

Statistical Considerations

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Survey Methodology

The Form EIA-23 survey is designed to provide reliable estimates for reserves and production of crude oil, natural gas, and lease condensate for the United States. Operators of crude oil and natural gas wells were selected as the appropriate respondent population because they have access to the most current and detailed information, and therefore, presumably have better reserve estimates than do other possible classes of respondents, such as working interest or royalty owners.

While large operators are quite well known, they comprise only a small portion of all operators. The small operators are not well known and are difficult to identify because they go into and out of business, alter their corporate identities, and change addresses frequently. As a result, EIA conducts extensive frame maintenance activities each year to identify all current operators of crude oil and natural gas wells in the country.

Sampling Strategy

EIA publishes data on reserves and production for crude oil, natural gas, and lease condensate by State for most States, and by State subdivision for the States of California, Louisiana, New Mexico, and Texas. To meet the survey objectives, while minimizing respondent burden, a random sampling strategy has been used since 1977. Each operator reporting on the survey is asked to report production for crude oil, natural gas, and lease condensate for each State/subdivision in which he operates. The term **State/subdivision** refers to an individual subdivision within a State or an individual State that is not subdivided.

The total volume of production varies among the State/subdivisions. To meet the survey objectives while controlling total respondent burden, EIA selected the following target sampling error for the 2002 survey for each product class.

- 1.0 percent for National estimates.
- 1.0 percent for each of the 5 States having subdivisions: Alaska, California, Louisiana,

New Mexico, and Texas. For selected subdivisions within these States, targets of 1.0 percent or 1.5 percent as required to meet the State target.

- 2.5 percent for each State/subdivision having 1 percent or more of estimated U.S. reserves or production in 2001 (lower 48 States) for any product class.
- 4 percent for each State/subdivision having less than 1 percent of estimated U.S. reserves or production in 2001 (lower 48 States) for all 3 product classes.
- 8 percent for States not published separately. The combined production from these States was less than 0.2 percent of the U.S. total in 2001 for crude oil and for natural gas.

The Certainty stratum, therefore, has three components.

- **Category I - Large Operators:** Operators who produced a total of 1.5 million barrels or more of crude, or 15 billion cubic feet or more of natural gas, or both in 2001.
- **Category II - Intermediate Operators:** Operators who produced a total of at least 400,000 barrels of crude oil or 2 billion cubic feet of natural gas, or both, but less than Category I operators in 2001.
- **Category III - Small Operators:** Operators who produced less than the Category II operators in 2001, but which were selected with certainty. Category III operators were subdivided into operators sampled with certainty (**Certainty**) and operators that were randomly sampled (**Noncertainty**).
- **Certainty** - A small operators who satisfied any of the following criteria based upon their production shown in the operator frame:
 - Operators with annual crude oil production of 200 thousand barrels or more, or reserves of 4 million barrels or more; or annual natural gas production of 1 billion cubic feet or more, or reserves of 20 billion cubic feet or more.
 - All other operators with production or reserves in a State/subdivision that

Table F1. 2002 EIA–23 Initial Number of Operators in Survey Sample

State and Subdivision	Number of Certainty Operators	Noncertainty Sample	
		Number of Single State Operators	Number of Multi-State Operators
Alabama Onshore	47	2	6
Alaska	7	0	0
Arkansas	90	7	6
California-Coastal Region Onshore	18	0	1
California-Los Angeles Basin Onshore	25	3	0
California-San Joaquin Basin Onshore	49	4	1
Colorado	124	20	10
Florida-Onshore	2	0	0
Illinois	32	11	14
Indiana	31	7	9
Kansas	168	70	24
Kentucky	25	9	13
Louisiana-North	165	9	7
Louisiana-South Onshore	190	4	7
Michigan	42	5	3
Mississippi-Onshore	91	1	2
Montana	63	1	4
Nebraska	33	2	11
New Mexico-East	161	1	6
New Mexico-West	58	1	0
New York	19	4	6
North Dakota	64	1	1
Ohio	31	50	4
Oklahoma	302	124	34
Pennsylvania	54	27	3
Texas-RRC District 1	138	8	12
Texas-RRC District 2 Onshore	154	2	7
Texas-RRC District 3 Onshore	236	7	11
Texas-RRC District 4 Onshore	179	5	8
Texas-RRC District 5	87	3	6
Texas-RRC District 6	170	4	9
Texas-RRC District 7B	225	23	15
Texas-RRC District 7C	169	2	10
Texas-RRC District 8	211	3	11
Texas-RRC District 8A	191	2	12
Texas-RRC District 9	170	8	11
Texas-RRC District 10	156	9	3
Utah	53	2	0
Virginia	12	0	0
West Virginia	60	25	7
Wyoming	137	1	4
Offshore Areas	273	0	0
Other States ^a	18	3	1
Total	b_{1,045}	470	b₁₆₂

^aIncludes Arizona, Connecticut, Delaware, Georgia, Idaho, Iowa, Massachusetts, Maryland, Minnesota, Missouri, North Carolina, New Hampshire, Nevada, New Jersey, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Washington, and Wisconsin.

^bNonduplicative count of operators by States.

Note: Sampling rate was 7 percent except in Alaska, Florida Onshore, Virginia, and Offshore areas where sampling rate was 100 percent.

— = Not applicable.

Source: Energy Information Administration, Office of Oil and Gas.

exceed selected cutoff levels for that State/subdivision.

- The largest operator in each State/subdivision regardless of level of production or reserves.
- Operators with production or reserves of oil or gas for six or more State/subdivisions.
- **Noncertainties** - Small operators not in the certainty stratum were classified in a noncertainty stratum.
 - In most areas, data from the noncertainty operators were sampled at a rate of 3 percent.
 - Only the operators in the following 10 states were included in the noncertainty sample: Illinois, Indiana, Kentucky, Maryland, New York, Pennsylvania, Tennessee, Virginia, and West Virginia.

In each State/subdivision the balance between the number of small certainty operators and the sample size was determined in an iterative procedure designed to minimize the number of total respondents. The iteration for each State/subdivision began with only the Category I and Category II operators in the certainty stratum. The size of the sample of small operators required to meet the target variance was calculated based on the variance of the volumes of those operators. For a number of State/subdivisions with high correlations between frame values across pairs of consecutive years, an adjusted target variance was calculated, that utilized the information about the correlations. This allowed the selection of a smaller sample that still met the target sampling error criteria. At each iteration a small operator, beginning with the largest of the Category III operators, was added to the certainty group and the required sample size was again calculated. The procedure of adding one operator at a time stopped when the proportion of operators to be sampled at random dropped below 3 percent. Independent samples of single location operators (operators who, according to the sampling frame, operate in only one State/subdivision) were selected from each State/subdivision using systematic random sampling.

An additional complexity is introduced because some small operators selected for the sample in another region or regions, sometimes report production volumes in a region in which EIA has no previous record of production.

State/subdivision volume estimates are calculated as the sum of the certainty strata and all of the estimates for the sampling strata in that region. The sampling variance of the estimated total is the sum of the sampling variances for the sampling strata. There is no sampling error associated with the certainty stratum. The square root of the sampling variance is the standard error. It can be used to provide confidence intervals for the State/subdivision totals.

For the States in which subdivision volume estimates are published, the State total is the sum of the individual volume estimates for the subdivisions. The U.S. total is the sum of the State estimates. A sampling variance is calculated for each State subdivision, State, and for the U.S. Total.

Sampling rates are shown in **Table F1**.

Total U.S. Reserve Estimates

Conceptually, the estimates of U.S. reserves and production can be thought of as the sum of the estimates for the individual States. Correspondingly, the estimates for the four States for which estimates are published separately by subdivision (California, Louisiana, New Mexico, and Texas) can be thought of as the sum of the estimates by subdivision. The remaining States are not subdivided and may be considered as a single subdivision.

The estimates of year-end proved reserves and annual production for any State/subdivision is the sum of the volumes in the State/subdivision reported by the certainty stratum operators and an estimate of the total volume in the State/subdivision by the noncertainty stratum operators. Mathematically, this may be stated as the following sum:

$$\hat{V}_s = V_{sc} + \hat{V}_{sr}$$

where

\hat{V}_s = estimated total volume in the State/subdivision

V_{sc} = total volume in the State/subdivision reported by Certainty operators

\hat{V}_{sr} = estimated total volume in the State/subdivision of Noncertainty operators.

The total volume of Certainty operators in the State/subdivision is simply the sum of individual operator's volumes:

$$V_{sc} = \sum_{m=1}^{n_{sc}} V_{scm}$$

where

n_{sc} = number of Certainty operators reporting production in the State/subdivision

V_{scm} = volume reported by the m -th certainty stratum operator in the State/subdivision.

The estimated total volume of Noncertainty operators in the State/subdivision is the weighted sum of the reports of the noncertainty sample operators:

$$\hat{V}_{sr} = \sum_{m=1}^{n_{sr}} W_{srm} V_{srm}$$

where

n_{sr} = number of Noncertainty operators reporting production in the State/subdivision

V_{srm} = volume reported by the m -th Noncertainty sample operator in the State/subdivision

W_{srm} = weight for the report by the m -th Noncertainty sample operator reporting production in the State/subdivision.

In many State/ subdivisions, the accuracy of the oil and gas estimates was improved by using the probability proportional to size procedure. This procedure took advantage of the correlation between year-to-year production reports. The weights used for estimating the oil production for a State / subdivision were different from the weights used for estimating the gas production.

The weight used for the estimation is the reciprocal of the probability of selection for the stratum from which the sample operator was selected. In making estimates for a State/ subdivision, separate weights are applied as appropriate for noncertainty operators shown in the frame as having had production in only the State/ subdivision, for those shown as having had production in that State/subdivision and up to four other State/ subdivisions, and for operators with no previous record of production in the State/subdivision. National totals were then obtained by summation of the component totals.

Imputation for Operator Nonresponse

The nonresponse rate for Certainty operators for the 2002 survey was 0.1 percent and for the Noncertainty operators 0.4 percent. An imputation was made for the production and reserves for these 3 nonresponding operators.

Imputation and Estimation for Reserves Data

In order to estimate reserve balances for National and State/subdivision levels, a series of imputation and estimation steps at the operator level must be carried out. Year-end reserves for operators who provided production data only were imputed on the basis of their production volumes. Imputation was also applied to the small and intermediate operators as necessary to provide data on each of the reserve balance categories (i.e., revisions, extensions, or new discoveries). Finally, an imputation was required for the natural gas data of the small operators to estimate their volumes of associated-dissolved and nonassociated natural gas. The final manipulation of the data accounts for the differences caused by different sample frames from year to year. Each of these imputations generated only a small percentage of the total estimates. The methods used are discussed in the following sections.

There were 514 operators sampled proportional to size (Table E1) that responded as Category III Noncertainty operators. Only 193 of these, located in 10 states, had their data weighted and used to estimate the production and reserves of the operators that were not sampled in those states. The remaining 321 Noncertainty sampled operators were treated as certainty sampled operators with a weight of 1 and were used in states where the bulk of the operator production data was obtained from Auxillary State Data.

The data reported by operator category on Form EIA-23 and data imputed and estimated for report year 2002 are summarized in **Tables F2, F3, F4, and F5**. The reported data in **Table F2** shows that those responding operators accounted for 99.7 percent of the published production for wet natural gas and 95.5 percent of the reserves shown in **Table 9**. Data shown in **Table F3** indicate that those responding operators accounted for 99.7 percent of the nonassociated natural gas production and 95.6 percent of the reserves published in **Table 10**. The reported data shown in **Table F4** indicate that those responding operators accounted for 99.6 percent of published crude oil production and 94.9

Table F2. Summary of Form EIA-23 Reported, Imputed, and Estimated Natural Gas Data for 2002, Wet after Lease Separation (Million Cubic Feet at 14.73 psia and 60 Degrees Fahrenheit)

Level of Reporting	Operator Category					Total
	I	II	Certainty III	Noncertainty III	Auxillary State Data	
Reported						
Number of Operators	164	426	731 ^a	193 ^a	11,539	13,053
Proved Reserves as of 12/31/01	172,712,687	11,960,730	219,620	-	-	184,893,037
(+) Revision Increases	18,306,878	1,443,815	53,532	-	-	19,804,225
(-) Revision Decreases	17,336,477	1,397,777	42,956	-	-	18,777,210
(-) Sales	9,002,529	1,030,453	72,771	-	-	10,105,753
(+) Acquisitions	9,521,240	1,040,754	6,156	-	-	10,568,150
(+) Extensions	13,302,479	1,715,041	7,359	-	-	15,024,879
(+) New Field Discoveries	1,289,495	70,945	0	-	-	1,360,440
(+) New Reservoirs in Old Fields	1,290,049	395,853	105	-	-	1,686,007
(-) Production With						
Proved Reserves Reported	17,272,536	1,417,427	112,537	6,318	-	18,808,818
(-) Production Without						
Proved Reserves Reported	14,580	523,407	190,429	16,278	643,447	1,388,141
Proved Reserves as of 12/31/02	172,819,334	12,810,212	1,080,294	91,659	-	186,801,499
Imputed and Estimated						
Number of Operators	0	0	0	9,770	0	9,770
Proved Reserves as of 12/31/01	0	0	-	-	-	0
(+) Revision Increases	10,121	523,583	349,103	81,204	471,886	1,435,898
(-) Revision Decreases	14,090	514,649	326,066	62,118	508,101	1,425,024
(-) Sales	6,104	171,757	121,178	5,101	254,987	559,128
(+) Acquisitions	7,247	203,950	106,835	5,475	201,020	524,527
(+) Extensions	6,068	199,713	94,141	20,889	122,722	443,533
(+) New Field Discoveries	287	6,065	3,070	1,205	3,044	13,671
(+) New Reservoirs in Old Fields	1,479	24,260	12,179	1,503	26,693	66,114
(-) Production With						
Proved Reserves Reported	0	0	0	16,323	-	16,323
(-) Production Without						
Proved Reserves Reported	0	0	0	31,899	0	31,899
Proved Reserves as of 12/31/02	83,824	3,756,375	1,377,404	563,041	2,978,940	8,759,584
Total						
Number of Operators	164	426	731	9,963	11,539	22,823
Proved Reserves as of 12/31/01	172,712,687	11,960,730	219,620	-	-	184,893,037
(+) Revision Increases	18,316,999	1,967,398	402,635	81,204	471,886	21,240,123
(-) Revision Decreases	17,350,567	1,912,426	369,022	62,118	508,101	20,202,234
(-) Sales	9,008,633	1,202,210	193,949	5,101	254,987	10,664,881
(+) Acquisitions	9,528,487	1,244,704	112,991	5,475	201,020	11,092,677
(+) Extensions	13,308,547	1,914,754	101,500	20,889	122,722	15,468,412
(+) New Field Discoveries	1,289,782	77,010	3,070	1,205	3,044	1,374,111
(+) New Reservoirs in Old Fields	1,291,528	420,113	12,284	1,503	26,693	1,752,121
(-) Production With						
Proved Reserves Reported	17,272,536	1,417,427	112,537	22,641	-	18,825,141
(-) Production Without						
Proved Reserves Reported	14,580	523,407	190,429	48,177	643,447	1,420,040
Proved Reserves as of 12/31/02	172,903,158	16,566,587	2,457,698	654,700	2,978,940	195,561,083
Summary						
Total Number of Operators	164	426	731	9,963	11,539	22,823
Percent of Total	0.7%	1.9%	3.2%	43.7%	50.6%	100.0%
Total Production in 2002	17,287,116	1,940,834	302,966	70,818	643,447	20,245,181
Percent of Total	85.4%	9.6%	1.5%	0.3%	3.2%	100.0%
Total Proved Reserves 12/31/02	172,903,158	16,566,587	2,457,298	654,700	2,978,940	195,561,083
Percent of Total	88.4%	8.5%	1.2%	0.3%	1.5%	100.0%

^aThere were 514 noncertainty responses, 193 were used with their sample weights and 324 were used like Certainty III operators.

- = Not applicable.

Notes: Table 9 totals include imputed and estimated wet natural gas proved reserves rounded at the State/subdivision level. Field level data are reported volumes and may not balance due to submission of incomplete reserve component records.

Source: Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2002.

Table F3. Summary of Form EIA-23 Reported, Imputed, and Estimated Nonassociated Natural Gas Data for 2002, Wet after Lease Separation (Million Cubic Feet at 14.73 psia and 60 Degrees Fahrenheit)

Level of Reporting	Operator Category					Total
	I	II	Certainty III	Noncertainty III	Auxillary State Data	
Reported						
Number of Operators	164	426	731 ^a	193 ^a	11,539	13,053
Proved Reserves as of 12/31/01	145,792,834	10,430,368	161,786	-	-	156,384,988
(+) Revision Increases	15,200,773	1,206,879	50,413	-	-	16,458,065
(-) Revision Decreases	15,236,917	1,139,366	256	-	-	16,376,539
(-) Sales	8,221,213	952,127	71,259	-	-	9,244,599
(+) Acquisitions	8,839,777	931,425	5,747	-	-	9,776,949
(+) Extensions	12,666,431	1,566,313	6,696	-	-	14,239,440
(+) New Field Discoveries	1,067,701	64,536	0	-	-	1,132,237
(+) New Reservoirs in Old Fields	978,536	380,937	0	-	-	1,359,473
(-) Production With						
Proved Reserves Reported	14,723,152	1,251,908	95,645	6,042	-	16,076,747
(-) Production Without						
Proved Reserves Reported	14,455	454,347	162,273	16,023	491,983	1,139,081
Proved Reserves as of 12/31/02	146,372,818	11,262,703	937,942	88,485	-	158,661,948
Imputed and Estimated						
Number of Operators	0	0	0	9,770	0	9,770
Proved Reserves as of 12/31/01	0	0	-	-	-	0
(+) Revision Increases	10,081	457,306	299,439	73,165	355,243	1,195,235
(-) Revision Decreases	13,983	452,362	277,434	54,697	390,236	1,188,712
(-) Sales	4,565	113,946	80,650	3,562	153,977	356,701
(+) Acquisitions	6,751	165,267	85,381	4,203	146,444	408,046
(+) Extensions	6,012	176,024	80,434	18,908	94,938	376,315
(+) New Field Discoveries	298	5,818	2,950	1,211	2,708	12,985
(+) New Reservoirs in Old Fields	1,555	23,458	11,459	1,557	23,609	61,639
(-) Production With						
Proved Reserves Reported	0	0	0	14,030	-	14,030
(-) Production Without						
Proved Reserves Reported	0	0	0	29,465	0	29,465
Proved Reserves as of 12/31/02	83,535	3,295,307	1,188,599	514,273	2,277,575	7,359,289
Total						
Number of Operators	164	426	731	9,963	11,539	22,823
Proved Reserves as of 12/31/01	145,792,834	10,430,368	161,786	-	-	156,384,988
(+) Revision Increases	15,210,854	1,664,185	349,852	73,165	355,243	17,653,300
(-) Revision Decreases	15,250,900	1,591,728	277,690	54,697	390,236	17,565,251
(-) Sales	8,225,778	1,066,073	151,909	3,562	153,977	9,601,300
(+) Acquisitions	8,846,528	1,096,692	91,128	4,203	146,444	10,184,995
(+) Extensions	12,672,443	1,742,337	87,130	18,908	94,938	14,615,755
(+) New Field Discoveries	1,067,999	70,354	2,950	1,211	2,708	1,145,222
(+) New Reservoirs in Old Fields	980,091	404,395	11,459	1,557	23,609	1,421,112
(-) Production With						
Proved Reserves Reported	14,723,152	1,251,908	95,645	20,072	-	16,090,777
(-) Production Without						
Proved Reserves Reported	14,455	454,347	162,273	45,488	491,983	1,168,5464
Proved Reserves as of 12/31/02	146,456,353	14,558,010	2,126,641	602,758	2,277,575	166,021,237
Summary						
Total Number of Operators	164	426	731	9,963	11,539	22,823
Percent of Total	0.7%	1.9%	3.2%	43.7%	50.6%	100.0%
Total Production in 2002	14,737,607	1,706,255	257,918	65,560	491,983	17,259,323
Percent of Total	85.4%	9.9%	1.5%	0.4%	2.9%	100.0%
Total Proved Reserves 12/31/02	146,456,353	14,558,010	2,126,541	602,758	2,277,575	166,021,237
Percent of Total	88.2%	8.8%	1.3%	0.4%	1.4%	100.0%

^aThere were 514 noncertainty responses, 193 were used with their sample weights and 324 were used like Certainty III operators.

- = Not applicable.

Notes: Table 10 totals include imputed and estimated nonassociated wet natural gas proved reserves rounded at the State/subdivision level. Field level data are reported volumes and may not balance due to submission of incomplete reserve component records.

Source: Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2002.

Table F4. Summary of Form EIA-23 Reported, Imputed, and Estimated Crude Oil Data for 2002,
(Thousand Barrels of 42 U.S. Gallons)

Level of Reporting	Operator Category					Total
	I	II	Certainty III	Noncertainty III	Auxillary State Data	
Reported						
Number of Operators	164	426	731 ^a	193 ^a	11,539	13,053
Proved Reserves as of 12/31/01	20,330,757	979,763	20,841	-	-	21,331,361
(+) Revision Increases	1,561,926	161,251	4,237	-	-	1,727,414
(-) Revision Decreases	903,968	100,503	1,602	-	-	1,006,073
(-) Sales	632,808	40,957	3,059	-	-	676,824
(+) Acquisitions	563,872	151,072	159	-	-	715,103
(+) Extensions	407,816	48,049	1,466	-	-	457,331
(+) New Field Discoveries	294,678	5,004	0	-	-	299,682
(+) New Reservoirs in Old Fields	140,296	9,976	240	-	-	150,512
(-) Production With						
Proved Reserves Reported	1,571,623	97,555	20,927	856	-	1,690,961
(-) Production Without						
Proved Reserves Reported	78	30,546	43,837	2,552	98,898	175,911
Proved Reserves as of 12/31/02	20,190,946	1,117,537	197,280	8,047	-	21,513,810
Imputed and Estimated						
Number of Operators	0	0	0	9,770	0	9,770
Proved Reserves as of 12/31/01	0	0	-	-	-	0
(+) Revision Increases	32	31,107	73,855	6,421	86,472	197,886
(-) Revision Decreases	35	25,990	65,258	1,659	106,430	199,371
(-) Sales	7	13,415	41,067	824	72,184	127,497
(+) Acquisitions	11	17,762	46,003	1,631	47,517	112,925
(+) Extensions	9	6,848	12,776	349	14,686	34,668
(+) New Field Discoveries	0	92	145	4	78	319
(+) New Reservoirs in Old Fields	3	814	1,076	45	1,772	3,710
(-) Production With						
Proved Reserves Reported	0	0	0	855	-	855
(-) Production Without						
Proved Reserves Reported	0	0	0	3,648	0	3,648
Proved Reserves as of 12/31/02	241	255,225	326,907	35,755	546,635	1,164,763
Total						
Number of Operators	164	426	731	9,963	11,539	22,823
Proved Reserves as of 12/31/01	20,330,757	979,763	20,841	-	-	21,331,361
(+) Revision Increases	1,561,958	192,358	78,092	6,421	86,472	1,925,300
(-) Revision Decreases	904,003	126,493	66,860	1,659	106,430	1,205,444
(-) Sales	632,815	54,372	44,126	824	72,184	804,321
(+) Acquisitions	563,883	168,834	46,162	1,631	47,517	828,028
(+) Extensions	407,825	54,897	14,242	349	14,686	491,999
(+) New Field Discoveries	294,678	5,096	145	4	78	300,001
(+) New Reservoirs in Old Fields	140,299	10,790	1,316	45	1,772	154,222
(-) Production With						
Proved Reserves Reported	1,571,623	97,555	20,927	1,711	-	1,691,816
(-) Production Without						
Proved Reserves Reported	78	30,546	43,837	6,200	98,898	179,559
Proved Reserves as of 12/31/02	20,191,187	1,372,762	524,187	43,802	546,635	22,678,573
Summary						
Total Number of Operators	164	426	731	9,963	11,539	22,823
Percent of Total	0.7%	1.9%	3.2%	43.7%	50.6%	100.0%
Total Production in 2002	1,571,701	128,101	64,764	7,911	98,898	1,871,375
Percent of Total	84.0%	6.8%	3.5%	0.4%	5.3%	100.0%
Total Proved Reserves 12/31/02	20,191,187	1,372,762	524,187	43,802	546,635	22,678,573
Percent of Total	89.0%	6.1%	2.3%	0.2%	2.4%	100.0%

^aThere were 514 noncertainty responses, 193 were used with their sample weights and 324 were used like Certainty III operators.
- = Not applicable.

Notes: Table 6 totals include imputed and estimated crude oil proved reserves rounded at the State/subdivision level. Field level data are reported volumes and may not balance due to submission of incomplete reserve component records.

Source: Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2002.

Table F5. Summary of Form EIA-23 Reported, Imputed, and Estimated Lease Condensate Data for 2002,
(Thousand Barrels of 42 U.S. Gallons)

Level of Reporting	Operator Category					Total
	I	II	Certainty III	Noncertainty III	Auxillary State Data	
Reported						
Number of Operators	164	426	731 ^a	193 ^a	11,539	13,053
Proved Reserves as of 12/31/01	1,260,452	91,957	369	-	-	1,352,778
(+) Revision Increases	232,807	15,422	1,240	-	-	249,469
(-) Revision Decreases	269,431	19,164	25	-	-	288,620
(-) Sales	77,854	14,339	911	-	-	93,104
(+) Acquisitions	108,381	8,223	2	-	-	116,606
(+) Extensions	96,181	9,660	0	-	-	105,841
(+) New Field Discoveries	17,578	282	0	-	-	17,860
(+) New Reservoirs in Old Fields	27,261	4,932	0	-	-	32,193
(-) Production With						
Proved Reserves Reported	181,389	14,968	355	6	-	196,718
(-) Production Without						
Proved Reserves Reported	354	4,594	863	9	4,692	10,512
Proved Reserves as of 12/31/02	1,213,977	82,079	2,107	56	-	1,298,219
Imputed and Estimated						
Number of Operators	0	0	0	9,770	0	9,770
Proved Reserves as of 12/31/01	0	0	-	-	-	0
(+) Revision Increases	323	5,424	1,386	33	5,067	12,232
(-) Revision Decreases	400	6,216	1,604	13	5,448	13,682
(-) Sales	117	1,688	538	9	2,499	4,852
(+) Acquisitions	112	2,636	695	11	2,384	5,838
(+) Extensions	103	1,592	352	6	1,206	3,259
(+) New Field Discoveries	10	88	8	0	33	139
(+) New Reservoirs in Old Fields	45	521	110	3	451	1,129
(-) Production With						
Proved Reserves Reported	0	0	0	2	-	2
(-) Production Without						
Proved Reserves Reported	0	0	0	7	0	7
Proved Reserves as of 12/31/02	1,547	22,049	3,810	48	18,292	45,746
Total						
Number of Operators	164	426	731	9,963	11,539	22,823
Proved Reserves as of 12/31/01	1,260,452	91,957	369	-	-	1,352,778
(+) Revision Increases	233,130	20,846	2,626	33	5,067	261,701
(-) Revision Decreases	269,831	25,380	1,629	13	5,448	302,302
(-) Sales	77,971	16,027	1,449	9	2,499	97,956
(+) Acquisitions	108,493	10,859	697	11	2,384	122,444
(+) Extensions	96,284	11,252	352	6	1,206	109,100
(+) New Field Discoveries	17,588	370	8	0	33	17,999
(+) New Reservoirs in Old Fields	27,306	5,453	110	3	451	33,322
(-) Production With						
Proved Reserves Reported	181,389	14,968	355	8	-	196,720
(-) Production Without						
Proved Reserves Reported	354	4,594	863	16	4,692	10,519
Proved Reserves as of 12/31/02	1,215,524	104,128	5,917	104	18,292	1,343,965
Summary						
Total Number of Operators	164	426	731	9,963	11,539	22,823
Percent of Total	0.7%	1.9%	3.2%	43.7%	50.6%	100.0%
Total Production in 2002	181,743	19,562	24	1,218	4,692	207,239
Percent of Total	87.7%	9.4%	0.0%	0.6%	2.3%	100.0%
Total Proved Reserves 12/31/02	1,215,524	104,128	104	5,917	18,292	1,343,965
Percent of Total	90.4%	7.7%	0.0%	0.4%	1.4%	100.0%

^aThere were 514 noncertainty responses, 193 were used with their sample weights and 324 were used like Certainty III operators.

- = Not applicable.

Notes: Table 15 totals include imputed and estimated lease condensate proved reserves rounded at the State/subdivision level. Field level data are reported volumes and may not balance due to submission of incomplete reserve component records.

Source: Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2002.

percent of the reserves shown in **Table 6**. Additionally, **Table F5** indicates that those responding operators accounted for 100 percent of the published production and 96.4 percent of the published proved reserves for lease condensate shown in **Table 15**.

Imputation of Year-End Proved Reserves

Category I operators were required to submit year-end estimates of proved reserves. Category II and Category III operators were required to provide year-end estimates of proved reserves only if such estimates existed in their records. Some of these respondents provided estimates for all of their operated properties, others provided estimates for only a portion of their properties, and still others provided no estimates for any of their properties. All respondents did, however, provide annual production data. The production reported by Noncertainty sample operators and the corresponding imputed reserves were weighted to estimate the full noncertainty stratum when calculating reserves and production as previously described in the section "Total U.S. Reserves Estimates" in this appendix.

R/P Function

A year-end proved reserves estimate was imputed from reported production data in each case where an estimate was not provided by the respondent. A R/P function was derived and used to calculate a reserves-to-production (R/P) ratio, based on operator size and the geographic region where the operator's

properties were located. The R/P function has the following functional form for each geographic region:

$$\text{Calculated } P/[P+R] = \text{Beta} * \text{EXP}(\text{Alpha} * \ln(1 + \text{MOS}))$$

- *Alpha, Beta* = Regional Coefficients (calculated).
- *MOS* = *Measure of size* for a respondent, which is equal to the barrel oil equivalent volume of a respondent's 2002 oil, gas, and condensate production (in units of thousand barrels per year).

Table F6 lists the coefficients used for each region and the number of observations on which it was based. The regional areas used are similar to the National Petroleum Council Regions (**Figure F1**). These regions generally follow the boundaries of geologic provinces wherein the stage of resource development tends to be somewhat similar.

Once the R/P ratio was obtained for an operator, it could be multiplied by the reported or estimated production to give a proved reserves estimate. Operators that had production plus end of year reserves equal to zero were excluded from the respondents selected to calculate the R/P coefficients.

In 2002, the R/P function was used to estimate the proved reserves of all noncertainty operators in these States -- Texas, California, Colorado, Louisiana, Montana, New Mexico, South Dakota, Utah, and Wyoming, rather than rely on a weighted sample. These States were chosen for this new procedure because of the many years of historical production and reserves data within EIA and availability of reliable

Table F6. Statistical Parameters of Reserves Estimation Equation by Region for 2002

Region Number	Region	Number of Nonzero R/P Pairs			Equation Coefficients					
		Oil	Gas	LC	Oil Alpha	Oil Beta	Gas Alpha	Gas Beta	LC Alpha	LC Beta
1	Alaska	8	10	0	-0.1331	0.3956	-0.1170	0.3465	-0.0816	0.3921
2	Pacific Coast States	55	63	3	-0.1331	0.3426	-0.1170	0.4123	-0.0816	0.6527
2A	Federal Offshore Pacific	6	6	0	-0.1331	0.2644	-0.1170	0.2979	-0.0816	0.3921
3	Western Rocky Mountains	93	142	61	-0.1331	0.3169	-0.1170	0.2873	-0.0816	0.2201
4	Northern Rocky Mountains	165	151	46	-0.1331	0.3169	-0.1170	0.2873	-0.0816	0.2201
5	West Texas and East New Mexico	534	548	181	-0.1331	0.3127	-0.1170	0.3456	-0.0816	0.3853
6	Western Gulf Basin.	546	855	570	-0.1331	0.4273	-0.1170	0.4223	-0.0816	0.3541
6A	Gulf of Mexico	71	131	106	-0.1331	0.6948	-0.1170	0.6550	-0.0816	0.5103
7	Mid-Continent	340	422	157	-0.1331	0.3333	-0.1170	0.3201	-0.0816	0.2234
8 + 9	Michigan Basin and Eastern Interior	94	65	14	-0.1331	0.2933	-0.1170	0.1863	-0.0816	0.2595
10 + 11	Appalachians	29	79	8	-0.1331	0.2933	-0.1170	0.1863	-0.0816	0.2595
	United States	1941	2472	1146	-0.1331	0.4062	-0.1170	0.3944	-0.0816	0.3921

Source: Based on data filed on Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves, 2002".

State government and commercial production data for these States. This technique improved the correlation of EIA data with State and commercial production data, and reduced the burden of reporting and analysis on both EIA and the noncertainty operators in these States.

Imputation of Annual Changes to Proved Reserves by Component of Change

Category II and Category III operators that do not keep reserves data were not asked to provide estimates of beginning-of-year reserves or annual changes to proved reserves by component of change, i.e., revisions, extensions, and discoveries. When they did not provide estimates, these volumes were estimated by either:

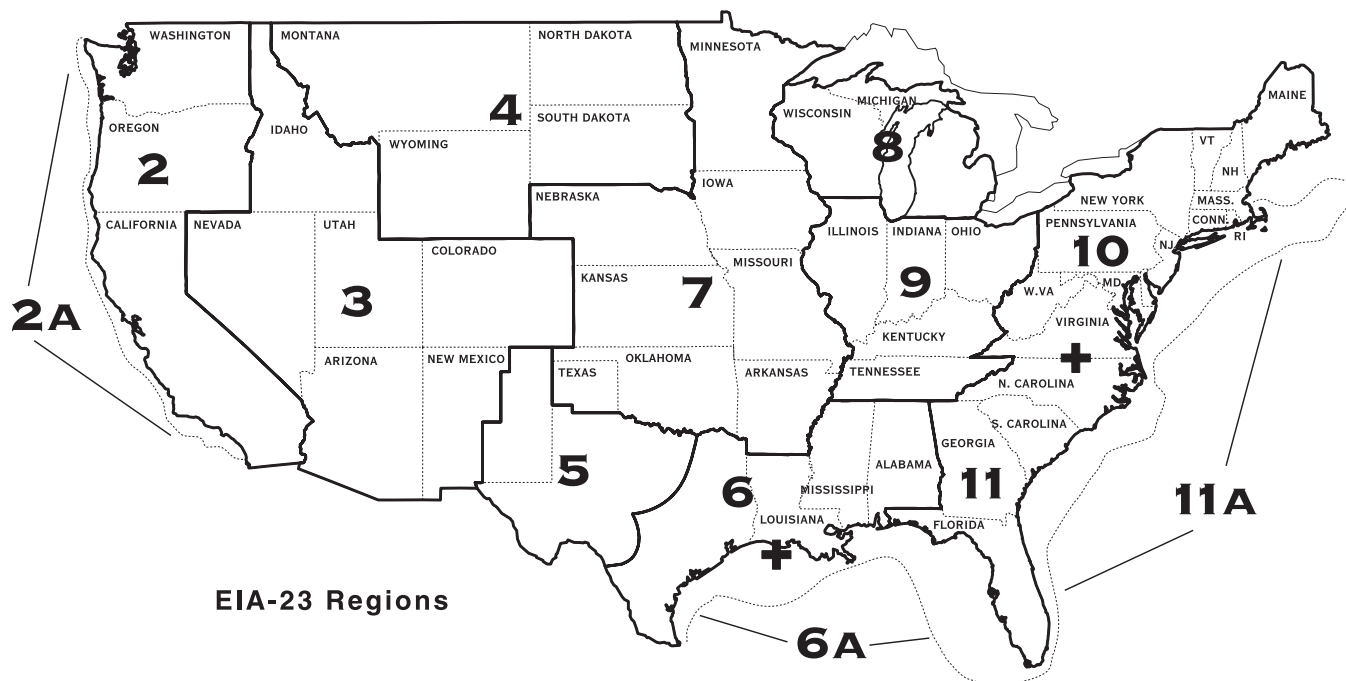
- applying an algebraic allocation scheme which preserved the relative relationships between these items within each State/subdivision, as reported by Category I and Category II operators, or
- applying a modified version of the R/P function to each separate component of change, calculated with its own set of geographically dependent coefficients. This method was used in all four states where the R/P Function was applied to calculate end of year reserves.

Both methods preserved an exact annual reserves balance of the following form:

Published Proved Reserves at End of Previous Report Year
+ Adjustments
+ Revision Increases
- Revision Decreases
- Sales
+ Acquisitions
+ Extensions
+ New Field Discoveries
+ New Reservoir Discoveries in Old Fields
- Report Year Production
= Published Proved Reserves at End of Report Year

The algebraic allocation method used for all but nine states in the 2002 survey worked as follows: A ratio was calculated as the sum of the annual production and year-end proved reserves of those respondents who did not provide the reserves balance components, divided by the sum of year-end proved reserves and annual production of those respondents of similar size who did provide these quantities. This ratio was then multiplied by each of the reserves balance components reported by Category I and some Category II operators, to obtain imputed volumes for the reserves balances of the other Category II operators and Certainty and Noncertainty operators. These were then added to the State/subdivision totals.

Figure F1. Form EIA-23 Regional Boundaries



Source: Energy Information Administration, Office of Oil and Gas.

Imputation of Natural Gas Type Volumes

Operators in the State/subdivision certainty and noncertainty strata were not asked to segregate their natural gas volumes by type of natural gas, i.e., nonassociated natural gas (NA) and associated-dissolved natural gas (AD). The total estimated year-end proved reserves of natural gas and the total annual production of natural gas reported by, or imputed to, operators in the State/subdivision certainty and noncertainty strata were, therefore, subdivided into the NA and AD categories, by State/subdivision, in the same proportion as was reported by Category I and Category II operators in the same area.

Adjustments

The instructions for Schedule A of Form EIA-23 specify that, when reporting reserves balance data, the following arithmetic equation must hold:

Proved Reserves at End of Previous Year
+ Revision Increases
- Revision Decreases
- Sales
+ Acquisitions
+ Extensions
+ New Field Discoveries
+ New Reservoir Discoveries in Old Fields
- Report Year Production
= Proved Reserves at End of Report Year

Any remaining difference in the State/subdivision annual reserves balance between the published previous year-end proved reserves and current year-end proved reserves not accounted for by the imputed reserves changes was included in the adjustments for the area. One of the primary reasons that adjustments are necessary is the instability of the Noncertainty operators sampled each year. There is no guarantee that in the smaller producing States/subdivision the same number of small operators will be selected each year, or that the operators selected will be of comparable sizes when paired with operators selected in a prior year. Thus, some instability of this stratum from year to year is unavoidable, resulting in minor adjustments.

Some of the adjustments are, however, more substantial, and could be required for any one or more of the following reasons:

- The frame coverage may or may not have improved between survey years, such that more or fewer Certainty operators were included in 2002 than in 2001.
- One or more operators may have reported data incorrectly on Schedule A in 2002 or 2001, but not both, and the error was not detected by edit processing.
- Operation of properties was transferred during 2002 from operators not in the frame or Noncertainty operators not selected for the sample to Certainty operators or Noncertainty operators selected for the sample.
- Respondent changed classification of natural gas from NA to AD or vice versa.
- The trend in reserve changes imputed for the small operators, which was based on the trend reported by the large operators, did not reflect the actual trend for the small operators.
- Noncertainty operators, who have grown substantially in size since they were added to the frame, occasionally cause a larger standard error than expected.
- The Noncertainty sample for either year in a state may have been an unusual one.

The causes of adjustments are known for some but not all areas. The only problems whose effects cannot be expected to balance over a period of several years are those associated with an inadequate frame or those associated with any actual trend in reserves changes for small operators not being the same as those for large operators. EIA continues to attempt to improve sources of operator data to resolve problems in frame completeness.

Sampling Reliability of the Estimates

The sample of Noncertainty operators selected is only one of the large number of possible samples that could have been selected and each would have resulted in different estimates. The standard error or sampling error of the estimates provides a measure of this variability. When probability sampling methods are used, as in the EIA-23 survey, the sampling error of estimates can also be estimated from the survey data.

The estimated sampling error can be used to compute a confidence interval around the survey estimate, with a prescribed degree of confidence that the interval covers the value that would have been obtained if all operators in the frame had been surveyed. If the estimated

volume is denoted by \hat{V}_s and its sampling error by S.E. (\hat{V}_s), the confidence interval can be expressed as:

$$\hat{V}_s \pm k S.E. (\hat{V}_s)$$

where k is a multiple selected to provide the desired level of confidence. For this survey, k was taken equal to 2. Then there is approximately 95 percent confidence that the interval:

$$\hat{V}_s \pm 2S.E. (\hat{V}_s)$$

includes the universe value, for both the estimates of reserves and production volumes. Correspondingly, for approximately 95 percent of the estimates in this report, the difference between the published estimate and the value that would be found from a complete survey of all operators is expected to be less than twice the sampling error of the estimate. **Tables F7 and F8** provide estimates for 2S.E. (\hat{V}_s) by product. These estimates are directly applicable for constructing approximate 95 percent confidence intervals. For example, the 95 percent confidence interval for dry natural gas proved reserves is 186,946 \pm 935 billion cubic feet. The sampling error of \hat{V}_s is equal to the sampling error of the noncertainty estimate \hat{V}_{sr} , because the certainty total is not subject to sampling error. The estimated sampling error of a noncertainty estimate is the square root of its estimated sampling variance.

The noncertainty estimate for a given State/subdivision had two separately weighted components based on reports of:

- **Type 1 Operators** shown in the frame as having crude oil or natural gas production in the State/subdivision.
- **Type 2 Operators** shown in the frame as having no crude oil or natural gas production in the State/subdivision.

Correspondingly, the sampling variance had two components associated with the estimated production from each component:

$$Var(\hat{V}_{sr}) = Var(\hat{V}_{sr1}) + Var(\hat{V}_{sr2})$$

The $Var(Vsr)$ was estimated as the sum of the estimated variances of the two component estimates. The variance for any component, say component j, was estimated from the formula:

$$Var(\hat{V}_{srj}) = n_{srj} \left(\frac{W_{srj} - 1}{W_{srj}} \right) S_{srj}^2$$

In general, \hat{V}_{srj} denotes the production estimate from component j for each of the two types of operator, and $Var(\hat{V}_{srj})$ denotes its variance where:

n_{srj} = Number of operators in sample in component j

w_{srj} = Weight for operator reports in component j

S_{srj}^2 = variance between operator reports in component j.

If the subscripts sr are dropped, S_j^2 can be expressed as:

$$S_j^2 = \frac{\sum_i^{n_j} V_{ji}'^2 - \left(\sum_i^{n_j} V_{ji}' \right)^2 / n_j}{n_j - 1}$$

Where

V_{ji}' = Weighted production or reserves volume for the i-th sample operator in the component j.

The variance of the estimated total volume for a State having subdivisions is the sum of corresponding Type 1 and Type 2 components where the classification of operators by type is with regard to the State as a whole; e.g. Type 2 operators at the State level are those that were not shown in the sample frame as having production anywhere in the State.

Since there are no operators in the frame who would be classified as Type 2 at the U.S. level, there would be no Type 2 components at the U.S. Level. Therefore, at the U.S. Level, there was only one sample variance component calculated for Type 1 operators.

Nonsampling Errors

Several sources of possible error, apart from sampling error, are associated with the Form EIA-23 survey. These include bias due to nonresponse of operators in the sample, proved reserve estimation errors, and reporting errors on the part of the respondents to the survey. On the part of EIA, possible errors include inadequate frame coverage, data processing error, and errors associated with statistical estimates. Each of these sources is discussed below. An estimate of the

Table F7. Factors for Confidence Intervals (2S.E.) for Crude Oil Proved Reserves and Production, 2002
(Million Barrels of 42 U.S. Gallons)

State and Subdivision	2002 Reserves	2002 Production	State and Subdivision	2002 Reserves	2002 Production
United States	17	2	Oklahoma ^b	0	0
Alabama ^b	0	0	Pennsylvania	4	1
Alaska ^a	0	0	Texas ^b	0	0
Arkansas ^b	0	0	RRC District 1 ^b	0	0
California ^b	0	0	RRC District 2 Onshore ^b	0	0
Coastal Region Onshore ^b	0	0	RRC District 3 Onshore ^b	0	0
Los Angeles Basin Onshore ^b	0	0	RRC District 4 Onshore ^b	0	0
San Joaquin Basin Onshore ^b	0	0	RRC District 5 ^b	0	0
State Offshore ^a	0	0	RRC District 6 ^b	0	0
Colorado ^b	0	0	RRC District 7B ^b	0	0
Florida ^a	0	0	RRC District 7C ^b	0	0
Kansas ^b	0	0	RRC District 8 ^b	0	0
Kentucky	7	0	RRC District 8A ^b	0	0
Louisiana ^b	0	0	RRC District 9 ^b	0	0
North ^b	0	0	RRC District 10 ^b	0	0
South Onshore ^b	0	0	State Offshore ^a	0	0
State Offshore ^a	0	0	Utah ^b	0	0
Michigan ^b	0	0	Virginia ^a	0	0
Mississippi ^b	0	0	West Virginia	5	0
Montana ^b	0	0	Wyoming ^b	0	0
New Mexico ^b	0	0	Federal Offshore ^a	0	0
East ^b	0	0	Pacific (California) ^a	0	0
West ^b	0	0	Gulf of Mexico (Louisiana) ^a	0	0
New York	0	0	Gulf of Mexico (Texas) ^a	0	0
North Dakota ^b	0	0	Miscellaneous ^c	5	0
Ohio	3	0			

^aSampling rate was 100 percent in Alaska, Florida Onshore, Virginia, and Offshore areas.

^bSampling was not used. Estimates for each operator were made using an imputation function.

^cIncludes Arizona, Illinois, Indiana, Maryland, Missouri, Nebraska, Nevada, Oregon, South Dakota, and Tennessee.

Notes: Confidence intervals are associated with Table 6 reserves and production data. Factors for confidence intervals for each State and the United States are independently estimated and do not add.

Source: Factor estimates based on data filed on Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2002.

Table F8. Factors for Confidence Intervals (2S.E.) for Natural Gas Proved Reserves and Production, Wet After Lease Separation, 2002 (Billion Cubic Feet at 14.73 psia and 60 Degrees Fahrenheit)

State and Subdivision	2002 Reserves	2002 Production	State and Subdivision	2002 Reserves	2002 Production
United States	453	39	Oklahoma ^b	0	0
Alabama ^b	0	0	Pennsylvania	196	15
Alaska ^a	0	0	Texas ^b	0	0
Arkansas ^b	0	0	RRC District 1 ^b	0	0
California ^b	0	0	RRC District 2 Onshore ^b	0	0
Coastal Region Onshore ^b	0	0	RRC District 3 Onshore ^b	0	0
Los Angeles Basin Onshore ^b	0	0	RRC District 4 Onshore ^b	0	0
San Joaquin Basin Onshore ^b	0	0	RRC District 5 ^b	0	0
State Offshore ^a	0	0	RRC District 6 ^b	0	0
Colorado ^b	0	0	RRC District 7B ^b	0	0
Florida ^a	0	0	RRC District 7C ^b	0	0
Kansas ^b	0	0	RRC District 8 ^b	0	0
Kentucky	68	7	RRC District 8A ^b	0	0
Louisiana ^b	0	0	RRC District 9 ^b	0	0
North ^b	0	0	RRC District 10 ^b	0	0
South Onshore ^b	0	0	State Offshore ^a	0	0
State Offshore ^a	0	0	Utah ^b	0	0
Michigan ^b	0	0	Virginia ^a	0	0
Mississippi ^b	0	0	West Virginia	108	8
Montana ^b	0	0	Wyoming ^b	0	0
New Mexico ^b	0	0	Federal Offshore ^{a,c}	0	0
East ^b	0	0	Pacific (California) ^a	0	0
West ^b	0	0	Gulf of Mexico (Louisiana) ^{a,c}	0	0
New York	107	6	Gulf of Mexico (Texas) ^a	0	0
North Dakota ^b	0	0	Miscellaneous ^d	0	0
Ohio	286	28			

^aSampling rate was 100 percent in Alaska, Florida Onshore, Virginia, and Offshore areas.

^bSampling was not used. Estimates for each operator were made using an imputation function.

^cIncludes Federal offshore Alabama.

^dIncludes Arizona, Illinois, Indiana, Maryland, Missouri, Nebraska, Nevada, Oregon, South Dakota, and Tennessee.

Notes: Confidence intervals are associated with Table 8 reserves and production data. Factors for confidence intervals for each State and the United States are independently estimated and do not add.

Source: Factor estimates based on data filed on Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2002

bias from nonresponse is presented in the section on adjustment for operator nonresponse.

Assessing the Accuracy of the Reserve Data

The EIA maintains an evaluation program to assess the accuracy and quality of proved reserve estimates gathered on Form EIA-23. Field teams consisting of petroleum engineers from EIA's Reserves and Production Division conduct technical reviews of reserve estimates and independently estimate the proved reserves of a statistically selected sample of operator properties. The results of these reviews are used to evaluate the accuracy of reported reserve estimates. Operators are apprized of the team's findings to assist them in completing future filings. The magnitude of errors due to differences between reserve volumes submitted by operators on the Form EIA-23 and those estimated by EIA petroleum engineers on their field trips were generally within accepted professional engineering standards.

Respondent Estimation Errors

The principal data elements of the Form EIA-23 survey consist of respondent estimates of proved reserves of crude oil, natural gas, and lease condensate. Unavoidably, the respondents are bound to make some estimation errors, i.e., until a particular reservoir has been fully produced to its economic limit and abandoned, its reserves are not subject to direct measurement but must be inferred from limited, imperfect, or indirect evidence. A more complete discussion of the several techniques of estimating proved reserves, and the many problems inherent in the task, appears in Appendix G.

Reporting Errors and Data Processing Errors

Reporting errors on the part of respondents are of definite concern in a survey of the magnitude and complexity of the Form EIA-23 program. Several steps were taken by EIA to minimize and detect such problems. The survey instrument itself was carefully developed, and included a detailed set of instructions for filing data, subject to a common set of definitions similar to those already used by the industry. Editing software is continually developed to detect different kinds of probable reporting errors and flag them for resolution by analysts, either through confirmation of

the data by the respondent or through submission of amendments to the filed data. Data processing errors, consisting primarily of random keypunch errors, are detected by the same software.

Imputation Errors

Some error, generally expected to be small, is an inevitable result of the various estimations outlined. These imputation errors have not yet been completely addressed by EIA and it is possible that estimation methods may be altered in future surveys. Nationally, 5 percent of the crude oil proved reserve estimates, 4 percent of the wet natural gas proved reserve estimates, and 3 percent of the lease condensate proved reserve estimates resulted from the imputation and estimation of reserves for those Certainty and Noncertainty operators who did not provide estimates for all of their properties, in combination with the expansion of the sample of Noncertainty operators to the full population. Errors for the latter were quantitatively calculated, as discussed in the previous section. Standard errors, for the former, would tend to cancel each other from operator to operator, and are, therefore, expected to be negligible, especially at the National level of aggregation. In States where a large share of total reserves is accounted for by Category III and smaller Category II operators, the errors are expected to be somewhat larger than in States where a large share of total reserves is accounted for by Category I and larger Category II operators.

Frame Coverage Errors

Of all the sources of controllable error connected with the Form EIA-23 survey, errors in the operator frame were expected to be the most important. If the frame does not list all operators in a given State, the sample selected from the frame for the State will not represent the entire operator population, a condition called under coverage. Under coverage is a problem with certain States, but it does not appear to be a problem with respect to the National proved reserve estimates for either crude oil or natural gas. While it is relatively straightforward to use existing sources to identify large operators and find addresses for them, such is not the case for small operators. A frame such as that used in the 2002 survey is particularly likely to be deficient in States where a large portion of total reserves and production is accounted for by small operators. These States are not likely to allocate sufficient resources to keep track of all operators on a current basis. Some under coverage of this type seems to exist, particularly,

with reference to natural gas operators. EIA is continuing to work to remedy the under coverage problem in those States where it occurred.

Calculation of Reserves of Natural Gas Liquids and Dry Natural Gas

Natural Gas Liquids Reserve Balance

The published reserves, production, and reserves change statistics for crude oil, lease condensate, and natural gas, wet after lease separation, were derived from the data reported on Form EIA-23 and the application of the imputation methods discussed previously. The information collected on Form EIA-64A was then utilized in converting the estimates of the wet natural gas reserves into two components: plant liquids reserve data and dry natural gas reserve data. The total natural gas liquids reserve estimates presented in **Table 14** were computed as the sum of plant liquids estimates (**Table 15**) and lease condensate (**Table 16**) estimates.

To generate estimates for each element in the reserves balance for plant liquids in a given producing area, the first step was to group all natural gas processing plants that reported this area as an area-of-origin on their Form EIA-64A, and then sum the liquids production attributed to this area over all respondents. Next, the ratio of the liquids production to the total wet natural gas production for the area was determined. This ratio represented the percentage of the wet natural gas that was recovered as natural gas liquids. Finally, it was assumed that this ratio was applicable to the reserves and each component of reserve changes (except adjustments), as well as production. Therefore, each element in the wet natural gas reserves balance was multiplied by this recovery factor to yield the corresponding estimate for plant liquids. Adjustments of natural gas liquids were set equal to the difference between the end of previous year reserve estimates, based upon the current report year Form EIA-23 and Form EIA-64A surveys, and the end of current year reserve estimates published in the preceding year's annual reserves report.

Natural Gas Reserve Balance

This procedure involved downward adjustments of the natural gas data, wet after lease separation, in estimating the volumes of natural gas on a fully dry

basis. These reductions were based on estimates of the gaseous equivalents of the liquids removed (in the case of production), or expected to be removed (in the case of reserves), from the natural gas stream at natural gas processing plants. Form EIA-64A collected the volumetric reduction, or shrinkage, of the input natural gas stream that resulted from the removal of the NGL at each natural gas processing plant.

The shrinkage volume was then allocated to the plant's reported area or areas of origin. Because shrinkage is, by definition, roughly in proportion to the NGL recovered, i.e. the NGL produced, the allocation was in proportion to the reported NGL volumes for each area of origin. However, these derived shrinkage volumes were rejected if the ratio between the shrinkage and the NGL production (gas equivalents ratio) fell outside certain limits of physical accuracy. The ratio was expected to range between 1,558 cubic feet per barrel (where NGL consists primarily of ethane) and 900 cubic feet per barrel (where NGL consists primarily of natural gasolines). When the computed gas equivalents ratio fell outside these limits, an imputed ratio was utilized to estimate the plant's natural gas shrinkage allocation to each reported area of origin.

This imputed ratio was that calculated for the aggregate of all other plants reporting production and shrinkage, and having a gas equivalent ratio within the aforesaid limits, from the area in question. The imputed area ratio was applied only if there were at least five plants to base its computation on. If there were less than five plants, the imputed ratio was calculated based on all plants in the survey whose individual gas equivalents ratio was within the acceptable limits. Less than one percent of the liquids production was associated with shrinkage volumes imputed in this manner. Based on the 2002 Form EIA-64A survey, the national weighted average gas equivalents ratio was computed to be 1,404 cubic feet of natural gas shrinkage per barrel of NGL recovered. The total shrinkage volume (reported plus imputed) for all plants reporting a given area of origin was then subtracted from the estimated value of natural gas production, wet after lease separation, yielding dry natural gas production for the area. The amount of the reduction in the wet natural gas production was then expressed as a percentage of the wet natural gas production. Dry natural gas reserves and reserve changes were determined by reducing the wet natural gas reserves and reserve changes by the same percentage reduction factor.

A further refinement of the estimation process was used to generate an estimate of the natural gas liquids reserves in those States with coalbed methane fields. The States where this procedure was applied were Alabama, Colorado, Kansas, New Mexico, Oklahoma, Pennsylvania, Utah, Virginia, West Virginia, and Wyoming. The first step in the process was to identify all Form EIA-23 reported coalbed methane fields. The assumption was made that coalbed methane fields contained little or no extractable natural gas liquids. Therefore, when the normal shrinkage procedure was applied to the wet gas volume reserve components, the estimate of State coalbed methane volumes were excluded and were not reduced for liquid extraction. Following the computation for shrinkage, each coalbed field gas volume reserve components was added back to each of the dry gas volume reserve components in a State. The effect of this is that the large increases in

reserves in some States from coalbed methane fields did not cause corresponding increases in the State natural gas liquids proved reserves.

Adjustments of dry natural gas were set equal to the difference between the end of previous year reserves estimates, based upon the current report year Form EIA-23 and Form EIA-64A surveys, and the end of current year reserve estimates published in the preceding year's annual reserves report.

Each estimate of end of year reserves and report year production has associated with it an estimated sampling error. The standard errors for dry natural gas were computed by multiplying the wet natural gas standard errors by these same percentage reduction factors. **Table F7** provides estimates for 2 times the $S.E. (\hat{V}_s)$ for dry natural gas.