Bureau *of* Business &
Economic Research

Oil and Gas Revenue Forecasting: New Mexico State Land Office

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I. INTRODUCTION

The UNM Bureau of Business and Economic Research (BBER) was requested by the State Land Office to explore alternative methodologies for estimating oil and gas renewable revenue sources (bonus payments, rents and interest earnings) as well as non-renewable sources (royalty income). Specifically, BBER was to do the following:

a. Review the legal basis for collection of oil and gas revenues;
b. Through discussions with staff and review of SLO internal documents, map out processes for the leasing of land units with oil and gas resources and for determining applicable rental and royalty rates;
c. Collect data from SLO, from ONGARD system and from other sources bearing on production, prices and SLO revenues;
d. Attempt to model SLO oil and gas revenues for leases, bonus and royalties and determine what additional information may be needed to forecast these revenue streams more accurately; and
e. Report findings and develop a research proposal for a more detailed study.

This report presents our findings. The first section of the report, which is based on a careful review of State statute and SLO documents as well as conversations with SLO staff responsible for leasing, discusses SLO oil and gas leases and issues related to leasing. The second section focuses on methodologies and issues related to forecasting bonus payments. The third section focuses on methodologies and issues related to forecasting royalty payments.

II. STATE LAND OFFICE OIL & GAS LEASES

The State Land Office has authority under Section 19-10-1 NMSA 1978 to enter into leases for "the exploration, development and production of oil and natural gas, from any lands belonging to the state of new Mexico, or held in trust by the state under grants from the United States of America, and including land which have been or may hereafter be sold by the state with reservations of minerals in the land…" Three important revenue streams can result from the leasing of a tract of land and/or of the subsurface oil and gas mineral rights: one time revenue in the form of the bonus payments made to acquire the lease, annual rental payments as stipulated in the lease; and royalty payments made monthly in accordance with the terms of the lease agreement. The minimum annual rental payment per acre is $0.25; the maximum is $1.00.

Rental payments and bonus payments are both classified as "renewable revenues" and are available to cover State Land Office expenses, with the balance deposited in the Current School Fund of the General Fund. Royalty payments depend upon the volume of production and the price paid per unit for the oil or natural gas with the royalty rate specified in the lease as governed by statute.[1] Royalty payments are considered "non-renewable revenues" and are deposited in the State Permanent Fund. The corpus of this fund is inviolate and is invested by the State Investment Officer. Income earned on the corpus is distributed to 22 beneficiaries on behalf of whom the State Land Office manages the lands and resources of the State. The distribution for the common schools is paid into the Common School Fund of the State's General Fund. Universities and other schools, which are beneficiaries under the State Constitution, receive monthly checks from the State Investment Officer.[2]

Significant is the language in Section 19-10-1 limiting the application of the act to new leases: amendments in the act "shall be effective only as to such leases issued subsequent to the effective date of this act…" Where there is production under an existing lease, the lease will be continually renewed with the maximum royalty rate equal to the historical rate charged. Statutory changes between 1975 and 1986 resulted in changes in the royalty rates that could be charged on new leases. Legislation during

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[1] As is noted elsewhere, where there is no production, the leases set a royalty rate based on a multiple of the annual rental.

[2] According to Article XII, Sec. 7 (Investment of permanent school fund), Paragraph F, "Except as provided in Subsection G of this section, the annual distributions from the fund shall be five percent of the average of the year-end market values of the fund for the immediately preceding five calendar years. " Under specified conditions and for specified periods of time, Section G provided extra distributions "to implement and maintain education reforms".

this period also changed the term of leases from the 10 years to 5 years. State Land Office staff in charge of leasing speak of the 1975 to 1985 V-series as set by statute:[3]

Table 1. Royalty Rates & Lease Terms by V-Series and Statutory Date

V-Series	Royalty Rate	Lease Term	Date of Statute
VO	1/6	5 years	1975
VA	1/8	5 years	1984
VB	3/16	5 years	1985
VC	1/5	5 years	1986

Current statute allows for royalty rates on new leases to be fractional between 1/8 and 1/5. However, as noted above, producing leases may automatically be renewed at the old rate. Since all the gas leases in the San Juan Basin continue to have production or, if shut-in, wells capable of material production, there is no leasing in this area and the old royalty rate of 1/8 as well as the old renewable 10 year term continues to apply.

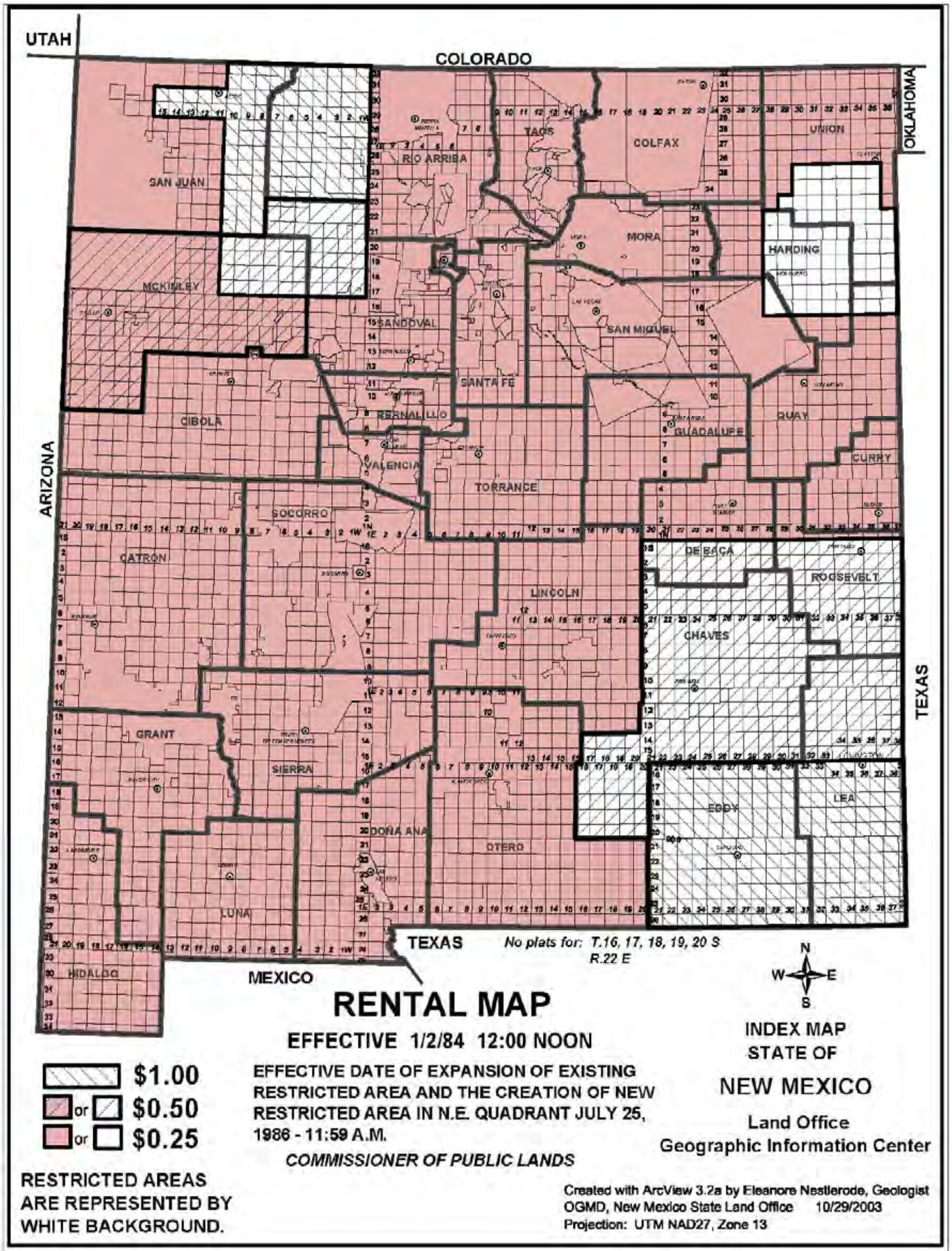
Section 19-10-16 establishes certain districts as **restricted**, with the balance of State land under the jurisdiction of the Land Commission classified as **unrestricted**. Essentially, the restricted districts for oil and gas are those preferred areas of the Permian Basin in southeastern New Mexico and those of the San Juan Basin in the northwest corner of the state, although new areas can be designated by the Commissioner. **Figure 1**, copied from the latest edition of the SLO *Oil and Gas Manual*, which is available online, shows the areas of the state which constitute restricted districts for oil and gas. The map also indicates areas where leases are subject to the maximum $1.00 per acre rent as well as those where a $0.50 or a $0.25 rental rent will be applied

Leases for restricted lands must be made competitively by sealed bid or public auction (Section 19-10-16). Other oil and gas areas are referred to as Frontier Basins. Leases for tracts classified as unrestricted lands are negotiated using the exploratory lease form (Section 19-10-4.1 NMSA 1978). The primary lease is a 5 year lease but can continue indefinitely if producing oil or gas[4] with a royalty rate of 1/8 (12.5%). The annual rental rate is $0.25 or $0.50 per acre, depending upon location, with a minimum annual rent for the lease of $40.

[3] See Oil and Gas Manual, Jan. 2011, p. 73 for a complete list of oil and gas lease dates of issue, prefixes, royalty rates and terms.

[4] For gas, there is an interesting provision, "This lease shall not expire at the end of either the primary or secondary term hereof if there is a well capable of producing gas in paying quantities located upon some part of the lands embraced herein, or upon lands pooled or communitized herewith, where such well is shut-in due to the inability of the lessee to obtain a pipeline connection or to market the gas there from and if the lessee timely pays an annual royalty on or before the annual rental paying date…." The royalty rates to be paid in the case of a shut-in well is laid out in the rental agreement and is based on both the rental rate and the number of terms the lease has been held without production.

Figure 1. State Land Office Map of Restricted and Unrestricted Areas and Applicable Rents per Acre



Source: New Mexico State Land Office Oil and Gas Manual, January 2011

Leasing within restricted districts is more carefully regulated by statute. According to Section 19-10-4, before it can be leased, each restricted tract must be further categorized as based upon: (1) oil and gas trends; (2) oil and gas traps; (3) reservoir volume and recovery rating; (4) lease bonus rating; and (5) exploration and activity. Each factor is allocated a percentage score of zero to 20%. If the total for all factors is greater than seventy-five percent (75%), the tract is categorized as **premium**; otherwise as **regular**.[5] The discovery lease form or the exploratory lease form is appropriate when the tract is classified as regular. The annual rental is $0.50 or $1.00 per acre; the applicable royalty rate for the discovery lease form is 1/6 (0.1667%).

If the tract is classified as premium any of the forms may be used, with a minimum rent of $0.50 or $1.00 per acre, depending upon location, but the royalty rate can exceed 3/16 (18.75%) only if the points awarded are at least 90%. The discovery form of the lease for premium tracts and the development form of the lease for the same both specify that the royalty rate will be not less than 3/16 nor more than one fifth (20%). The lease expires at the end of the primary term (5 years) only if there is not a well capable of producing oil or gas and unless an annual royalty equal to two times the rent up to 10 years and not less than $320 per well per year is paid. A similar set of conditions apply at the end of the secondary term (after 10 years) except that the royalty amount shall equal four times the annual rental due and be not less than $2000 per well. [6]

The statutes anticipate changing market conditions, denial of access to pipelines, etc., with provisions allowing lessees to opt out and the State to modify the terms of the lease.

In determining the form of the lease and the royalty rate to be charged, SLO staff take into consideration the royalty rates charged by other mineral owners.[7] Currently, on Indian lands, the royalty rate is 1/8 for a 10 year lease; on Bureau of Land Management (BLM) lands, the royalty rate is 1/8. According to David Abbey, however, the BLM is currently considering an increase in their royalty rate.[8] On private lands, the royalty rate is typically 1/5 or 1/4 with 3 year lease. According to SLO staff, the SLO tries to keep in the middle, to avoid appearance of “scalping.” The SLO accounts for some 40% of the lands in the Permian Basin, the private sector, roughly the same, with the Federal government, holding some 20%.

[5] This determination is made by staff (geologists) in the Oil, Gas and Minerals Division.
[6] Discovery Form of Lease, Section 19-10-4.2 NMSA, Paragraph 2.
[7] Conversation with Joe Mraz and Dan Fuka, May 10, 2011.
[8] Conversation, May 10, 2011.

SLO staff determine the acreage that will be offered for lease, but private industry will often request that certain tracts be included on the list. There is one regular sale every month and there may also be a special sale. Currently, the SLO is continuing the practice of leasing some 10,000 acres every month; although more recently, the average leased in any month is closer to 7,000 or 8,000. A lease may involve as little as 40 acres but never for more than 6,400 acres. In the regular sale on June 21, 2011, 29 tracts were offered and 29 were sold, yielding a total of $17.2 million. The highest sealed bid averaged $5,078 per acre; the highest oral bid, $5,630, with the average for all 29 tracts, $2,061 per acre. By contrast, the May regular sale generated income of $5.0 million for 35 tracts, with the bids averaging $498 per acre.

III. BONUS PAYMENT REVENUE FORECASTING[9]

The purpose of this section is three-fold. First: to provide a picture of the underlying land lease data provided by the State Land Office, particularly the bonus payment revenue component of that data. Second: to identify data trends and develop testable hypotheses pertaining to the estimation (or forecast) of bonus payment revenues. Third: to compare State Land Office forecasts with preliminary BBER forecasts.

Results

While leased acreage is distributed throughout the state, the overwhelming majority of bonus revenues received by the State Land Office originate from acreage leased in Lea, Eddy and Chavez Counties. Therefore, a revenue forecast may be improved by incorporating information about upcoming leases that are expected to become available in those counties, particularly in regions of high productivity or high market demand. This information may be included explicitly in a model or it may be used to adjust a forecast after it is produced by a model.

Since 1994, bonus revenues seem to be correlated with market conditions, specifically the price of oil (West Texas Intermediate) and national employment in the petroleum and coal products sector. Therefore, a reasonable linear model can be utilized which treats oil price and petroleum and coal employment as independent variables that predict/forecast bonus payment revenues on a quarterly basis. It is possible that other variables, or a more sophisticated modeling process, may be used in the future which improves the predictive power of the model.

The BBER forecast model, while not strictly better than the State Land Office forecasts performs better in 5 of the 7 fiscal years for which data is available. The BBER model does have the benefit of perfect hindsight because the dependent variables used are known with certainty (because the data is historical). Nevertheless, BBER's forecasting method is expected to generally perform better than the State Land Office's current method and it can be used as a framework for developing a systematic and rigorous forecasting process.

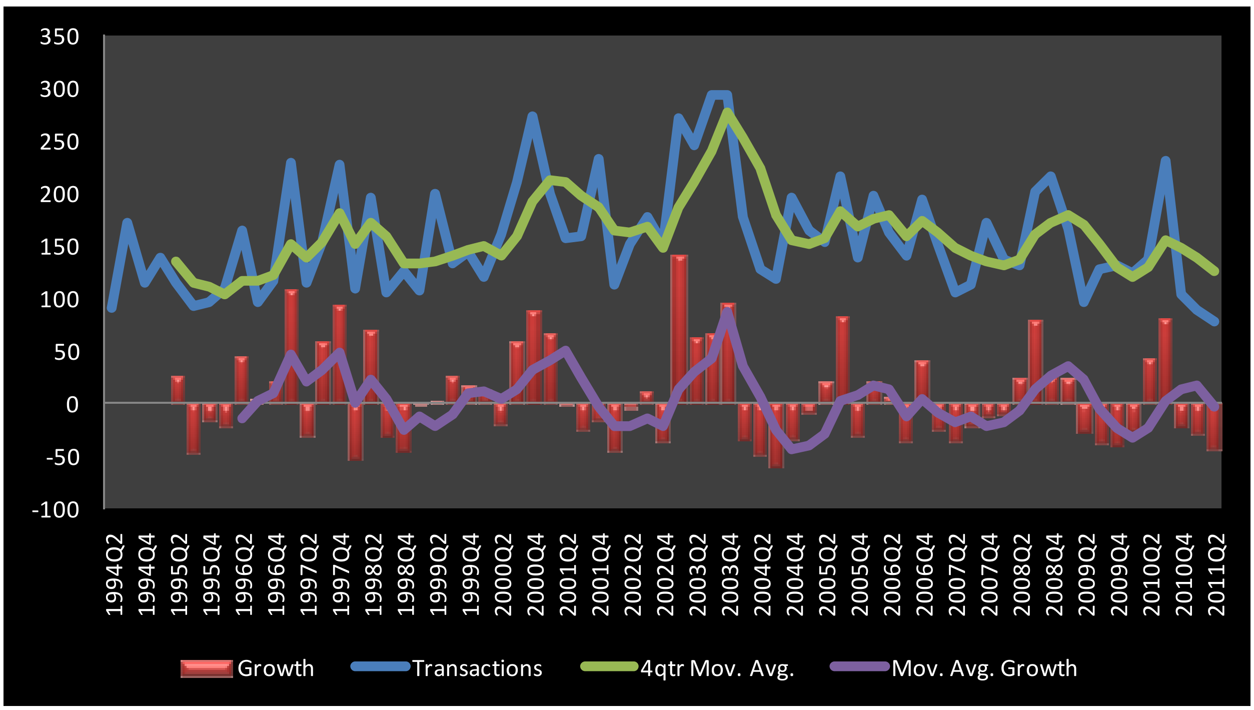
[9] The New Mexico State Land Office provided historical data on leases, bonuses and its own forecasts. IHS Global Insight data was used to inform BBER's forecasting model. BBER's forecast was produced by BBER analysts.

Transactions Involving Bonus Payments & Leased Acreage

According to State Land Office data, there have been 10,852 transactions involving bonus payments since 1994Q2. **Figure 2** shows the total number of transactions by quarter as the solid blue line, the 4 quarter moving average of transactions by the solid green line, year-over-year growth rates as red bars and the year-over-year growth rates of the 4 quarter moving average as a solid purple line. The transaction data appear to be cyclical but somewhat erratic. The 4 quarter moving average data (particularly the growth rate) tends to smooth out some variability and further highlight cyclical tendencies. The vertical axis represents the number of transactions for the two transaction series and year-over-year growth rates for the two growth series.

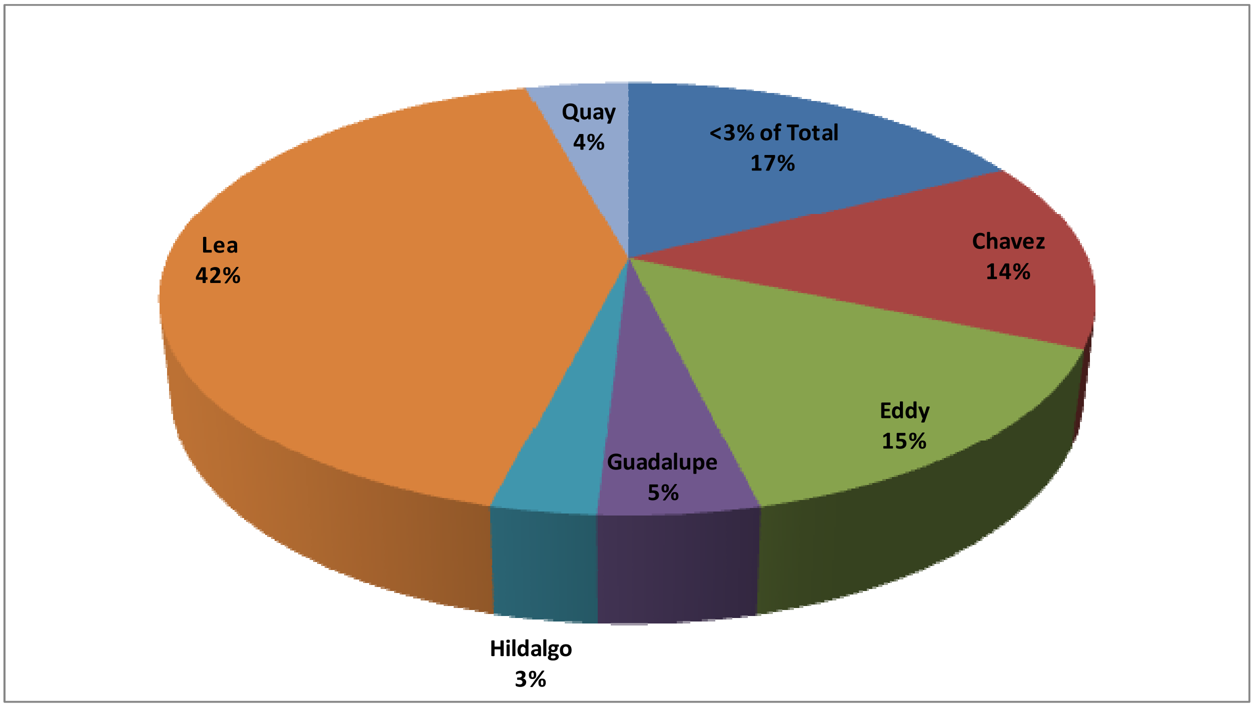
Note that these transactions are invariant to the amount paid by a particular bidder and only represent a count of transactions.

Figure 2. Total Transactions, 4 Quarter Moving Average & Growth Rates by Quarter



Transactions involving bonus payments are highly concentrated in three counties: Lea, Eddy and Chavez counties. Since 1994Q2, those counties constituted 42%, 15% and 14% of all transactions, respectively. Every other county comprise less than 5% of all transaction during the period. **Figure 3** shows the distribution of transactions by county. Each county comprising *at least* 3% of all transactions is individually enumerated while counties comprising *less than* 3% than the total are aggregated.

Figure 3. Distribution of Transactions by County



The most significant single geography, in terms of the number of acres successful bidders receive on a quarterly basis is Lea County. Between 1995 and 2010, over 1/3 of all acreage leased in the state was in Lea. Eddy and Chavez counties were less prominent as each contributed approximately 13% and 14% of total leased acreage, respectively. The rest of the state (not including the three aforementioned counties) contributed over 1/3 of all leased acreage.

Table 2. Contribution to Total Leased Acreage 1995-2010

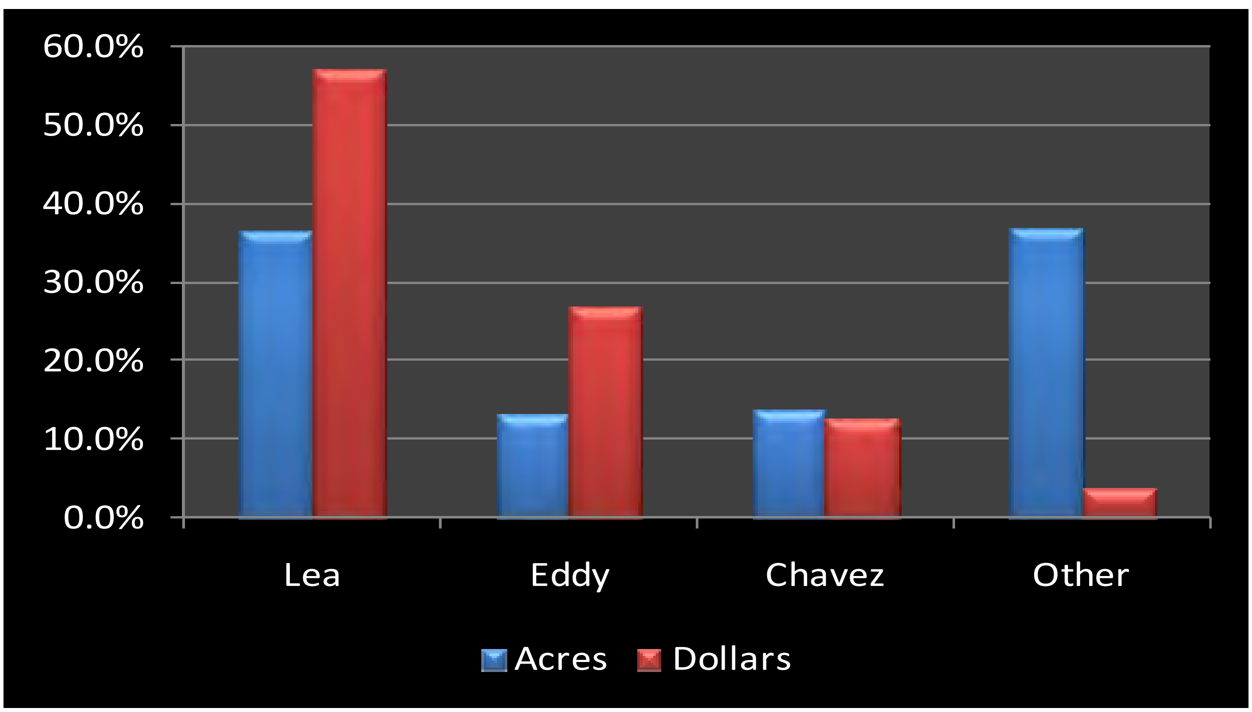
County	Contribution to Total
Lea	36.5%
Eddy	13.0%
Chavez	13.7%
Other	36.9%

Bonus Payment Data

The variable that the State Land Office is interested in predicting is the receipt of bonus payments, as the payments directly impact revenues. Along this front, the most important geography is Lea County. For the period 1995-2010, Lea contributed over 57% of all bonus payment revenues. Despite the relatively small number of acres leased in Eddy County, it contributed over 25% of all revenues during the period. Chavez County was approximately half as important as Eddy, bringing in 12.5% of the total. Together, these three counties contributed 96.4% of all bonus payment revenues while counties in the rest of the state contributed a paltry 3.6%.

Figure 4 is included to show the relative importance of the four geographies in terms of acres leased and bonus payments received by the state. The graph shows that Lea County is the major contributor to acreage, and more importantly, revenues. It also shows that Eddy and Chavez Counties are important contributors, particularly to revenues. Finally, while significant acreage is leased in places other than the three counties, revenues in those geographies are relatively insignificant.

Figure 4. Contribution to Total Leased Acreage and Total Bonus Payment Dollars 1995-2010



Lea County's relatively high contribution to the total bonus payments has stayed fairly consistent through the years. **Figure 5** shows the contribution to total bonus payments by each geography annually beginning in 1994 and ending in 2011. Note that only partial year data is available for the first and last year. Lea County generally predominates, vacillating between 40% and 80% of total in any given year. Eddy County also expands to nearly 40% of total in some years and contracts to approximately 10% of total in others. Chavez County generally stays in a fairly narrow band of 5% to 15% of total for the majority of the series. In 2006, however, Chavez begins to make serious (and anomalous) inroads such that by 2007 it contributes over 40% of all bonus payment revenues. All other counties (combined) contribute less than 8% in every year.

Figure 5. Proportional Contribution to Total Bonus Payment Revenues by Geography – Annually Since 1994

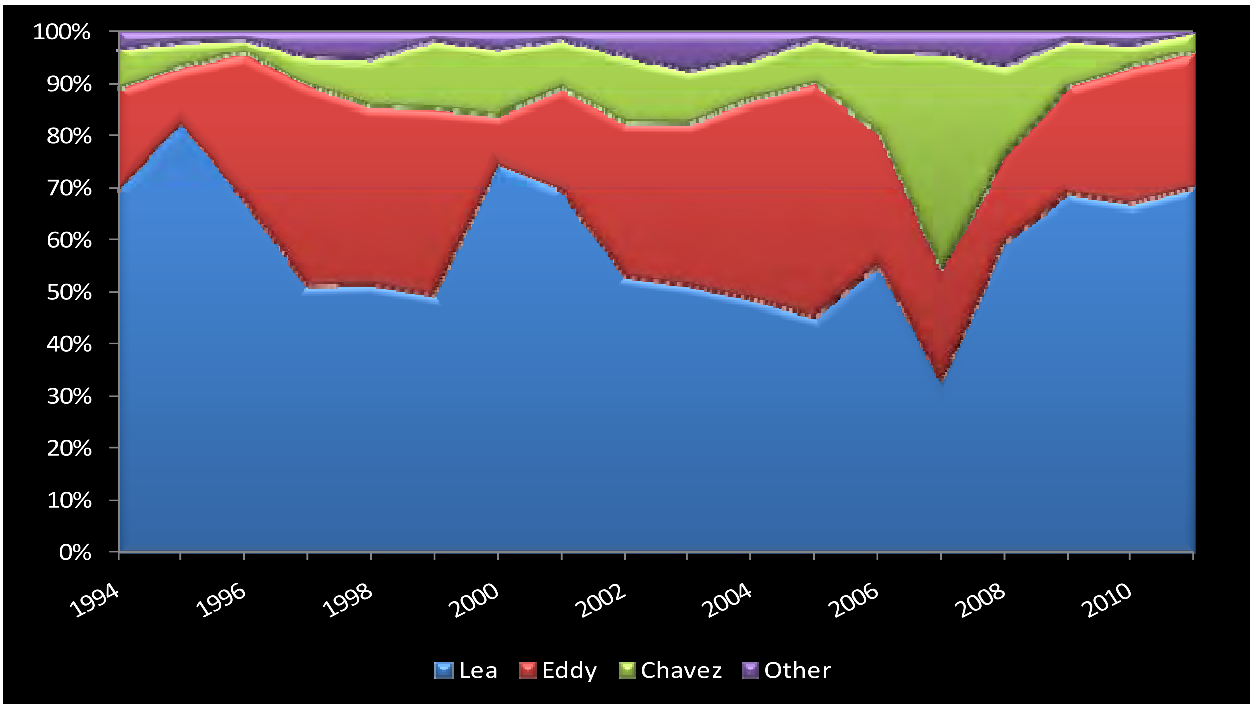


Table 3 shows the underlying data from which **Figure 5** is constructed as well as indicates the total dollar contribution of each geography annually.

Table 3. Total & Proportional Contribution of Bonus Payments by County – Annually Since 1994

	Total Contribution by Year					Proportional Contribution by Year			
Year	**Lea**	**Eddy**	**Chavez**	**Other**	**Total**	**Lea**	**Eddy**	**Chavez**	**Other**
1994	4,507,488	1,260,916	488,576	228,709	6,485,689	69.5%	19.4%	7.5%	3.5%
1995	7,797,456	1,036,535	466,465	196,800	9,497,256	82.1%	10.9%	4.9%	2.1%
1996	8,520,434	3,537,561	346,283	207,185	12,611,463	67.6%	28.1%	2.7%	1.6%
1997	7,006,345	5,234,111	725,794	683,038	13,649,289	51.3%	38.3%	5.3%	5.0%
1998	6,516,179	4,293,730	1,138,636	678,509	12,627,054	51.6%	34.0%	9.0%	5.4%
1999	5,331,401	3,849,519	1,415,085	182,738	10,778,743	49.5%	35.7%	13.1%	1.7%
2000	18,122,615	2,308,728	3,027,656	866,957	24,325,957	74.5%	9.5%	12.4%	3.6%
2001	20,475,711	5,769,963	2,706,687	464,170	29,416,531	69.6%	19.6%	9.2%	1.6%
2002	6,769,314	3,743,845	1,592,367	617,428	12,722,954	53.2%	29.4%	12.5%	4.9%
2003	9,763,792	5,888,850	1,929,060	1,397,238	18,978,941	51.4%	31.0%	10.2%	7.4%
2004	15,948,126	12,506,122	2,442,728	1,790,903	32,687,878	48.8%	38.3%	7.5%	5.5%
2005	25,750,666	25,266,159	4,760,223	915,777	56,692,826	45.4%	44.6%	8.4%	1.6%
2006	29,808,570	13,663,145	8,261,271	2,155,553	53,888,539	55.3%	25.4%	15.3%	4.0%
2007	12,501,863	8,169,770	15,644,217	1,598,806	37,914,656	33.0%	21.5%	41.3%	4.2%
2008	27,753,183	7,744,801	8,021,188	3,061,790	46,580,961	59.6%	16.6%	17.2%	6.6%
2009	28,988,552	8,521,140	3,716,570	738,482	41,964,744	69.1%	20.3%	8.9%	1.8%
2010	36,988,118	14,330,442	2,372,792	1,421,264	55,112,616	67.1%	26.0%	4.3%	2.6%
2011	13,817,332	5,000,971	777,716	54,042	19,650,061	70.3%	25.5%	4.0%	0.3%

Forecasting Bonus Payments

New Mexico State Land Office Method

The State Land Office uses a 5-year moving average to forecast Bonus Payment revenues.

Other States' Methods

Several other states use some method of averaging to forecast bonus payment revenues. According to the 2009 Louisiana Short Term Oil and Gas Forecast published by the Louisiana Department of Natural Resources, that state estimates bonus payments by using the average or the lowest of the last five years' actual data collected. In that document, the current year forecast (2009) appears to be adjusted to reflect current conditions; however, the revenue forecast for the period 2011-2014 is pegged at the lowest of the previous 5 years.

The state of Montana receives rent, bonus and small source royalty revenues for mineral production within the state on federal land. The state indicates that the revenue sources show great variation from period to period and follow now particular pattern. Therefore, the three revenue sources are combined and the forecast is computed by taking the average of the past 13 quarters. The quarterly averages are then multiplied by 4 to obtain a fiscal year revenue estimate.

The state of Alaska produced a semi-annual revenue estimate which includes revenues related to oil exploration and production. While the state carefully estimates and forecasts royalty revenues by using some type of econometric or other modeling process, it does not do the same for estimating bonus payment revenues. Rather the state uses an averaging method to peg bonus payment revenues. The level for which it is pegged is kept the same for every forecast year.

BBER's Proposed Method

A semi-log ordinary least squares regression model with two independent variables and an autoregressive term was used to predict bonus payment revenues (TOTAL) on a quarterly basis. The two independent variables chosen were the price of West Texas Intermediate Crude Oil (POILWTI) and national employment in the petroleum and coal products sector (EMN324). The independent variables were chosen because it was believed that they may have some relationship the dependent variable. The autoregressive term was included as it was discovered that the dependent variable exhibited autoregressive tendencies. Additionally, the effects of seasonality were not included as the data does not appear to be influenced by seasonal factors.

Data for the dependent variable was obtained using the New Mexico State Land Office online lease sales results query at http://www.nmstatelands.org/LeaseSalesResultsQuery.aspx. Data was compiled in excel and converted from monthly into quarterly data by summing all bonus payment revenues for each year and quarter. Full data for the first and second quarters of 1994 and second quarter of 2011 was not available at the time of analysis. Independent variables were obtained from IHS Global Insight's 0611 Baseline Forecast.

In order test whether a relationship exists between the dependent variables and the independent variable, the correlation between the variables was computed and is shown in **Table 4**. The table shows that POILWTI and TOTAL are positively correlated while EMN324 and TOTAL are negatively correlated. Additionally, EMN324 and POILWTI are negatively correlated. This implies that as oil price increases, bonus payment revenue tends to increase and that as national petroleum and coal products employment increases, bonus payment revenue tends to decrease.

Table 4. Correlation Among Variables

Correlations	POILWTI	TOTAL	EMN324
POILWTI	1		
TOTAL	0.770	1	
EMN324	-0.660	-0.688	1

Results for the ordinary least squares regression are shown in **Table 5** and show at least three important results: First, that oil price indicators and employment indicators both are statistically significant and related to State Land Office bonus revenue on a quarterly basis. Second: the overall model is statistically significant, as given by the high F-statistic value. Third: the simple model performs relatively well with an adjusted R-squared of 0.820, meaning that roughly that 82% of the variation can be explained by the model.

Table 5. Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	18.305	1.179	15.523	0.000
POILWTI	0.012	0.003	4.109	0.000
EMN324	-26.449	9.029	-2.929	0.005
AR(1)	0.544	0.105	5.162	0.000

R-squared	0.828	**Mean dependent var**	15.577
Adjusted R-squared	0.820	**S.D. dependent var**	0.673
S.E. of regression	0.285	**Akaike info criterion**	0.386
Sum squared resid	5.122	**Schwarz criterion**	0.518
Log likelihood	-8.934	**Hannan-Quinn criter**	0.438
F-statistic	101.388	**Durbin-Watson stat**	1.908
Prob(F-statistic)	0.000		

Given the significance of the model, **Figure 6** shows actual revenues by quarter (blue bars) compared to forecasted revenues (red line), as produced by the model. Because the model is not perfectly predictive, the forecast doesn't exactly match actual revenues; however, the Figure shows that the general pattern of forecasted revenues generally follows the trends of actual revenues.

Note that there is perfect information concerning historical data. Specifically, the independent variables are known with certainty during the historical period. In future periods, forecasted values of the independent variables would be required to inform the bonus payment revenue forecast. There are multiple forecasting services (such as ISH Global Insight) that provide the required forecasted series.

Figure 6. Forecasted versus Actual Revenue by Quarter

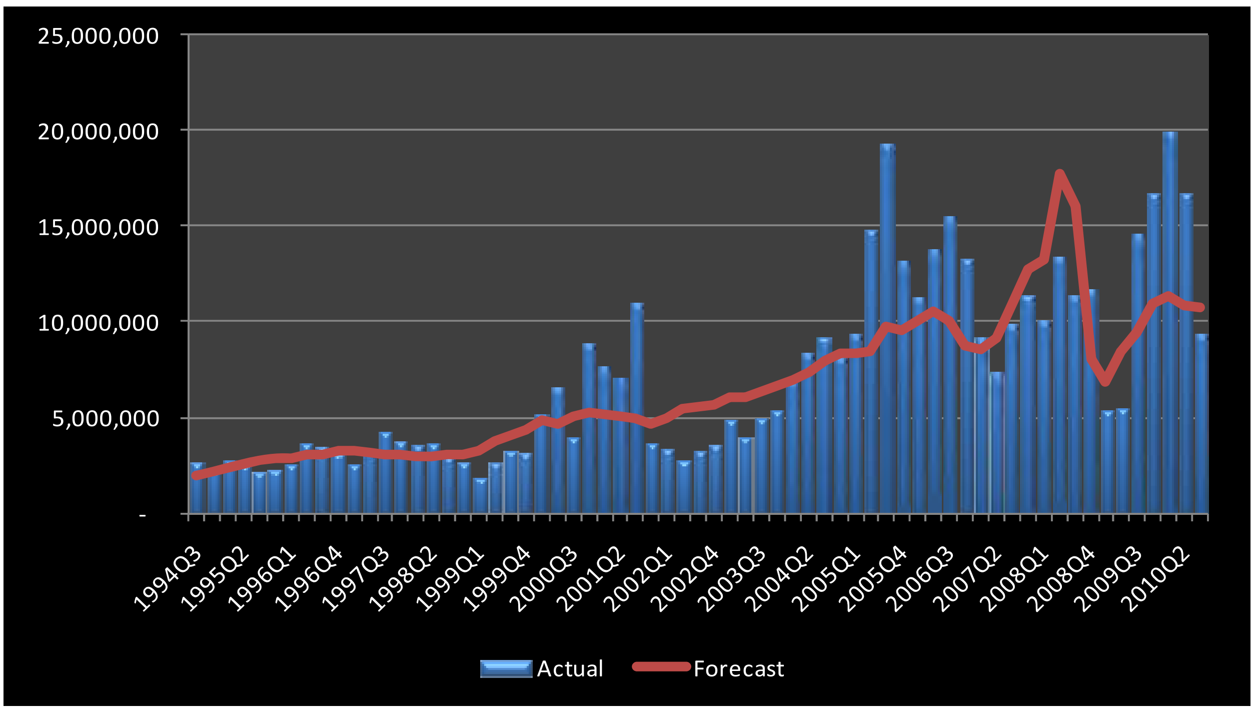
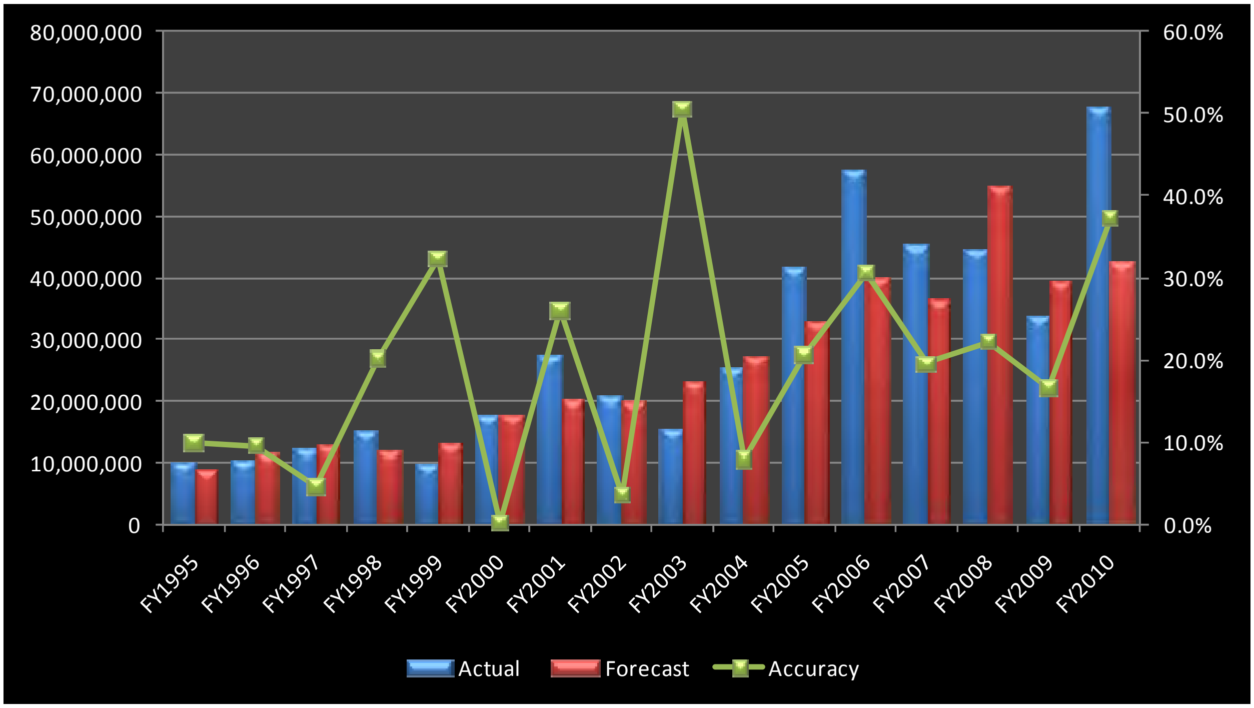


Figure 7 repeats the data shown in **Figure 5** where blue bars represent actual revenues and the red bars represent forecasted revenues. A measure of accuracy is also included (green line). The accuracy line is computed by subtracting the quotient of forecasted revenue and actual revenue from one, taking the absolute value of the number and converting to a percentage term. A measure of 0% indicates that forecasted revenues exactly match actual revenues. The farther away from 0%, the relatively worse the forecast for a particular quarter, as measured in percentage terms.

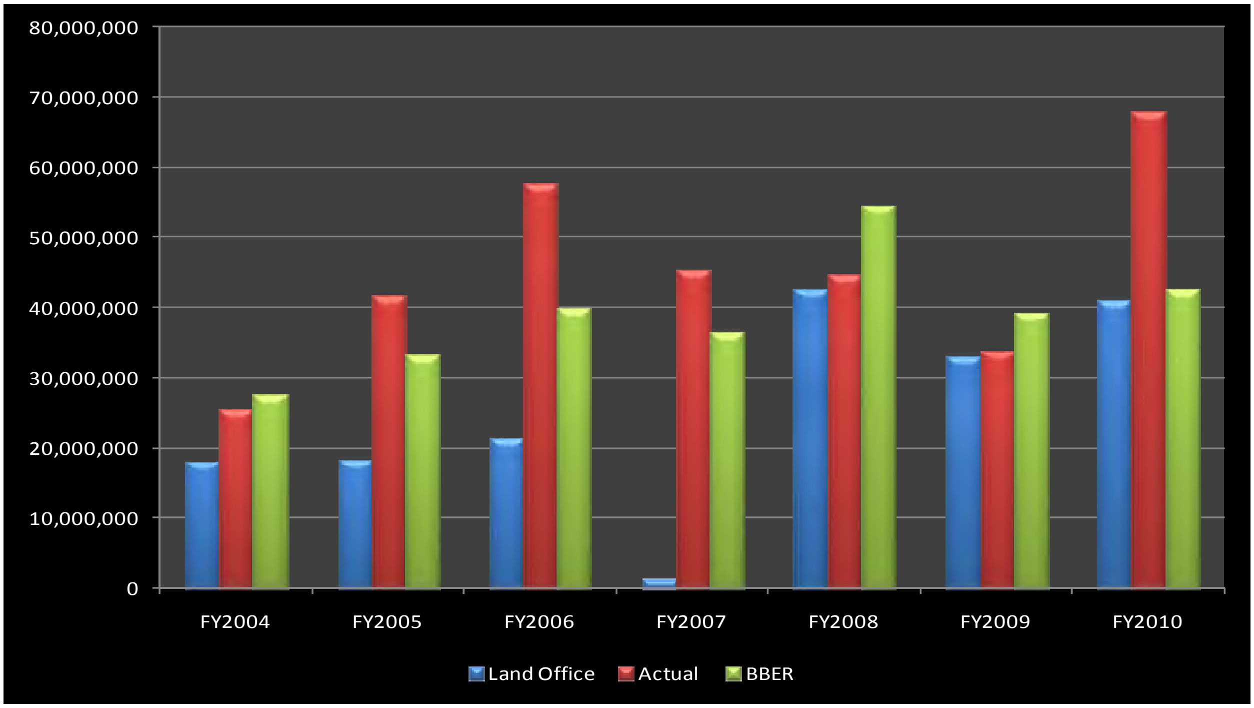
Figure 7. Forecasted versus Actual Revenue by Fiscal Year (left axis) and Accuracy by Fiscal Year (right axis)



Comparison of SLO & BBER Forecasts

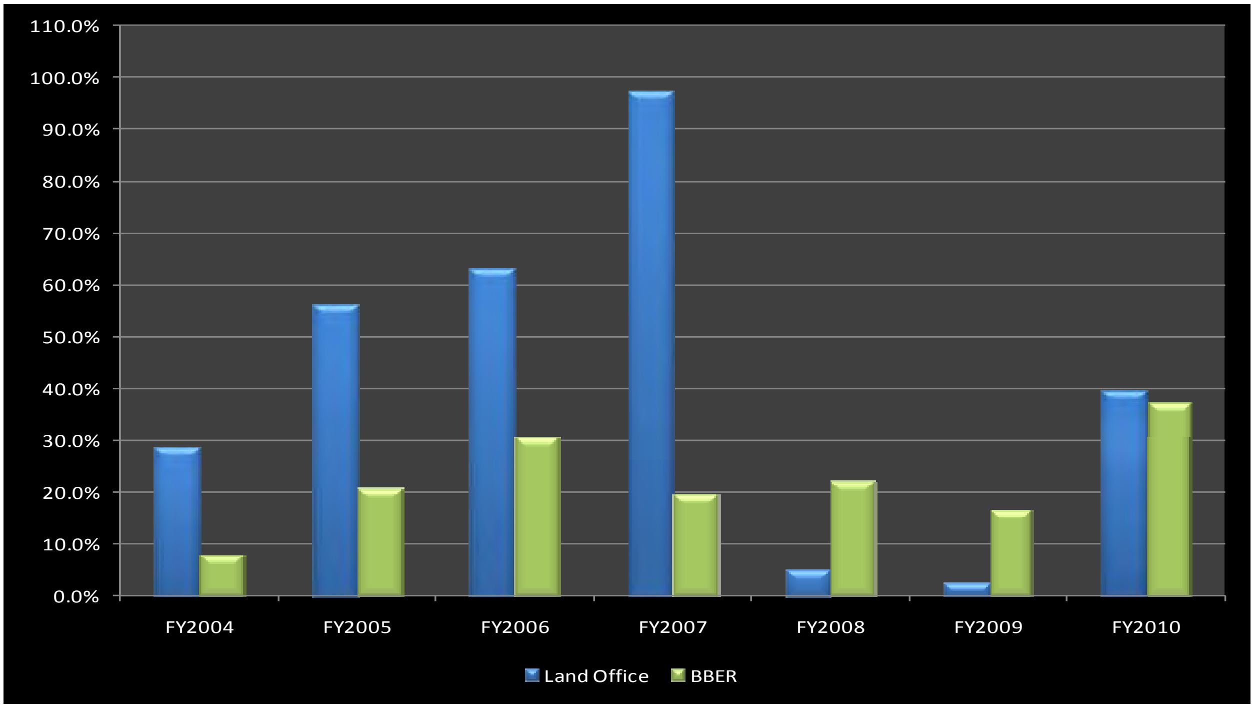
The previous figures show BBER forecasted revenues versus actual revenues; however, it does so without comparison to State Land Office forecasts. **Figure 8** shows the same BBER forecast and actual data shown in the previous two figures but also includes Land Office forecasts beginning in FY 2004. The figure shows that BBER forecasts perform closer to actual in the first 4 periods and the final period while Land Office forecasts perform relatively better in FYs 2008 & 2009.

Figure 8. Comparison of State Land Office and BBER Forecasts with Actual Revenues by Fiscal Year



In order to show how close each forecast is to the actual for any given fiscal year, a measure of accuracy is shown in **Figure 9** in percentage terms. The accuracy bars are computed by subtracting the quotient of forecasted revenue and actual revenue from one, taking the absolute value of the number and converting to a percentage term. A measure of 0% indicates that forecasted revenues exactly match actual revenues. The farther away from 0%, the relatively worse the forecast for a particular quarter, as measured in percentage terms. As already discussed, BBER forecasts perform better in FYs 2004-2007 & 2010, while Land Office forecasts perform better in FYs 2008 & 2009.

Figure 9. Accuracy of Forecast (In Absolute Terms) by Fiscal Year



The data used to create the preceding two figures is included in **Table 6**.

Table 6. Forecasted and Actual Data & Measure of Forecast Error

	Data & Forecasts			Measure of Error	
	Land Office	**Actual**	**BBER**	**Land Office**	**BBER**
FY2004	$18,099,439	$25,428,722	$27,434,639	28.8%	7.9%
FY2005	$18,200,446	$41,646,196	$33,059,066	56.3%	20.6%
FY2006	$21,285,432	$57,554,955	$39,937,229	63.0%	30.6%
FY2007	$1,200,000	$45,417,440	$36,520,502	97.4%	19.6%
FY2008	$42,466,604	$44,796,777	$54,670,785	5.2%	22.0%
FY2009	$32,882,777	$33,768,214	$39,356,727	2.6%	16.5%
FY2010	$41,075,735	$67,839,687	$42,567,664	39.5%	37.3%

Summary & Follow-up

Lea, Eddy and Chavez Counties are particularly important geographies with regard to the receipt of bonus payments because they contribute over 90% of all bonus payment revenues. Therefore, a revenue forecast could potentially be improved by incorporating information about leases that are expected to become available in those counties, particularly in regions of high productivity or high market demand. This information may be included explicitly in a modeling process or it may be used to adjust a forecast after it is created. With respect to the later, if the State Land Office has reason to believe that certain acreage is likely to become available in a productive location within Lea County within the next year (or next several years), for instance, that information may be used as a context for adjusting the revenue estimate upward. With respect to the former, acreage expected to become available within the productive areas can be forecasted by the experts at the State Land Office. That forecast may potentially be directly used as a independent variable that informs a bonus payment revenue forecast.

Even absent the inclusion of information pertaining to leasing behavior (or forecasts) in particular geographies, other variables seem to be correlated with bonus payment revenues; specifically the price of oil (West Texas Intermediate) and national employment in the petroleum and coal products sector. By relating those two variables to bonus payment revenues on a quarterly basis, it is possible to develop a reasonable linear model can be utilized which treats oil price and petroleum and coal products employment as independent variables that predict/forecast bonus payment revenues. It is possible other variables, or a more sophisticated modeling process, may be used in the future which improves the predictive power of the model.

Finally, the BBER forecast model generally appears to perform better than the current State Land Office model on a Fiscal Year basis. It is important to reiterate that the BBER model does have the benefit of perfect hindsight because the dependent variables used are known with certainty (because the data is historical). Therefore, the accuracy of a forecast into the future will largely be predicated upon the forecast accuracy of the chosen independent variables and their continuing relationship with the dependent variable (namely, bonus payment revenue). Nevertheless, BBER's forecasting method is expected to generally perform better than the State Land Office's current method and it may be used as a framework for developing a systematic and rigorous forecasting process. The possibility of including additional variables, and possibly alternative modeling processes, should be investigated further to determine whether the predictive power and accuracy of the model can be improved.

IV. ROYALTY FORECASTING

BBER believes it can increase the accuracy of Oil and Gas Royalty forecasts. The following summary describes the projection model, its components, and possible component data sources.

The Royalty Projection Model

The royalty projection model is structured the same way royalties are calculated, but where the State Land Office uses historical data, we propose to use projections of those data.[10] Royalties are the product of the value of the mineral resource sold less allowed deductions and the royalty rate. The value is the product of the quantity of the mineral resource sold at the price for which it was sold. Allowed deductions include transportation, processing, and marketing costs.

In the simplest case, Equation (1) describes how royalties for a historical period (here designated as time **t**) are calculated from production and price data for the same period and the applicable royalty rate, e.g., 1/8.[11]

$$(1)\ \text{Royalty}_{\mathbf{t}} = (\text{Price}_{\mathbf{t}}*\text{Quantity}_{\mathbf{t}} - \text{Deductions}_{\mathbf{t}})*\text{Royalty Rate}_{\mathbf{t}}$$

Equation (2) describes how royalties are proposed to be projected with projected data.

$$(2)\ \text{Royatly}_{\mathbf{f}}= (\text{Price}_{\mathbf{f}}*\text{Quantity}_{\mathbf{f}} - \text{Deductions}_{\mathbf{f}})*\text{Royalty Rate}_{\mathbf{f}}.$$

Where **f** = some period in the future.

With the Royalty Projection Model constructed, the next step is to specify its components. The model is applicable to oil or to gas, but for demonstration purposes we'll proceed with crude oil royalty projections.

[10] The states of Louisiana and Montana structure their royalty projection models like this. However, Louisiana projects oil and gas prices and production and doesn't rely on outside projections. Montana does not project oil and gas production, but assumes it will be similar to recent history. Department of Natural Resources, Technology Assessment Division , *Louisiana Short-Term Oil and Gas Forecast with Production, Severance and Royalty Price Sensitivity,* February 23, 2009

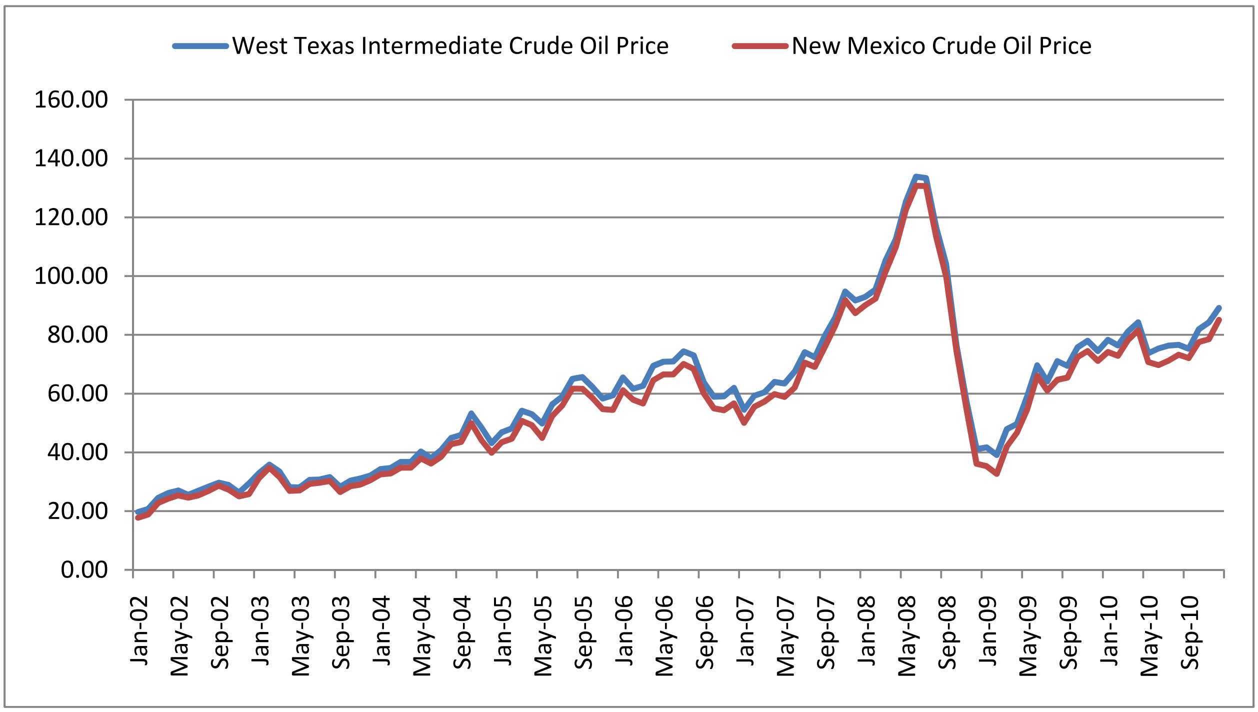
[11] Expanding to the case of multiple royalty rates would require a summation of the products of the net value of production subject to each rate times that rate.

Price Projections

Oil price projections are not available for New Mexico oil, generally called New Mexico Sour, so a quantitative relationship between the average spot price of New Mexico crude oil and the spot price of West Texas Intermediate (WTI) oil must be established. Once the relationship between the two spot prices has been established we assume it will hold for the future prices as well.

There are different grades of New Mexico oil but generally the average price is very closely related to that for West Texas Intermediate. Also, the two are closely related geographically and share the same delivery infrastructure, as opposed to international oil that is shipped in, and should have a similar cost structure. **Figure 10** charts the price of New Mexico Sour and West Texas Intermediate from 2002 January through 2010 September. The price of WTI has been consistently above the price of NMCS, but both prices track very closely to each other.

Figure 10. West Texas Intermediate and New Mexico Sour Oil Prices, Monthly, 2002 to 2010



A regression of the NM price on WTI price indicates a statistically significant relationship (R2=.998). The regression indicates that given the WTI price the NMCS price can be estimated by taking 98% of the WTI price and subtracting $1.96 from it. We will use this relationship to estimate NMCS oil price projections from WTI price projections.

Oil and Price Projections and Projection Methods
The literature is full of oil price projections and projection methods. Each method will be briefly discussed and remain as a candidate to be used as an input to the royalty projection model. The methods that produce the highest and lowest oil price projections will serve as the bounds to show variation that may exist in royalty projections.

Futures Prices for West Texas Intermediate. A futures price represents the contract price between a buyer and seller for a specified amount of oil at a specified price on a future date. The European Central Bank, International Monetary Fund, and the Federal Reserve use oil future prices to forecast inflation and output gap, future spot prices and in policy discussions respectively.[12] Oil future prices are widely available for many different terms. However, Alquist, et al. conclude that for terms of less than a year, the spot price of oil better projects the future price of oil and terms of longer than a year, the oil futures market is not very liquid and losses accuracy.

Oil Price Forecasts from the Energy Information Agency (EIA). The U.S. Department of Energy, Energy Information Administration has as its mission to "… collect, analyze, and disseminate … energy information to promote … policy making, efficient markets, and public understanding of energy." In order to fulfill its mission, the EIA publishes the *Annual Energy Outlook*, with projections on energy information. Projections of WTI are included AEO annually starting in 2015.

Oil Price Forecasts for IHS Global Insight. Global Insight is an information company that provides on a wide range of economic variables for the US and foreign countries. The Global Insight forecast is used by BBER in producing economic forecasts for New Mexico and its MSAs using the FOR-UNM forecasting model. Global Insight forecasts macro economic variables including the average price of WTI oil. The forecasts are quarterly and extend past 2021 Q4.

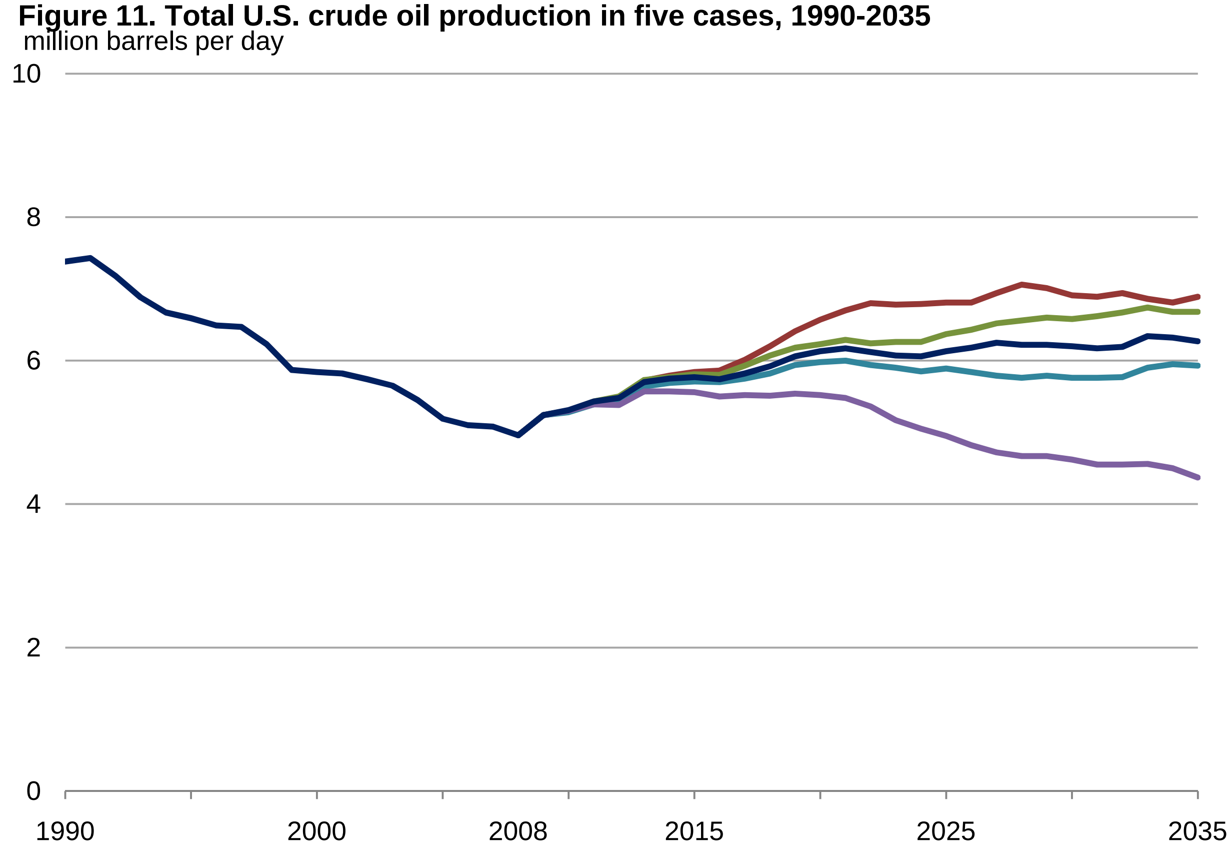
Future Oil Production. Projecting future oil production is a difficult task because the total reserves of oil are not known with certainty and extraction diminishes this unknown quantity. However, new technology (apply described as "oil production enhancement") allows for the production of oil that was previously too costly to extract. One particular new technology, horizontal drilling with hydraulic fracturing (fracking), can dramatically increase the yield today from a new well. Unfortunately, the current ONGARD database includes no variable regarding either the type of well, e.g., horizontal or vertical, nor the use of chemical solutions to release oil trapped in shale deposits thousands of feet below the surface. If the technology lives up to its promise (something that has not happened always with natural gas), the future yield from horizontal wells using this technology will vastly exceed yield from more traditional vertical wells. But the question

[12] Ron Alquist, Kilian Lutz, Robert Vigfusson, "Forecasting the Price of Oil", May 5, 2011.

is how to forecast the impact on total production. Adding to the difficulty, there are no oil production projections specific for New Mexico available.

Energy Information Agency Projections. The Energy Information Agency publishes oil production forecasts in the *Annual Energy Outlook*, but not specifically for New Mexico. Total U.S crude oil production is projected for five cases, high oil price, rapid technology, reference, low technology, and low oil price. The reference case is based on the most likely scenario, while the other cases tweak the oil price and technology assumptions. The annual projections are made out to 2035. New Mexico oil production is not forecast, but the growth rates forecast nationally could be applied to production from SLO leases. **Figure 11** illustrates the different total U.S. crude oil production cases.

Figure 11. Total U.S. crude oil production in five cases, 1990-2035



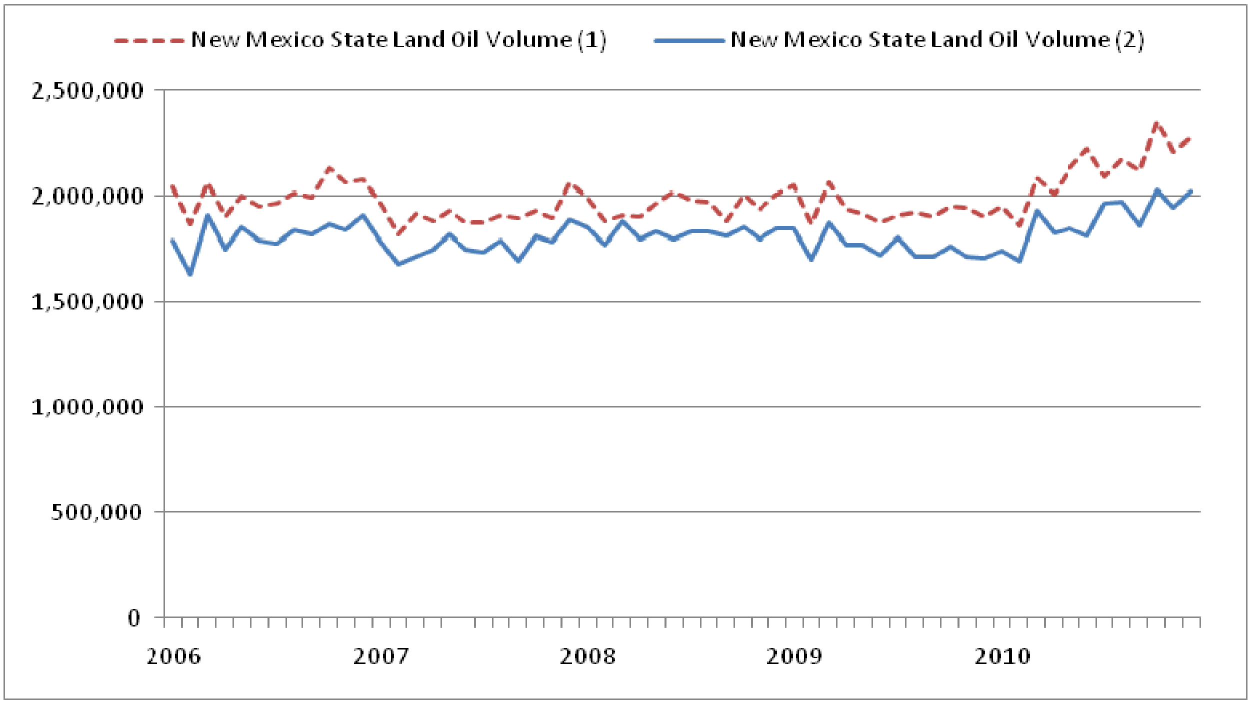
Source: US Department of Energy, Energy Information Agency, Annual Energy Outlook

ONGARD Data. ONGARD data can be also used to project future oil productionl. However, the data must be quality checked and verified for accuracy. **Figure 12** displays the volume of New Mexico oil produced on state lands from two different ONGARD sources. Although there is a general pattern shared between both, the volumes are different. The lower blue solid line is that derived from a data query by the

BBER Databank from the ONGARD system in May 2011, and it captures series revisions. The higher red dotted line is from the data supplied by the Royalty Management Division in June of this year.

The volume of each series slowly declines from 2006 until the early part of 2010 and then rapidly increases. Technology advances were cited as possible explanation for the underestimates of royalty revenues in the past, and could also be the source for the increase in oil production beginning in 2010.

Figure 12. Volume of New Mexico Crude Oil Production, 1990-2035



Source: UNM Data Bank extracted from ONGARD; State Land Office extracted.

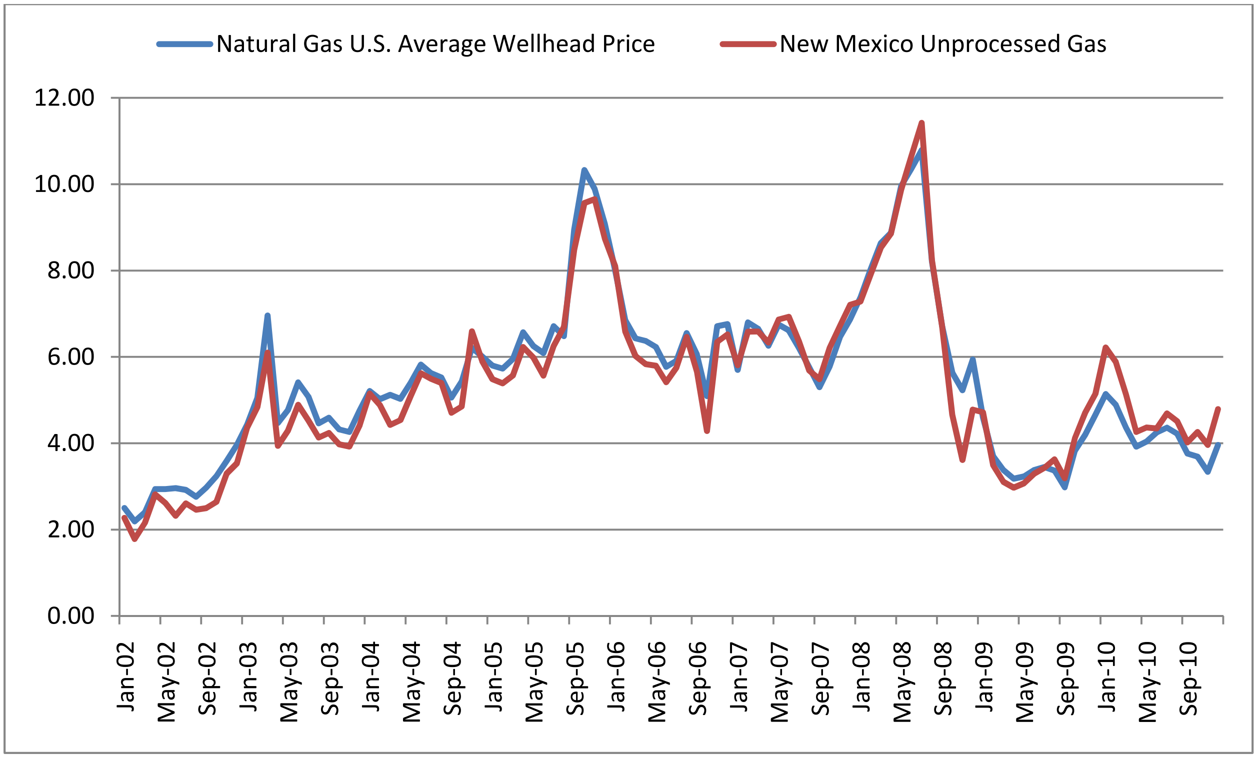
Future Deductions. Future deductions could be projected from historical data assuming similar transportation and other cost factors are applicable. Unfortunately, deductions are self reported and not always in a consistent manner. The majority of leases do not report deductions separately, but discount the gross proceed value.

Future Royalty Rates. Forecasting future royalty rates is complicated since the average royalty rate will depend upon the amount of production subject to different royalty rates. In general, new leases and particularly in the restricted areas of the Permian basin will be at rates higher than the historical 1/8. Production on older leases would be expected to diminish in the absence of new drilling or some form of production enhancement. What is happening? Production from new leases could be much higher than that from existing leases because of the application of new technology. In general, we might expect the average royalty rate to rise gradually. Such should already be reflected in the data (to be tested empirically), but the application of new technologies may be expected to accelerate the trend. In addition, there may be complicating factors. If the BLM proceeds to raise royalty rates, will the State Land Office staff feel more comfortable with leases at the maximum 1/5 instead of 3/16?

While the general concept of forecasting royalty income using a royalty projection model such as that described above is straightforward, the devil is in the details. There is analysis of existing data that will be required. The most productive way to forecast royalty income will be to develop separate databases for oil producing acreage subject to the same royalty rate and to analyze the emerging trends for individual leases within different basins for each of these royalty rates. We will also want to examine the impacts of new technology in other basins.

Appendix: Gas Data & Model Results

Figure 13. Relationship between Price for New Mexico Unprocessed Gas (ONGARD) and the US Average Wellhead Price



	Coefficients
Intercept	-0.09858
Natural Gas U.S. Average Wellhead Price	0.993482

V. CONCLUSIONS

In this report, we provided a review of leasing rules and statutes and demonstrated the feasibility of utilizing alternative forecasting methods to those currently employed by the State Land Office. Specifically, the second chapter of this report provided a survey of the statutes underlying oil and gas leasing on State lands. The third chapter provided an analysis of bonus payment revenue forecasting demonstrated how a simple model may be used to improve forecast accuracy. The third chapter provided a framework for producing a model forecasting royalty revenues.

We believe that the methods explained in this report will generally produce more accurate and defensible revenue forecasts than the current forecasting methods used by the State Land Office and provide a foundation for further exploration and fine-tuning. Given the time and resources, we believe that we can improve our revenue forecasting capabilities and produce a systematic method for producing future revenue forecasts.

Prior to writing a full proposal, however, we are interested in obtaining the State Land Office's input regarding whether to continue to pursue the methods enumerated in this report. If the State Land Office approves of the methodology and wishes us to continue, we would like to discuss the scope of an agreement.