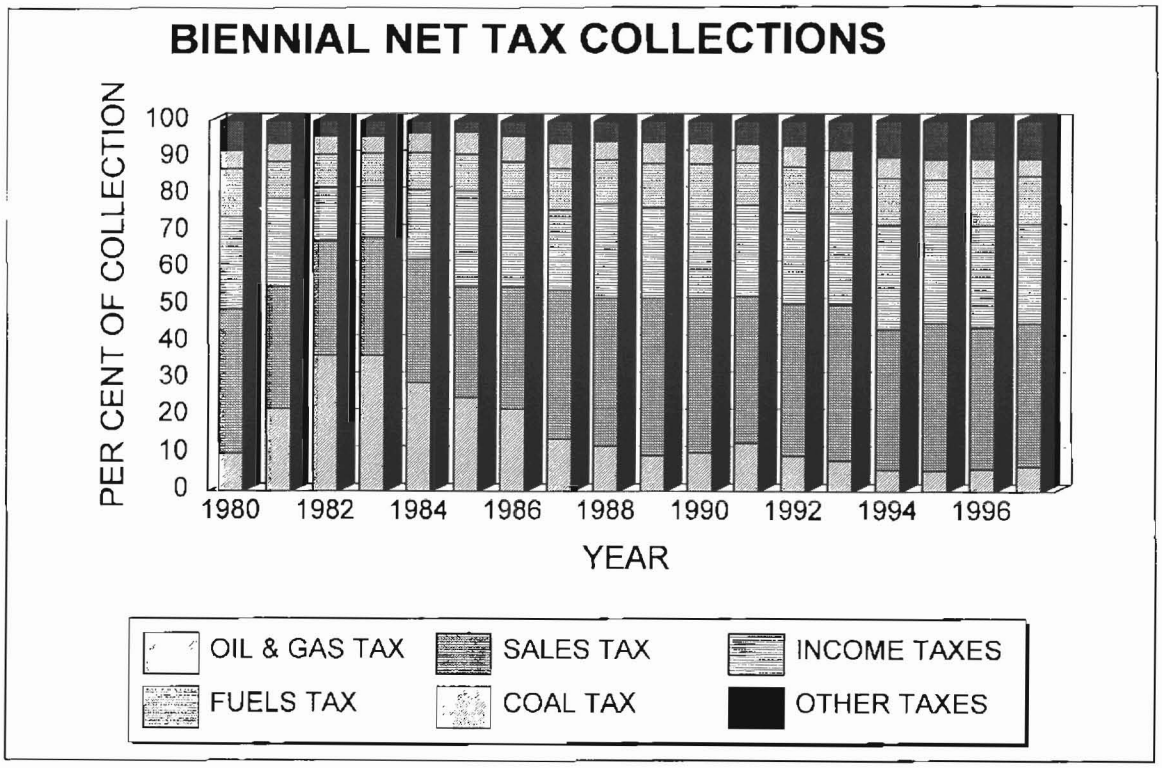

Figure 7. Bar diagrom of the net tax collections in North Dakota since 1980. Source of tax collections are shown as a percentage of total collection. (Source: N.D. State Tax Commission).

OIL PRODUCTION

Annual oil production in North Dakota declined between five and 10 percent per year from 1985 through 1989. From 1989 to 1990, annual production remained virtually flat, declining only 21,057 barrels (.0005%) over the year (*Figure 6*). The fact that annual production did not decline between 1989 and 1990 was due to production from two new fields and wells completed in the horizontal Bakken play. Approximately 2.2 million BO were produced from Wabek and Plaza fields along the Sherwood and Bluell shorelines in Ward and Mountrail counties and another 2.7 million BO were produced from horizontal Bakken wells in western North Dakota. The 4.9 million BO that they produced canceled the production decline from the other 3,500 wells in the state.

Production declined a modest 2% to 35,895,278 BO in 1991 as new production was no longer able to stave off decline. During 1992, 1993, and 1994 production fell eight, six, and 11%, respectively (*Figure 6*). However, during 1995, oil from two new plays, the horizontal Red River and the Lodgepole mound plays, came on-line and annual production rose 1,758,147 BO, more than 6% above 1994 annual production. Annual production during 1996 rose again by 10% and by 11% during 1997 to 35,832,705 BO. Part of the increase can be attributed to the number of wells completed in Cedar Hills Field, but an equal amount of oil came from the discovery and subsequent unitization of the Lodgepole mound fields around Dickinson. Without increased or new production, annual production will eventually begin to decline again. The drilling in the horizontal Red River play, together with the activity in Lodgepole play, clearly illustrate some of the best ways to offset the state's decline in oil production: find and develop a single large oil field, develop a new oil play with many new fields, or do both at the same time. Wells completed in both plays had higher initial potentials (IP's) than did the average North

Dakota oil well, a necessity in order to reverse declining production. Either more new, high IP wells, many more average new wells, or large numbers of marginal wells must be completed to increase annual production. In each of these three cases, increasing amounts of capital are needed to drill the number of wells required to raise annual production. At current oil prices only the first case appears feasible although the second case may also be feasible especially if it involves the unitization of oil fields.

A successful secondary recovery project, like those formed around the Lodgepole fields, will produce the remaining primary reserves in an oil field, usually at a higher rate than an equivalent non-unitized field, and then go on to produce additional barrels of secondary reserves that otherwise could not be produced. Units can be a cost-effective way of increasing production in existing oil fields. Six new units were formed during 1996 and five during 1997 (*Figure 10*). The 1991 North Dakota legislature encouraged the unitization of oil fields by enacting legislation that lowered the percentage of mineral and working-interest owners required to form a unit. An increase in unitizations began in North Dakota during 1992 just when many oil fields were approaching the end of their primary productive life-spans. Legislation like this encourages companies to invest the capital necessary to unitize an oil field and the unitization of fields is instrumental in minimizing declining oil production in North Dakota.

Another way to slow or possibly reverse declining annual production might be to drill horizontal wells in existing Madison Group fields. The effect that a successful horizontal well program could have in North Dakota might be surmised from recent events in Saskatchewan's part of the Williston Basin. Stalwick (1994) reported that between 1987, when the first horizontal Madison wells were drilled, and the end of 1992, a total of 452 horizontal wells had been drilled in the province. During

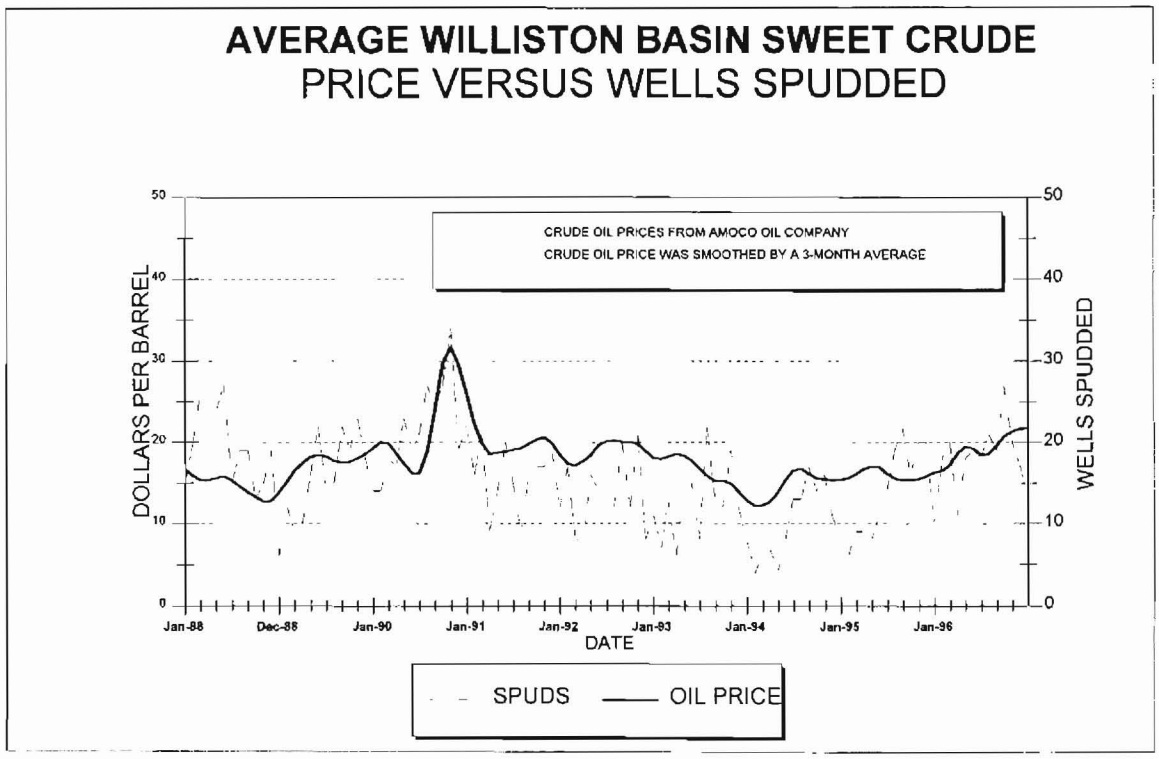

Figure 8. Line graph of the monthly average posted price for Williston Basin 40-gravity "sweet" crude oil and the number of wells spudded monthly since January 1, 1988. (Source: Oil prices are from Amoco Oil company and wells spudded Oil & Gas Division).

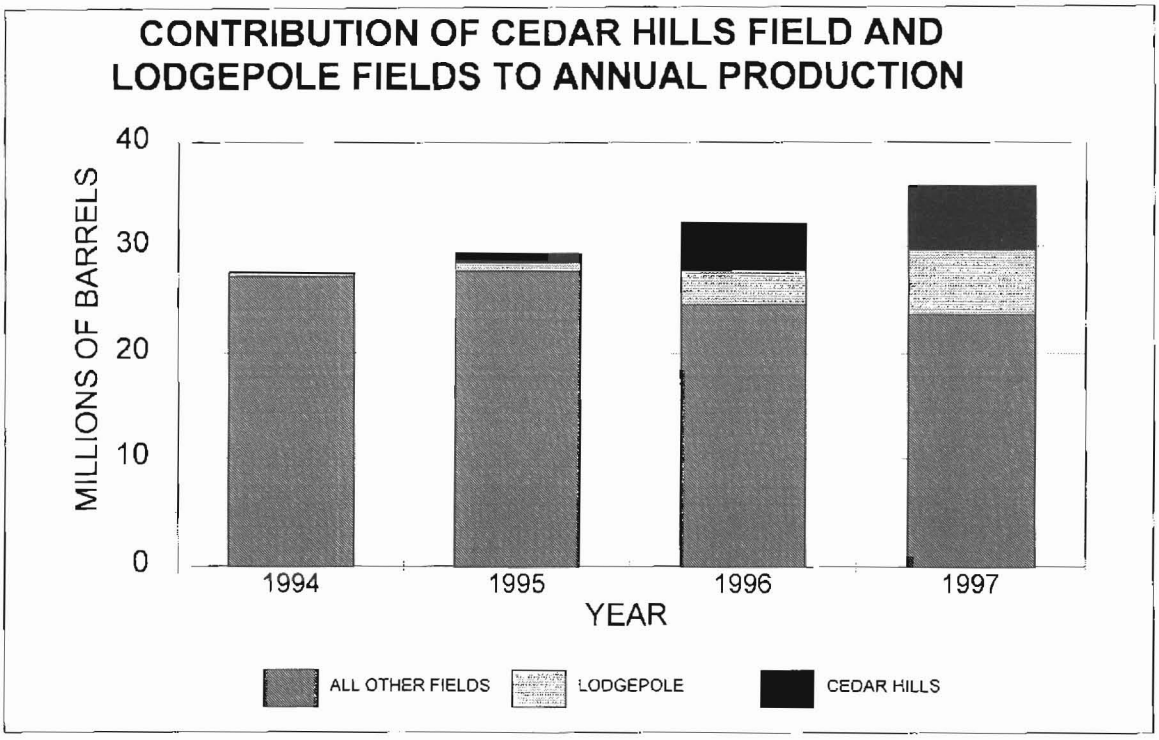

Figure 9. Bar diagram of the annual oil production from Cedar Hills Field, all known Lodgepole mound fields, and the rest of the oil wells producing in North Dakota. (Source: N.D. Oil & Gas Division).

1997 alone, 461 horizontal wells were drilled in southeast Saskatchewan, the most in any year (*Figure 11*). From 1987 through 1997, 1,952 horizontal wells were drilled in the Saskatchewan Williston Basin and they contributed 51% of the year's oil production during 1997 (*Figure 12*). Horizontal wells have contributed so much oil that the province's oil production has increased instead of declining as it previously had been. The same strata that produce in Saskatchewan are present and productive in North Dakota. A similar horizontal drilling program in North Dakota has the potential to dramatically increase the state's oil production, just as it did in Saskatchewan.

At the end of 1997, thanks to some important new discoveries and to reasonably high and steady oil prices (*Figure 8*), North Dakota's oil industry was producing more oil and was drilling more wells than it had for several years. Drilling was focused on development drilling in the horizontal Red River play, but the horizontal Madison play was once again being evaluated. The North Dakota oil-industry appeared to be in good shape.

EXPLORATION POTENTIAL

The North Dakota Williston Basin is under explored and many opportunities remain for finding large new oil fields and new plays. A 1991 study of the petroleum potential of the Little Missouri National Grasslands by Fischer, et al. estimated that at least 100 million barrels of oil equivalents remained undiscovered in McKenzie, Dunn, Billings, Golden Valley, Stark, and Slope counties. Some of this oil was discovered during the horizontal Bakken and the Lodgepole plays, but much of the potential resource in these area remains to be discovered. LeFever and Heck (1995) estimated that more than 800 million barrels of oil equivalents remained undiscovered in the productive portion of North Dakota. They suggested that Ordovician strata, like the Red River Formation, would contain the bulk of

these resources. Cedar Hills Field will produce more than 40 million barrels during its primary production lifetime. This field is a very significant discovery in North Dakota as it will be one of the ten largest oil fields ever found in the state. In addition, it probably is one of the largest onshore oil fields discovered in the U.S. during the past five years. Bowman County, where the field was discovered, is an area where oil was first discovered more than 30 years ago. This discovery is proof that new concepts and technologies can lead to surprising results in mature areas; other, similar opportunities may exist elsewhere in North Dakota. The discovery of a single five-million-barrel or larger oil field would result in many new wells as operators explore for similar fields, just as they did as a result of the Lodgepole and horizontal Red River plays.

HISTORICAL ANALYSIS

From 1980-1985, record oil prices, revenues, and numbers of wells drilled were set in North Dakota. In 1986, a major price drop caused drilling to plummet. Drilling remained in the 200-plus wells per year range during the late 1980s, but steadily decreased from 1990 to 1994 to a level not seen since the 1970s (*Figure 3*). From the recent historical record, it appears that if more than 175 wells are drilled during a year it is because a large field or fields are being developed and/or a new play or plays are active. This is what happened during the late 1980s when Wabek Field was being developed and the Bakken play was active. If no significant plays or fields are being developed, it is likely that fewer than 175 wells will be drilled.

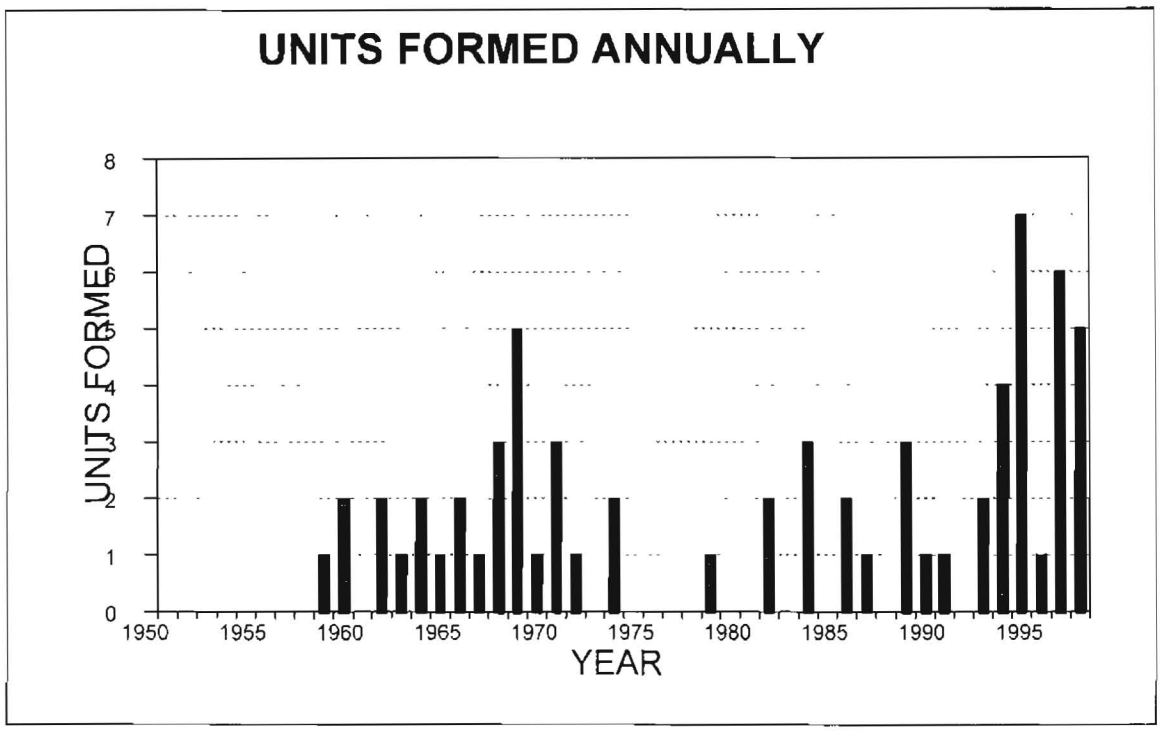

Figure 10. Bar diagram of the annual number of unitized oil fields since 1950. Units were included in the year in which operations began. (Source: N.D. Oil & Gas Division).

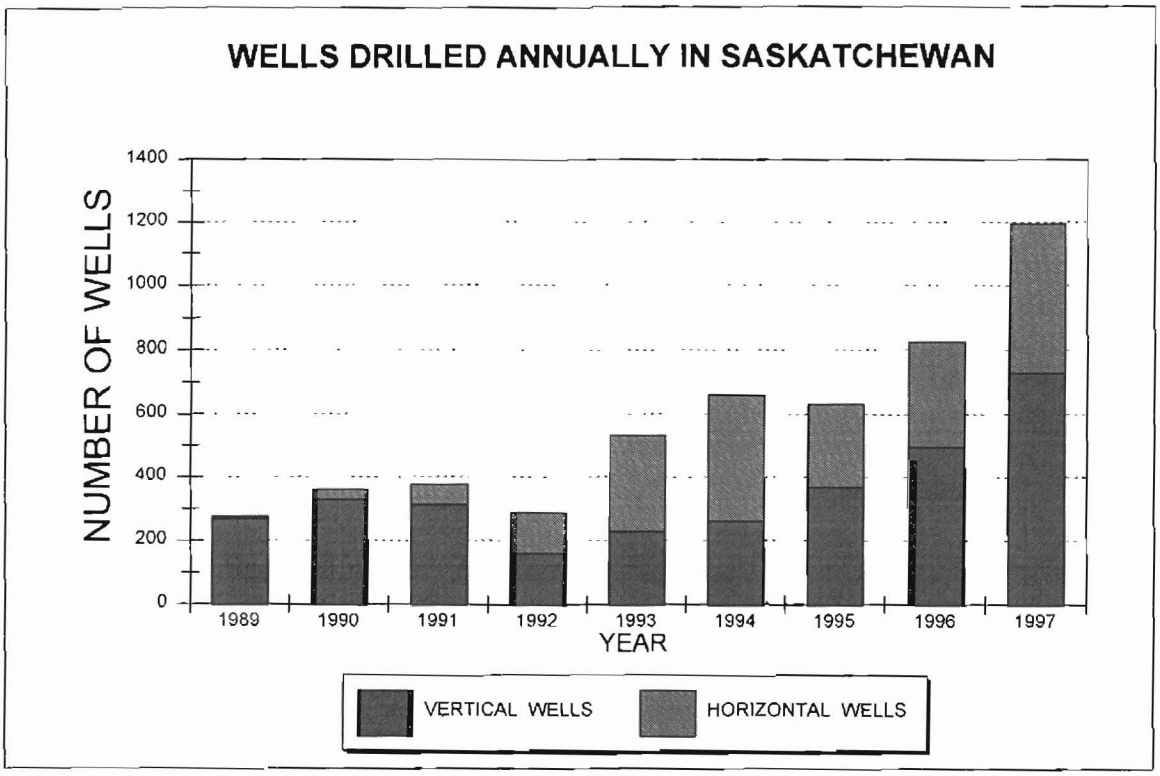

Figure 11. Bar diagram of the number of horizontal and vertical wells drilled annually in the Saskatchewan Williston Basin since 1989. (Source: Saskatchewan Energy and Mines).

Annual oil production began to decline during 1983 as fields aged and uneconomic wells were plugged. In 1990, production from two important plays, the Sherwood shoreline and the horizontal Bakken Shale plays, temporarily stopped the decline. The effect, however, was short-lived and production declined again during 1991. Decline rates of six to 10% per year were recorded between 1992 and 1994. Annual production during 1995 rose more than 6% above 1994 production as new wells in the Red River and Lodgepole plays were brought on-line. Annual production rose another 10% during 1996 and 11% during 1997 as Cedar Hills Field was further developed and most of the Lodgepole fields were unitized and producing at optimal rates (*Figure 9*).

1996

Statistics

Two hundred and twelve wells were drilled during 1996, an increase of 63 wells or 42% from 1995 (*Figure 3*). Sixteen unit or water-disposal wells are included in this total, but not in any other statistics. The number of wildcat wells drilled during 1996 nearly tripled from the 17 drilled during 1995 to 46 (*Figure 4*). However, only 15 pools were discovered, one fewer than in 1995 (*Figure 5*) despite the increase in wildcat drilling. These new pool discoveries are summarized in Appendix 1. Those new pools that also were new field discoveries are located on Figure 13. Five new fields or pools were discovered in Stark County during 1996, the most in any county in North Dakota. McKenzie County was second with four, Renville County had two, and Bottineau, Divide, Dunn, and Williams counties each had one new field or pool discovered during 1996 (Table 2).

The 1996 wildcat success rate was 17% with eight of 46 wildcats completed as oil or gas wells, approximately one-half the 1995 success rate of 35%. The success rate for development and exten-

sion wells was 75% as 112 of 150 wells were completed producing oil or gas, 2% lower than the 1995 success rate.

Total footage drilled during 1996 was 2,227,203 feet, an increase of 860,424 feet (63%) more than 1995 footage. The increased footage is both because more wells were drilled but mainly because many of the wells drilled were horizontal development wells in Cedar Hills Field. The eighty wells drilled in Cedar Hills Field had an average total depth of 13,889 feet. The average total depth of the other 132 wells drilled in the state was 8,455 feet. Wildcat footage more than doubled from the 160,573 feet drilled during 1995 to 384,582 feet during 1996.

Oil production, which had risen during 1995 for the first time since 1983, rose even higher during 1996. A total of 32,311,349 BO were produced, an increase of 2,977,831 barrels, or 10%, over the 29,333,518 BO produced during 1995. Cedar Hills Field produced 4,492,588 BO and the eight Lodgepole fields or units produced another 3,204,040 barrels during 1996. The importance of these two plays to North Dakota can be seen in Figure 9. Total production has risen every year since 1994, but without production from either the Lodgepole play or the Cedar Hills Field, total production would have remained flat at approximately 27 million barrels per year between 1994 and 1996.

Drilling Activity

During 1996, drilling was concentrated in the horizontal Red River B and Lodgepole plays. One hundred and ten of the 212 wells drilled during 1996 were drilled in one of these two plays with 80

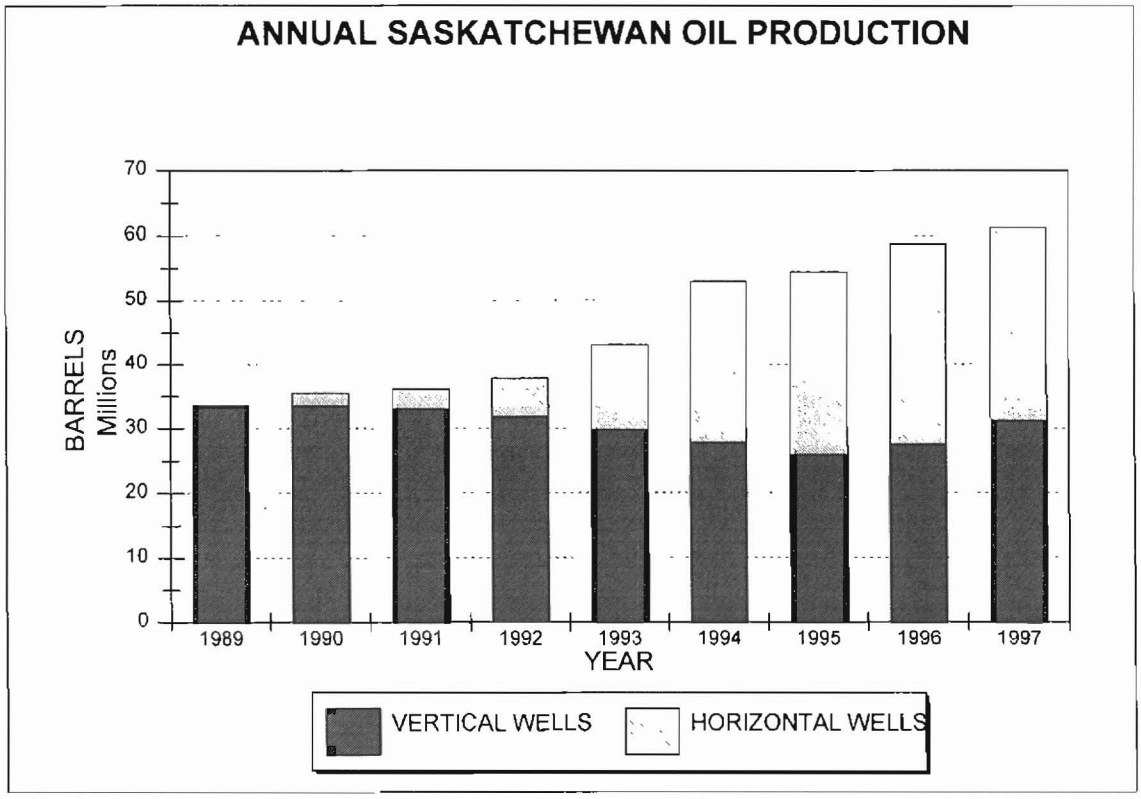

Figure 12. Bar diagram of annual oil production from vertical and horizontal wells in the Saskatchewan Williston Basin. Production has been converted from cubic meters to U.S. barrels. (Source: Saskatchewan Energy and Mines).

Table 2

1996 and 1997 New Pool and Field Discoveries
(Listed by County and Formation)

	1996	1997
Bottineau County		
Total	1	0
Madison	1	0
Bowman County		
Total	0	3
Red River	0	1
Red River "B"	0	1
Red River "C"	0	1
Burke County		
Total	0	3
Midale/Nesson	0	2
Winnipegosis	0	1
Divide County		
Total	1	1
Bakken	1	0
Gunton	0	1
Dunn County		
Total	1	0
Madison	1	0
Golden Valley County		
Total	0	2
Birdbear	0	1
Madison	0	1
McKenzie County		
Total	4	5
Duperow	2	2
Madison	1	1
Winnipeg/Deadwood	1	0
Stonewall	0	1
Renville County		
Total	2	0
Madison	2	0
Stark County		
Total	5	2
Lodgepole	3	1
Silurian	1	0
Stonewall	1	0
Tyler	0	1
Ward County		
Total	0	1
Madison	0	1
Williams County		
Total	1	0
Madison	1	0

wells drilled in Cedar Hills Field while at least 30 wells were drilled to test the Lodgepole. Of the two drilling programs, the Red River B program was more successful with 75 of the 80 wells completed as producing wells. The average IP of the 75 wells was 346 BO + 164 BW + 103 MCFPD. Drilling in the Lodgepole play resulted in seven of 30 wells completed as producers and three of the seven were new field discoveries. The average IP of those seven wells was 1,598 BO + 22 BW + 500 MCFPD. The average Lodgepole IP is so high because two wells completed in Stadium Field were allowed to produce at above-normal rates for a non-unitized Lodgepole field. The high IPs demonstrate the prolific, sustained production rates possible from a Lodgepole mound.

Of the 212 wells drilled during 1996, a total of 94 were drilled horizontally. Eighty of the ninety-four horizontal wells were drilled in Cedar Hills Field with only 14 drilled elsewhere in the state. Two of the 14 were drilled in Cedar Creek Field, next to Cedar Hills Field. They too targeted Red River B porosity and the average IP of the two Cedar Creek Field wells was 278 BO + 97 BW + 20 MCFPD, close to the average well completed in Cedar Hills Field. All but one of the remaining 12 horizontal wells targeted the Madison Group.

Three wells were drilled in Wayne Field, two by Ballantyne Oil while Geo Resources, Inc. drilled the third. Horizontal drilling in Wayne Field is the most successful horizontal Madison drilling program

in the state to date. The average IP of the three wells drilled during 1996 was 436 BO + 50 BWPD, higher than the average IP of 336 BO + 28 BWPD for the first six horizontal wells in Wayne Field. During 1996, nine horizontal wells produced 286,057 BO while 32 vertical wells produced 91,779 BO. Clearly, considerable oil remained in Wayne Field that is recoverable with horizontal wells. The same might be true in other Madison fields as well.

Two horizontal wells were drilled in Haas Field by Tidal Resources (USA) Inc. during 1996. The better of the two wells had an IP of 411 BO and 15 BWPD while the other well had an IP of 115 BO + 142 BWPD. The average IP of the two wells was 263 BO + 79 BWPD, 79 BOPD higher and 126 BWPD lower than the average horizontal well completed in Haas Field during 1995. However, by the end of 1997, the two wells were producing an average of 39 BO + 25 BWPD and only 16,526 BO had been produced. The two wells had a cumulative produced water-oil ratio of 4.28 BW per BO. Tidal Resource's horizontal Madison program in Haas Field has not been an economic venture.

RJL Oil & Gas, Inc. drilled two horizontal Madison wells in Kimberly Field. The first of the two wells, the RJL GCRL Kimberly #13-7 HZ, had an IP of 108 BO + 386 BW + 199 MCFPD while the second produced only water and is shut-in. The first well has produced a great deal of water. It's cumulative production at the end of 1997 was 9,091 BO + 129,867 BW, an oil-water ratio of 1:14.3.

Four of the remaining five horizontal wells were drilled in Black Slough, Lone Tree, Grassy Butte, and South Antler Creek fields and none of the four has produced much oil. The last horizontally drilled well was a wildcat well that tested the Bakken Shale in Billings County. The current status of the well is shut-in and the well will probably never produce oil. Except in Wayne Field and in the Cedar Hills area, horizontal drilling was not very successful during 1996.

There were 104 vertical wells drilled in North Dakota during 1996. Forty-six of these wells were wildcat wells of which only eight were completed producing oil or gas. The remaining 58 wells were drilled in many different fields. One of the better wells completed during the year was the discovery well for the Blue Buttes Winnipeg/Deadwood pool for Amerada Hess Corp. The #6-32 Lovaas, located in the NE quarter of section 6-T150N-R95W in McKenzie County, was completed flowing 3,366 MCF + 7 BWPD. This well demonstrates that lower Paleozoic strata on the Nesson anticline have not yet been fully evaluated, much less developed. Undoubtedly other parts of the anticline will also produce natural gas from deeper horizons.

Another 1996 discovery was the Armstrong Operating, Inc. #24-1 Heidt, located in section 24-T138N-R97W in Stark County. The well is interpreted to have drilled into the central uplift of a meteorite crater, or astrobleme, formed during Middle Silurian. Seismic data over the field includes features interpreted as the central uplift, crater moat, and an outer rim of a typical meteorite crater. The IP of the well was 185 BO + 93 MCFPD, but an offset to the #24-1 Heidt was not successful. While astroblemes are a geologic curiosity and significant amount of hydrocarbons can be trapped in one like Red Wing Creek Field does, finding one is more a matter of luck than it is a typical part of an exploration program.

Cabernet Field was discovered in Dunn County by Armstrong Operating, Inc. with their #36-1 Beaudoin test in section 36-T144N-R97W, near the southeast end of Little Knife Field. The well had an IP of 283 BO + 108 BW + 145 MCFPD on pump from Madison perforations. The well has produced nearly 38,000 BO through 1997, but has not yet been offset by a well capable of similar production rates although several offset wells have been drilled.

Another well was the Edward Mike Davis #33-25 Davis Perron in section 31-T163N-R85W. The well discovered North Mouse River Park Field and had an IP of 105 BOPD. Unfortunately, it is another well that has not lived up to the promise of its IP as it has produced less than 4,000 BO through 1997 and has not been successfully offset.

Not all of the interesting completions in the state are made by drilling new wells. Intoil, Inc. recompleted the #2-32 Danielson pumping 255 BO + 35 BW + 187 MCFPD from Madison rocks. The well was drilled in Harding Field during 1994 and was initially completed in the Red River Formation, but later recompleted in the Silurian pool. The well is located near the middle of the field, adjacent to a well that has produced more than 300,000 BO since 1985 from a deeper Madison porosity zone. This well is the highest IP recompletion made during 1996 and is an illustration of the multiple-zone potential of many of the oil fields in the deeper part of the basin.

1997

Statistics

Two hundred and two wells were drilled during 1997, ten less than in 1996 (*Figure 3*). Twenty-nine wells were wildcats, 156 were development or extension wells, and 17 were classified as "other." The 1997 "Oil in North Dakota," published by the Oil & Gas Division, reported that 194 wells were drilled during 1997. The drilling statistics in "Oil in North Dakota" were compiled before all the wells were off confidential status so it was necessary to add eight wells to the drilling statistics used in this report to reflect the final data. Wells classified as "other" are included only in the total well count. The 29 wildcats drilled during 1997 were a decrease of 18 from 1996 (*Figure 4*). Seventeen new pools were discovered during 1997, up two from 1996 (*Figure 5*) and are summarized in Appendix II. Those new pools that were also new field discoveries are shown on Figure 14. McKenzie County had five new pools discovered, the most of any county. Bowman and Burke counties each had three, Golden Valley and Stark each had two, and Divide and Ward counties each had one new field or pool discovery (Table 2).

Wildcat drilling fell from 46 during 1996 to 29 during 1997, 63% of the 1996 wildcats drilled. At least nine of the 29 wildcats had the Lodgepole Formation as their primary target, seven fewer than the number of wildcats whose primary objective appeared to be the Lodgepole Formation during 1996. Four of the 29 wildcats drilled were completed producing oil and gas, a 14% success rate. While the number of wildcat wells drilled fell 63% during 1997, the overall percentage success rate was only 3% lower than during 1996.

Drilling Activity

In some ways 1997 repeated the drilling activity of 1996. Drilling focused primarily on two areas; the continued development of Cedar Hills Field and exploration for Lodgepole mounds. The year differed in that a third play, the horizontal Madison play, was seeing increased activity. In the two main areas of interest, sixty-seven wells were drilled in Cedar Hills Field and at least 19 other wells, based upon location and total depth, had the Lodgepole as one of their primary objectives. In total, 86 of the 202 wells drilled in North Dakota during 1997 were drilled to evaluate one of these two plays. Drilling in Cedar Hills Field was very successful, as it was during 1996, with 64 of 67 wells completed producing oil for a 96% success rate. The average IP of the 64 wells was 343 BO + 168 BW + 95 MCFPD, about the same as the 1996 average well of 346 BO + 164 BW + 103 MCFPD. Drilling the Lodgepole play was less successful than it was during 1996 with five of the 19 Lodgepole tests completed producing oil. Only one of the five was a new-field discovery. The average IP of the five com-

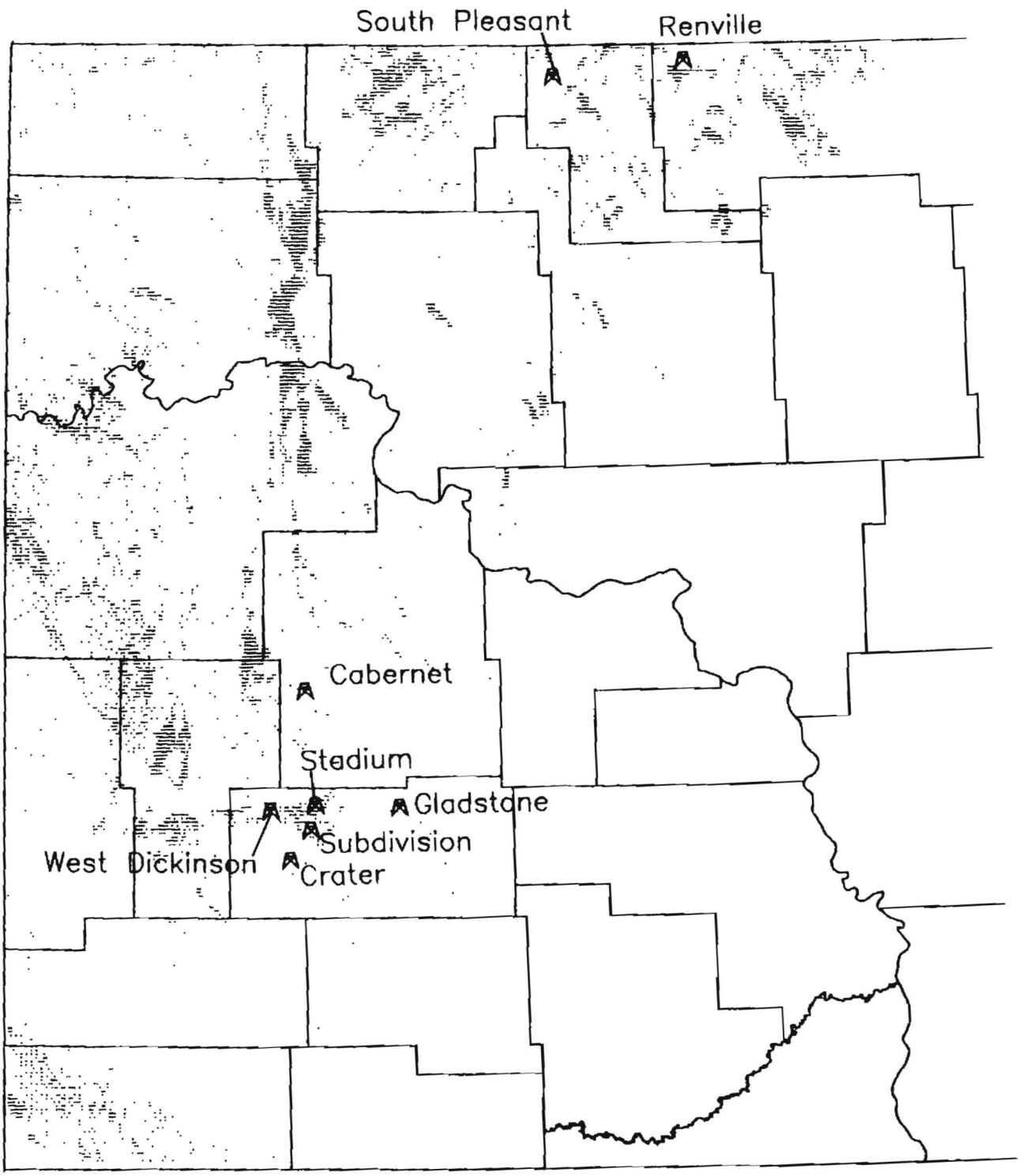

Figure 13. Map of western North Dakota with the location of all known producing wells and the 1996 new field discoveries shown.

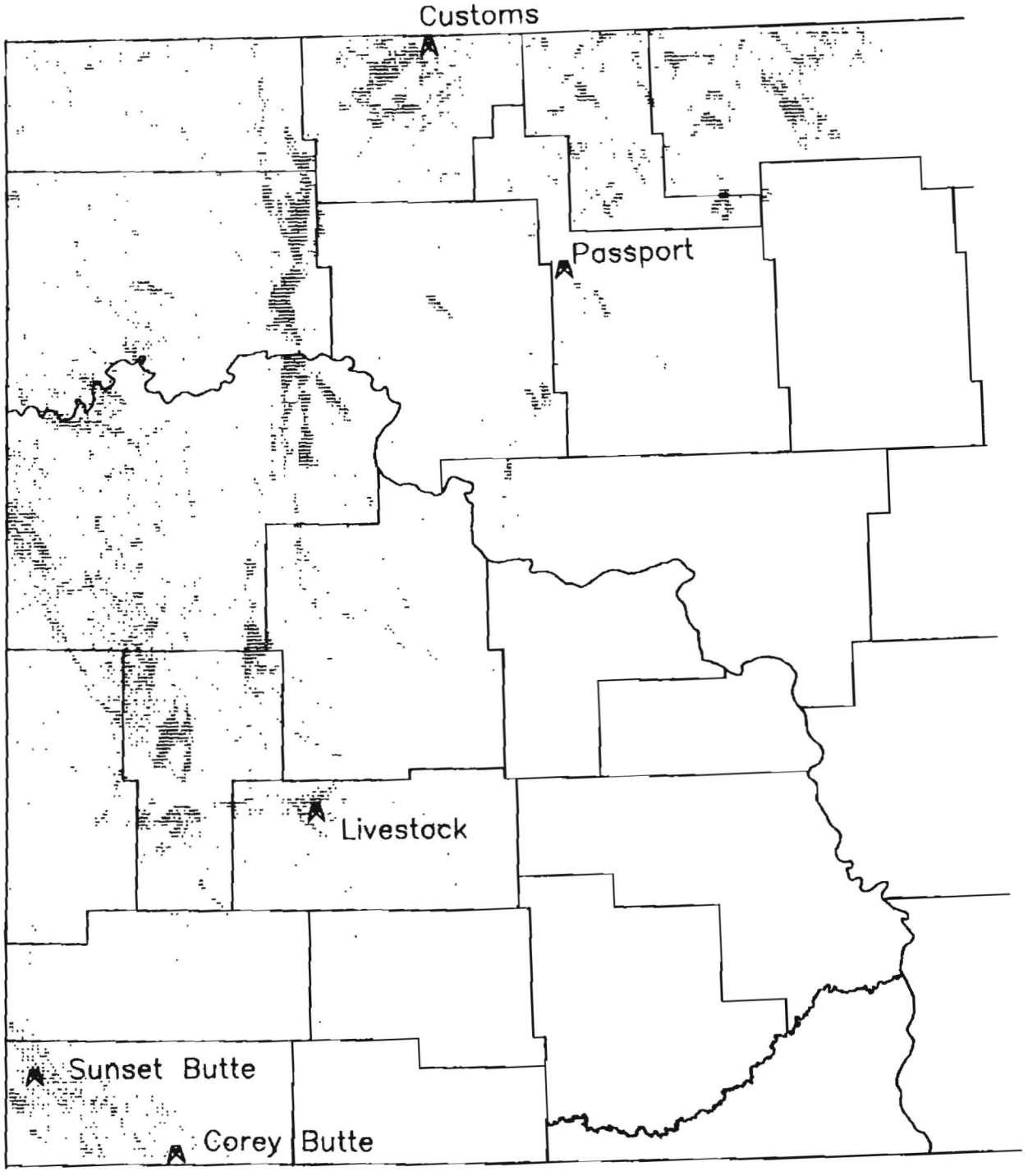

Figure 14. Map of western North Dakota with the location of all known producing wells and the 1997 new field discoveries shown.

pletions was 1,537 BO + 29 BW + 563 MCFPD, close to the 1996 average of 1,598 BO + 22 BW + 500 MCFPD. The 1997 average was so high because the Duncan Oil, Inc. #1-3 Dinsdale was completed pumping 5,106 BO + 0 BW + 1,414 MCFPD, a higher than normal initial production rate for a Lodgepole well.

The only Lodgepole discovery made during 1997 was by Duncan Oil, Inc. with the #1-10 Dinsdale in section 10, T139N-R97W. The well discovered was named Livestock Field and is a one-well Lodgeple field.. The well's IP was 561 BO + 224 MCFPD on pump. The field is close to both Stadium and Hiline fields, but a pressure test of Livestock Field generated a reservoir pressure that was different from the pressures in the other two fields, proof that it is a separate reservoir. The field was estimated to have 700,000 BO in-place, but the ultimate recovery from the field will depend on the properties of the reservoir and how carefully the field is managed by the operator.

Nearly half of all the wells drilled in the state, ninety-eight of the 202 wells drilled, were drilled horizontally during 1997. Sixty-seven were drilled in Cedar Hills Field with 31 being drilled elsewhere, more than double the 14 drilled outside of Cedar Hills Field during 1996.

Horizontal Madison wells were drilled in several different parts of the state, but drilling focused on the Midale-Nesson play in Burke County and the Nesson play in south-central Williams County. The first well in the Midale/Nesson play, completed in January 1997, discovered the Carter Midale/Nesson pool (Appendix I). The Burlington Resources Oil & Gas Company #11-24 Durward et al. was completed pumping 193 BO + 25 BW + 207 MCFPD. By the end of 1997 the well had produced 23,711 BO and was still producing 36 BOPD. A second well was completed in the pool late in 1997. It did not produce as much oil, but it produced significantly more water than the initial well did. At about the same time that the Carter Midale/Nesson pool was discovered, Burlington Resources also discovered Customs Field. This too is in the Midale/Nesson pool and the discovery well, the #13-12H Warner et al., had an IP of only 46 BO + 37 BW + 37 MCFPD. The well produced 10,137 BO through the end of 1997. A second well in Customs Field was completed late in the year. It had a much higher IP than either the field's discovery well or either well in Carter Field. The Burlington Resources Oil & Gas Company #44-7H Agribank had an IP of 247 BO + 113 BW + 400 MCFPD and produced 4,762 BO in the 15 days it produced during 1997. Neither the two wells in Carter Field nor the discovery well for Customs Field are likely to be economic at the production rates seen at the end of 1997. However, the second well in Customs Field could be economic if its production rate remains high.

Burlington Resources Oil & Gas Company adapted its drilling practices to better drain the rocks between their first and second wells in both Customs and Carter fields. In both fields the first horizontal well was drilled with a single-leg borehole while the second well was a multilateral with 3 legs. The multilateral design is much more likely to drain an entire spacing unit and seems to be the better design. Both multilateral wellbores produced more fluid than did the two single-leg wellbores, but the multilateral in Customs Field resulted in greater oil productivity than did the one in Carter Field. The reason for the difference in oil and water production is not known, but two possibilities are: 1) that a water-bearing fracture was encountered, cutting off the oil, or 2) that the rocks have a lower oil saturation and cannot produce more oil. Whatever the reason for the water, both multilateral wells did produce more fluid and all the new horizontal wells drilled in Burke County are now multilateral.

The second horizontal Madison play targets the Nesson pay in Williams County. A total of eight horizontal wells were drilled in the play during 1997 by Ocean Energy, Inc. and Chesapeake Operating, Inc. Together they drilled three wells in East Fork Field, two in Last Chance and Williston fields, and

one in Cow Creek Field. The average IP of each field's wells was 279 BO + 171 MCF + 63 BWPD in Cow Creek Field, 128 BO + 62 MCF + 104 BWPD in East Fork Field, 78 BO + 49 BWPD in Last Chance Field, and 215 BO + 51 BWPD in Williston Field. By the end of 1997 the average daily horizontal well's oil production from the four fields was 77, 77, 16, and 97 BOPD respectively; less than half the initial daily average. Most of the wells produced for eight or fewer months during the year and a greater than 50% annual decline rate is evidence that none of the wells will ultimately produce significant amounts of oil.

Outside of these two main horizontal Madison plays, horizontal wells with initial potentials greater than 500 BOPD were completed from Madison strata in two fields, the Burlington Resources Oil & Gas Co. #11-15H Josoden in Willmen Field and the Ballantyne Oil #1H Rice et al. in Renville Field. The wells had IPs of 508 BO + 450 MCF + 56 BWPD and 560 BO + 114 BWPD, respectively. During 1997, the Josoden produced 40,083 BO in 211 days of production, a sustained average of 190 BOPD, while the #1H Rice produced 11,131 BO in 61 days for a sustained average of 182 BOPD.

Ballantyne Oil drilled three more horizontal wells in Wayne Field bringing the field total to twelve. The average IP of the three wells was 262 BO + 193 BWPD, a good rate, but much lower than the 1996 three-well-average of 436 BO + 50 BWPD. The drilling in Wayne Field remains the most successful horizontal Madison well program in North Dakota to date. During 1997, 30 vertical wells produced 79,186 BO while the 12 horizontal wells produced 384,350 barrels. The horizontal Madison wells in the field are producing oil that otherwise would have not been produced by the vertical wells.

A new horizontal Madison program was begun in north-central North Dakota by Citation Oil & Gas Corp. which drilled one horizontal Madison well in Cimbel and Stinson fields and two horizontal wells in Elms Field. The average IP of the four wells was 114 BOPD. By the end of 1997, the average had fallen to 77 BOPD but, compared to many horizontal Madison wells in North Dakota, these four maintained their oil-production rate at a high percentage of their IP. In contrast to the good oil-production rate, three of the four wells initially produced more than 300 BWPD. By the end of 1997 all four wells had produced a total 69,271 BO + 446,302 BW, a cumulative oil-water ratio of 1:6. Without a low-cost water disposal system it is unlikely that these wells will be economic ventures.

New vertical wells drilled during 1997 resulted in several discoveries, as did several recompletions. One existing play that saw some new wells was the Lodgepole play in Stark County where five Lodgepole-mound wells were completed. Three wells were completed in Stadium Field, one in Eland Field, and one in Livestock Field. The latter well also was the discovery well for the one-well Livestock Field. The IP of the five wells averaged 1,537 BO + 29 BW + 563 MCFPD. One well in Stadium Field, the Duncan Oil, Inc. #1-3 Dinsdale, was completed pumping 5,106 BO + 1,141 MCFPD, a much higher IP than the other two completions in the field. Duncan Oil, Inc. also completed the other two wells, the 33 #1 Kostelecky for 268 BO + 134 MCF + 146 BWPD and the #1-9 HR for 876 BO + 696 MCFPD. The #1-9 HR was probably capable of oil-production rates similar to that of the #1-3 Dinsdale, but the Kostelecky well produced so much water that it probably was not capable of sustaining such a high oil-production rate.

Duncan Oil, Inc. also discovered Livestock Field with their #1-10 Dinsdale well in section 10-T139N-R96W. The well was completed pumping 561 BO + 224 MCFPD from a small Lodgepole mound. The field was fully developed by the discovery well and was the last Lodgepole field discovered in Stark County.

Renewed drilling in Schefield Field by Fortson Oil Company, added three new Silurian oil wells during 1997. Until these wells were drilled, the field had been a one-well field since its discovery in 1981. The Fortson Oil Company #1 Koppinger was drilled in section 20-T137N-R95W and completed in the Silurian Interlake Formation pumping 437 BO + 132 MCFPD. The #1 Koppinger offset the field discovery well that had produced more than 200,000 BO from the Silurian pool. The two other wells completed during 1997 had initial potentials of 413 BO + 360 MCF + 3 BWPD and 103 BO + 172 BWPD. The three wells produced 97,641 BO during 1997, but only 480 barrels came from one of the wells.

Six Tyler or Heath tests produced oil during 1997, although one of them was plugged and abandoned after producing only 42 BO. The Burlington Resources Oil & Gas Co. #11-7 MOI Patterson Lake test in section 7-T139N-R96W pumped 70 BOPD from the Tyler Formation and discovered the Eland Tyler pool. The well was originally drilled as a northeast extension to the Lodgepole mound in Eland Field, but was dry. Amerada Hess Corp. completed the #30 Medora Heath-Madison Unit well pumping 221 BO + 3 BW + 14 MCFPD from the Heath Pool after the Madison Pool was proven to be nonproductive. In Fryburg Field, Westport Oil & Gas C., Inc. completed two Tyler wells. The first well, the #11-24 SFTU, pumped 112 BO + 105 BWPD, while the #30-26 SFTU pumped 490 BO + 20 BWPD. The last Tyler well completed during 1997 was in Tracy Mountain Field, a few miles south of the Westport wells where the Chesapeake Operating, Inc. #1-17 Tracy Mountain Federal pumped 128 BO + 8 BW + 22 MCFPD.

Eight new pools were discovered by recompletions in existing wells during 1997 (Appendix II). Six of the eight discoveries are from pre-Madison pools and are of interest simply because they are a demonstration of the multiple zone potential in North Dakota. The remaining two are Madison pool discoveries. One of the two is significant because it extends the limit of Madison production several townships to the southwest.

The new pre-Madison pools include two Birdbear pools and one each in the Gunton, Stonewall, Winnipegosis, and Duperow formations. The two Birdbear pools, discovered in South Boxcar and Beaver Creek fields, had IPs of 133 BO + 43 BW + 125 MCFPD and 81 BO + 18 BW + 49 MCFPD, respectively. The Gunton pool discovery in Daneville Field was made by Basic Earth Science Systems, Inc. The well initially pumped 149 BO + 29 BW + 41 MCFPD, but had declined to 79 BOPD by the end of the year. In Sioux Field, Exxon Company, U. S. A. completed the #1 Wiser Oil for 132 BO + 33 BW + 201 MCFPD. This well also declined significantly producing only 54 BOPD at year's end.

North Tioga Field was the location of a new Winnipegosis pool. Berco Resources, Inc. completed the #1 Strombeck for 189 BO + 104 MCFPD. The well was reported as producing 8,513 BO from the Winnipegosis between June and August 1997. However, Winnipegosis production was commingled with existing Stonewall production and fingerprint analysis is unable to distinguish the two crudes. Since August 1997, all the production has been assigned to the Stonewall pool. Because of the similarity of the oils, 100% of the production has been assigned to one or the other of the pools and the percentage that is Winnipegosis is unknown.

The only other pre-Madison recompletion was made by Naumann Oil & Gas, Inc. in the #1 State Rogness in Bully Field. There, the Duperow Formation was the target and the well was completed for 74 BO + 368 BWPD and produced 2,091 BO and 9,740 BW during 1997. The well maintained a 1:5 oil-water ratio, but did not produce a significant amount of oil.

The last new pool recompletion was in Williams Creek Field. The field lies in T137N-R105W in Golden Valley County. Before this discovery, the southernmost Madison production was in Square Butte Field approximately 22 miles northeast of Williams Creek Field. The discovery well was the Berco Resources, Inc. #1 Gearey with an IP of 91 BO + 143 BW + 40 MCFPD. The well was still producing 71 BOPD at the end of 1997 and had produced 7,082 BO and nearly 13,000 BW during the 90 days it produced during 1997. This discovery extends Madison Group production southwest of its previously known productive limit and is evidence that the true southern limit of Madison production remains, unknown. If so, other structures south of existing production in Square Butte and Knutson fields could also be productive.

SUMMARY

The most active play during the late 1980's and early 1990's was the horizontal Bakken Shale play. By the end of 1995, drilling in the horizontal Bakken had ceased and the play was over. The play was important to North Dakota because it generated heightened interest in the state, caused new leases to be taken, caused many wells to be drilled, produced enough oil to help stop the decline in annual oil production during 1990, and helped prove that horizontal drilling was both mechanically possible and an economically desirable technology. Even though the horizontal Bakken play is over, there will always be a few Bakken completions made as a bailout zone before a well is abandoned.

During 1993 the Lodgepole Waulsortian mound play began around Dickinson. The play drew national attention because of the prolific flow-rates seen from mound wells. Interest in the Lodgepole play was the highest of any play in the basin since the Bakken play and possibly exceeded it. Several fields, each containing several million barrels of oil, were discovered close to Dickinson between 1993 and 1996, but there has not been a significant find since then. The fact that the play was not successfully extended beyond the immediate Dickinson area also caused a drop in activity.

During 1994, the horizontal Red River "B" zone play in Bowman and Slope counties began with the discovery of Cedar Hills Field. This play has some common origins with the horizontal Bakken play as the first wells in this play were drilled in Montana at about the same time that the first horizontal Bakken tests were drilled in 1986 and 1987. The two plays are also similar in that very few of the wells are dry holes and initial production rates are often high. By comparison, the horizontal Red River wells in Cedar Hills Field produced slightly more oil during 1997 than did all the known Lodgepole mounds. Lodgepole mound wells had tremendous initial flow rates, but the greater number of Red River wells has made up for the higher production rates from the Lodgepole units. Production from the Lodgepole and Red River plays caused North Dakota's annual oil production to rise for the first time since 1982.

Another bright spot in the state is that the number of units formed annually was up three straight years (1995-1997). In general, unitization of oil fields results in increased oil production over both the short and the long term, and often is both a less expensive and less risky way to add new reserves than an active exploration program. Hopefully, this trend will continue into 1996 and beyond.

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APPENDIX I. 1996 New Field Discoveries

County File No. Order No.	Comp. Date Disc. Type	Operator Well Name & Location	Field - Pool (No. of Producing Wells in Pool on (2/31/97)	Total Measured Depth of Spacing	Perforated Intervals	IP (Cur. BOPD)	Gas (MCF) Grav.	Water GOR
Stark 13789 7557	11/8/95 N	Conoco, Inc. Karsky 35 #2 Sec. 35, T140N, R97W	West Dickinson** Lodgepole 3	10,260	9,812-9,854g	1081 170	540 45°	22 499
Renville 13929 7268	1/18/96 N	Edward Mike Davis Davis Perron #33-25 Sec. 31, T163N ,R85W	North Mouse River Park Madison 1	5,780 40	4,716-4,720g	105 13	0 29°	0 0
Bottineau 13884 7267	2/9/96 R	Ballantyne Oil Rice Trust #1 Sec. 8, T163N, R82W	Renville Madison 3	5,400 40,4/640OH 2/320OH	4,221-4,225g	14 8	0 30.2°	2 0
Renville 13992 7362	2/25/96 N	Hugoton Energy Corp. Watne "31" #1 Sec. 31, T163N, R86W	South Pleasant Madison 1	5,000 80	4,818-4,846g	10 0	0 26.9°	42 0
Divide 13825 7571	5/19/96 N	Samedan Oil Corp. Bekkedahl #44-25 Sec. 25, T160N, R96W	Hamlet Bakken 1	11,281 160	9,222-9,238g	32 0	64 40°	7 2000
Stark 13973 7558	6/12/96 N	Conoco, Inc. State Addition 5 #1 Sec. 5, T139N, R96W	Subdivision Lodgepole 1	10,040 320	9,657-9,682g	631 58	0 45°	300 475
McKenzie 11747 7624	6/19/96 R	Westport Oil & Gas Co., Inc. Nelson 17 #1 Sec. 17, T152N, R101W	Camp Duperow 1	13,850 320	11,396-11,444g	137 37	385 41.3°	151 2,810
Williams 11126 7644	6/26/96 R	Citation Oil & Gas Corp. Leonardo Fee #1 Sec. 19, T157N, R95W	Midway Madison 1	12,935 320	8,334-8,346g	15 0	16 41°	67 1066
Stark 13851 7566	6/27/96 N	True Oil Co. Tormaschy #32-34 Sec.34, T140N, R94W	Gladstone Stonewall 1	12,015 320	11,526-11,536g	48 25	0 46°	24 0
Stark 13937 7331	9/21/96 N	Armstrong Operating, Inc. Heidt #24-1 Sec. 24, T138N, R97W	Crater Silurian 1	12,010 160	10,941-11,044g	185 45	93 37.6°	0 500

APPENDIX I. 1996 New Field Discoveries
Continued

County File No. Order No.	Comp. Date Disc. Type	Operator Well Name & Location	Field - Pool (No. of Producing Wells in Pool on (2/31/97)	Total Measured Depth of Spacing	Perforated Intervals	IP (Cur. BOPD)	Gas (MCF) Grav.	Water GOR
McKenzie 8969 7685	9/23/96 R	Texaco Inc. A. Johnsrud "A" #1 Sec. 9, T150N, R99W	Tobacco Garden Madison 1	14,430 320	9,822-9,837g	10 0	0 41.4°	150 0
Dunn 14,442 7681	10/15/96 N	Armstrong Operating, Inc. Beaudoin #36-1 Sec. 36, T144N, R97W	Cabernet Madison	9,618 160	9,529-9,565g	283 77	145 40.8°	108 511
McKenzie 9995 7686	10/18/96 R	William Herbert Hunt Trust Estate Dore #3-10X Sec. 3, T150N, R104W	Nelson Bridge Duperow 1	12,930 320	10,926-10,959g	101 27	65 47°	35 644
McKenzie 14,399 7793	11/16/96 N	Amerada Hess Corp. Lovaas #6-32 Sec.6, T150N, R95W	Blue Buttes Winnipeg/Deadwood 1	15,025 640	14,610-14,792g	0 0	3366 NA	7 >3,000,000
Stark 14212 7733	11/22/96 N	TransTexas Gas Corp. Heart River #1-4 Sec. 5, T139N, R96W	Stadium Lodgepole 5	10,620 Unit	10,174-10,208g	4331 832	800 43.3°	0 185

** Note: West Dickinson was actually discovered during late 1995 but because it was on confidential status at the time the 1995 production report was issued it was not included in 1995 statistics. Instead I am reporting it with the 1996 discoveries but I have added one new pool to the 1995 value from the previous update.

R = Recompletion
N = New Well

APPENDIX II. 1997 New Field Discoveries

County File No. Order No.	Comp. Date Disc. Type	Operator Well Name & Location	Field - Pool (No. of Producing Wells in Pool on (2/31/97)	Total Measured Depth of Spacing	Perforated Intervals	IP (Cur. BOPD)	Gas (MCF) Grav.	Water GOR
Burke 14531 7665	1/17/97 N	Burlington Resources Oil & Gas Company Durward et at #11-24 Sec.24, T162N, R90W	Carter Midale/Nesson 2	14,531 640	6,061-9,900	193 36	207 40.3°	25 1073
Bowman 14265 7855	1/18/97 N	Burlington Resources Oil & Gas Company Federal Harr #41-18H Sec. 18, T131N, R105W	Sunset Butte Red River C 1	12,841 320	9,265-12,841	93 8	23 33.1°	93 250
Burke 14578 7815	1/31/97 N	Burlington Resources Oil & Gas Company Warner et at #13-13H Sec. 12, T163N, R90W	Customs Midale/Nesson 2	9,335 320	5,638-9,335	46 19	37 39.8°	37 800
Stark 13836 7941	5/20/97 N	Duncan Oil, Inc. Dinsdale #1-10 Sec. 10, T139N, R96W	Livestock Lodgepole 1	10,430 320	10,070-10,105	561 96	224 45°	0 200
Divide 6705 7968	6/8/97 R	Basic Earth Science Systems, Inc. George C. Anderson #25-1 Sec. 25, T161N, R103W	Daneville Gunton 1	11,300 320	10,864-10,914	149 79	41 36.6°	29 2751
Burke 12062 7940	6/10/97 R	Berco Resources, Inc. Strombeck #1 Sec. 31, T160N, R94W	North Tioga Winnipegosis 1	12,560 160	10.920-10,929	189 0	104 46°	0 550
McKenzie 10848 7969	6/15/97 R	Exxon Company, U. S. A. Wiser Oil #1 Sec. 6, T151N, R101W	Sioux Stonewall 1	13,650 320	12,0990-13,022	132 54	201 49 7°	33 1523
McKenzie 11125 8089	6/17/97 R	Naumann Oil & Gas, Inc. State Rogness #1 Sec. 16, T148N, R100W	Bully Duperow 1	14,089 320	11,724-11,771	74	0 42°	368 0
McKenzie 13442 7868	6/27/97 N	Burlington Resources Oil & Gas Company Missouri #1 Sec. 30, T151N, R104W	Nohly Lake Madison 1	12,800 320	8,895-8,938	9 5	0 38.4°	40 0

APPENDIX II. 1997 New Field Discoveries
Continued

County File No. Order No.	Comp. Date Disc. Type	Operator Well Name & Location	Field - Pool (No. of Producing Wells in Pool on (2/31/97)	Total Measured Depth of Spacing	Perforated Intervals	IP (Cur. BOPD)	Gas (MCF) Grav.	Water GOR
Golden Valley 11422 8059	7/10/97 R	Westport Oil & Gas Co., Inc Mesa Federal #1-9 Sec. 9, T143N, R103W	Beaver Creek Birdbear 1	12,600 320	10,554-10,562	81	49 42.8°	18 605
McKenzie 12983 8056	8/6/97 R	Choctaw II Oil & Gas, Ltd. Spring Creek #27X-31BN Sec. 27, T148N, R102W	South Boxcar Birdbear 1	13,560 320	11,036-11,078	133 118	125 42°	43 940
Bowman 14634 8007	8/16/97 N	The Exploration Company Martha #1-36 Sec. 36, T129N, R102W	Corey Butte Red River 1	9,250 320	9,018-9,040	92 15	5 32°	114 54
Stark 14308 8037	9/13/97 N	Burlington Resources Oil & Gas Company MOI Patterson Lake #11-7 Sec. 7, T139N, R96W	Eland Tyler 1	10,285 160	7,768-7,774	70 58	0 34.4°	0 0
Golden Valley 12227 8109	10/2/97 R	Berco Resources, Inc. Gearey #1 Sec. 22, T137N, R106W	Williams Creek Madison 1	10,734 320	8,354-8,357	91 71	40143 41°	 440
McKenzie 14728 8167	11/6/97 N	Summit Resources, Inc. Summit State Saetz #8-36R Sec. 36, T147N, R98W	Lone Butte Duperow 1	11,940 320	11,735-11,765	120 216	200 39.2°	2 1666
Ward 14743 8147	11/11/97 N	Alenco Oil & Gas (ND) Inc. Alenco Eckmann 156-87-5 #AAA Sec. 5, T156N, R87W	Passport Madison 1	8,071 160	6,728-6,736	240 69	0 30°	0 0
Bowman 14171 8183	11/26/97 N	The Exploration Company Marty #1-17 Sec. 17, T130N, R102W	Cold Turkey Creek Red River B 1	12,963 320	10,078-12,963	113 70	25 36°	290 221

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