Development of the DOE Gas Information System (GASIS) – Final Report

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1. INTRODUCTION

1.1 INTRODUCTION

The goal of the U.S. Department of Energy's Gas Information System (GASIS) project was to develop the first national-scale public domain electronic database of reservoir property and ultimate recovery data for lower-48 oil and gas reservoirs. The project was carried out by Energy and Environmental Analysis of Arlington, Virginia with Dwight's Energydata (now IHS Energy) as the primary subcontractor.

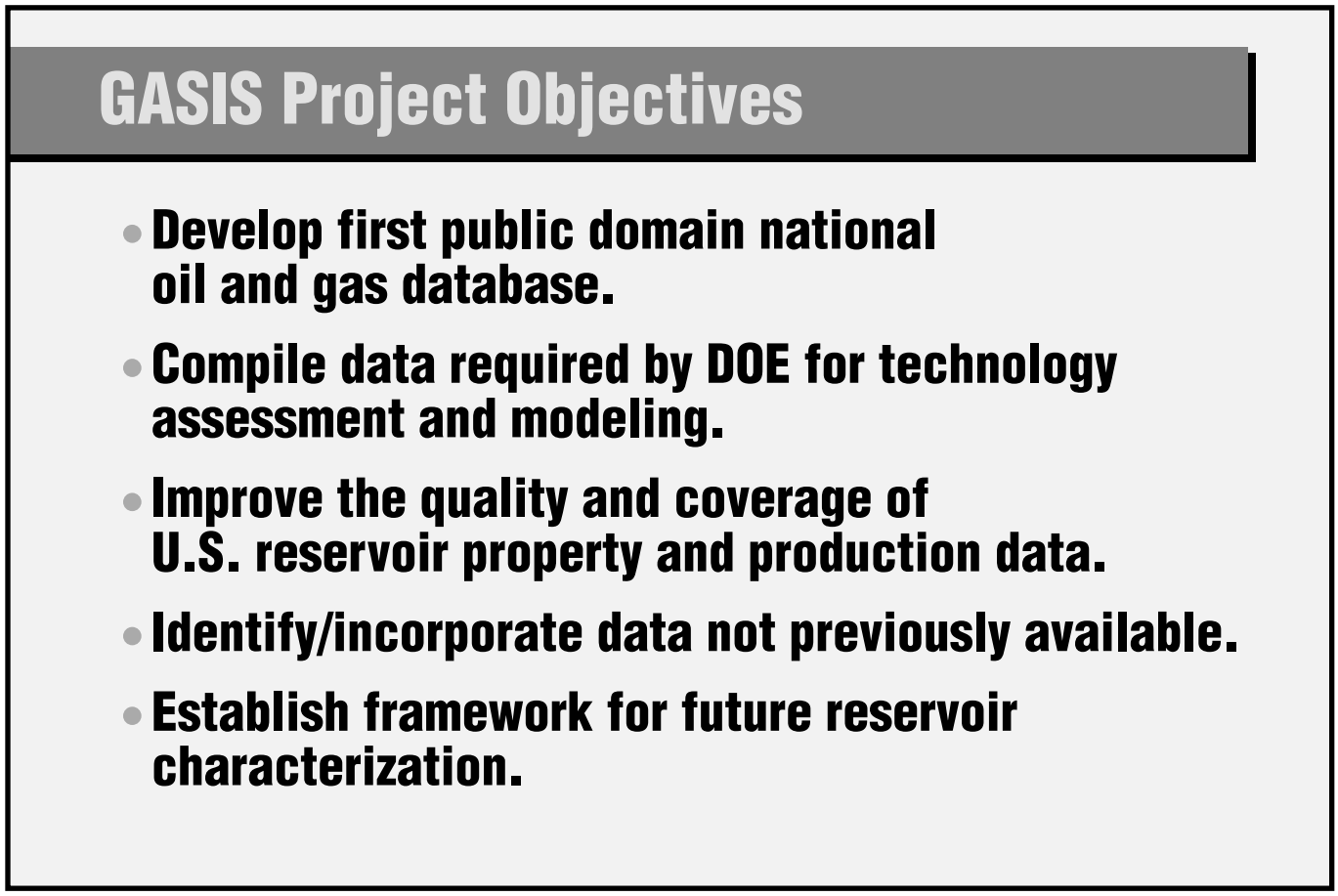
GASIS can be viewed as the national extension of the Gas Research Institute/ Department of Energy gas atlas project, which produced six regional atlases and their corresponding reservoir property databases. Gas atlas projects included Texas, the Mid-Continent, the Central and Eastern Gulf Coast, the Rockies, the Appalachian Region, and the Gulf of Mexico. GASIS combines gas atlas information with information from Dwight's Energydata and other sources to produce a database with powerful capabilities for exploration, development, planning, economic analysis, and market assessment.

The GASIS database on CD-ROM is available through the Federal Energy Technology Center in Morgantown, West Virginia. GASIS Release 2 was published in June 1999 and includes 19,220 oil and gas reservoir records representing 21 producing states and the Gulf of Mexico. The reservoir database contains 185 data fields per record. GASIS also includes a directory of information sources for U.S. reservoirs. GASIS comes with a Windows-based software application that allows query and retrieval of information.

1.2 OBJECTIVES

As shown in Figure 1-1, the objectives of the GASIS project were as follows:

FIGURE 1-1
GASIS PROJECT OBJECTIVES



- Develop the first national-scale public domain oil and gas reservoir property and gas recovery database.
- Compile the reservoir data needed by DOE for supply technology assessment, resource characterization, and modeling.
- Improve the quality and coverage of lower-48 reservoir property and production data.
- Identify and incorporate reservoir data sources not previously available.
- Establish a framework for future natural gas resource characterization.

1.3 APPROACH

The GASIS reservoir database or "Reservoir Data System" combines gas atlas data, selected data from a commercial reservoir and completion level database, new data from GASIS geological reservoir studies, previously assembled electronic data from the Gas Research Institute, and new processed and statistical data. Information from multiple sources was used to both expand the scope of information in the database and to improve the quality and reliability of the data. Where multiple sources of data were available, the best source was used. In addition, data element "source codes" document the source of data. Automated quality control procedures were applied to the database to ensure consistency and to identify and remove erroneous data.

A reservoir study/database development project involving approximately 1,000 reservoirs was a key component of the GASIS project. This effort was designed to improve the quality and coverage of lower-48 reservoir property and production data and provide the first true "reservoir definition" for many fields in the Mid-Continent and elsewhere. Each reservoir study involved analysis of a sufficient number of wells to determine representative values of reservoir properties such as porosity, net pay, and gas saturation. Documentation of a geological type well and type log provides information about the producing interval and its log characteristics.

In addition to the database development project, a GASIS "Source Directory" was developed and is included on the CD. The Source Directory documents major public domain and commercial databases that contain geological, engineering, production, well completion, and related data of interest to industry. The Source Directory also describes industry information centers, sample

repositories, and technology transfer centers. The directory is searchable by subject area and company or organization.

Information from all sources was processed and converted to uniform formats and definitions. The entire database was assembled on CD-ROM for personal computer applications with a Windows-based query and retrieval interface.

2. PROJECT OVERVIEW

2.1 OVERVIEW OF GASIS DEVELOPMENT

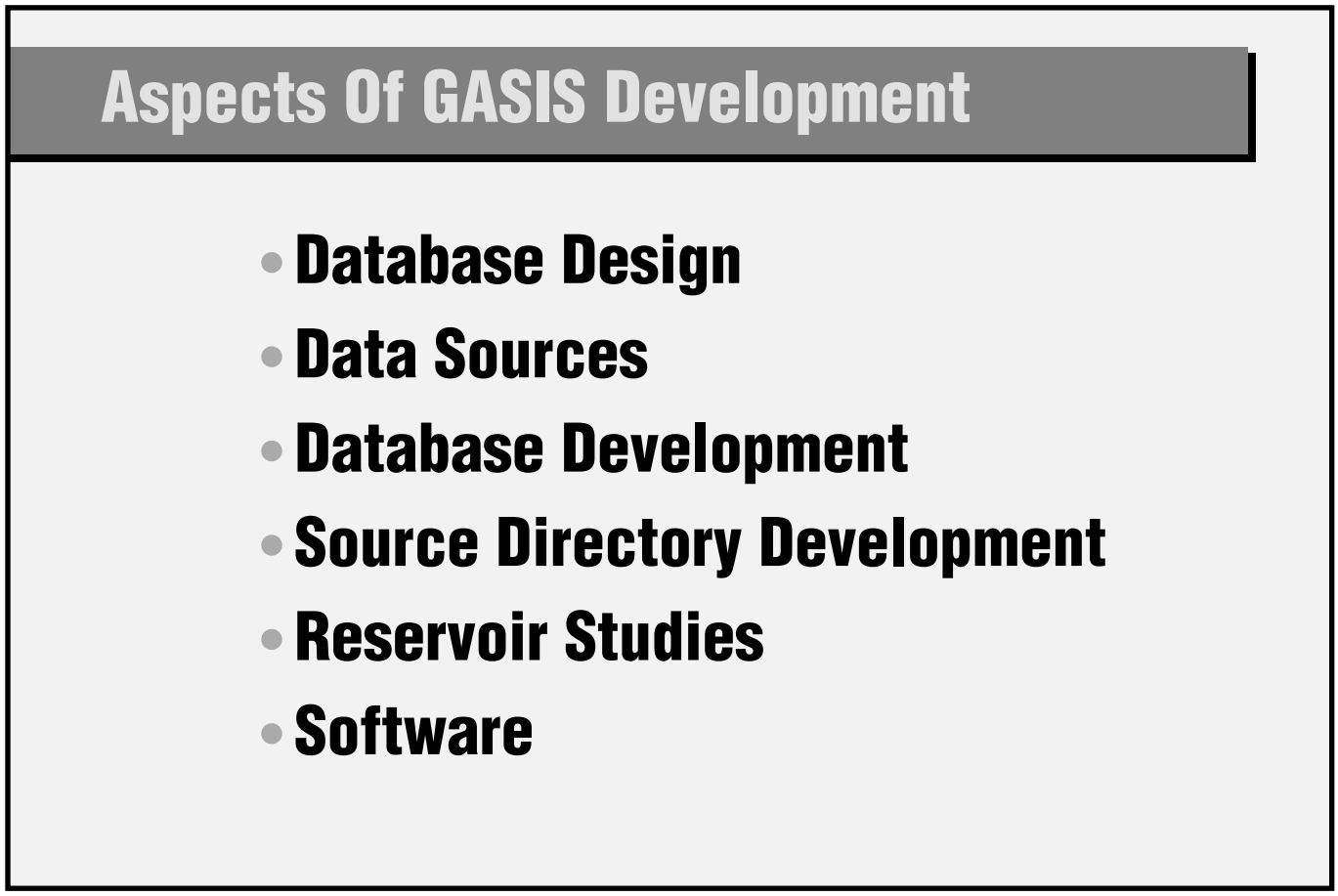
Figure 2-1 lists the major aspects of GASIS development: database design (content and structure), evaluation of data sources for each type of data, reservoir database development, Source Directory development, geological reservoir studies and related data collection, and software design and development.

2.1.1 Database Design

The initial GASIS task was to conduct a survey of potential GASIS users. The primary objective of this "User Needs Assessment" (Appendix G) was to obtain input on the content, design, and research priorities for GASIS from all major sectors of the gas industry. Other objectives were to determine potential applications for GASIS and to evaluate software options and requirements for the GASIS CD. The survey also identified additional sources of reservoir data. The User Needs Assessment was based upon in-person interviews with representatives of major oil companies, independents, pipelines, service companies, financial institutions, research groups, and government agencies. Over 85 individuals participated in this effort.

Survey participants indicated that the most important types of data for inclusion in GASIS are accurate production data, reservoir engineering attributes such as porosity, pay, and water saturation, gas and fluid properties, field status information, and geological data. These types of data were given priority because of their importance in performing reservoir engineering and economic analysis, as well as their usefulness in exploration and development applications. The coverage of such reservoir property data in existing databases (including commercial data) prior to GASIS generally ranged from fair to poor. The status of "reservoir definition" in the Mid-Continent was very poor, and improving this information was a high priority for the GASIS project.

FIGURE 2-1
ASPECTS OF GASIS DEVELOPMENT



Other types of data, such as drilling and completion data and rock mechanical properties were generally considered lower in priority. While this type of information could be valuable in certain applications, it was recognized that it would be difficult to obtain and that the GASIS effort should concentrate on improving the coverage and quality of basic reservoir property data.

2.1.2 Data Sources

One of the initial GASIS projects was to identify and evaluate all sources of information that could be used in developing GASIS. This included research for both the Reservoir Data System and the Source Directory. Numerous public domain sources were researched. Dwight's Energydata has an extensive library of data on U.S. reservoirs, and that information was evaluated. The User Needs Assessment also identified data sources.

Information sources for the Reservoir Data System include new reservoir studies, regional GRI/DOE gas atlas datasets, Dwight's databases, GRI databases, and other public domain information. Each of these sources was evaluated for content, coverage, data quality, and format. Procedures were established for instances in which a reservoir data element was included in more than one data source.

The data sources for the most important reservoir parameters in GASIS are documented in the database. Source codes were developed to assist the GASIS user in evaluating the reliability or accuracy of specific reservoir data elements.

2.1.3 Reservoir Database Development

The primary component of GASIS is the Reservoir Data System, which consists of 19,220 reservoir records containing 185 data fields. Information includes field identification and location, field code, reservoir name, reservoir and fluid properties, play classification, cumulative production, and estimated ultimate recovery.

The Reservoir Data System includes all of the onshore and offshore areas included in the GRI/DOE regional gas atlas projects (Figure 2-2). The coverage area represents the majority of lower-48 production and reserves. The only significant areas of production not included in GASIS are the Michigan/Illinois basins, the Williston Basin of Montana and North Dakota (primarily an oil province), and California. These areas were not covered by gas atlas projects.

2.1.4 Source Directory Development

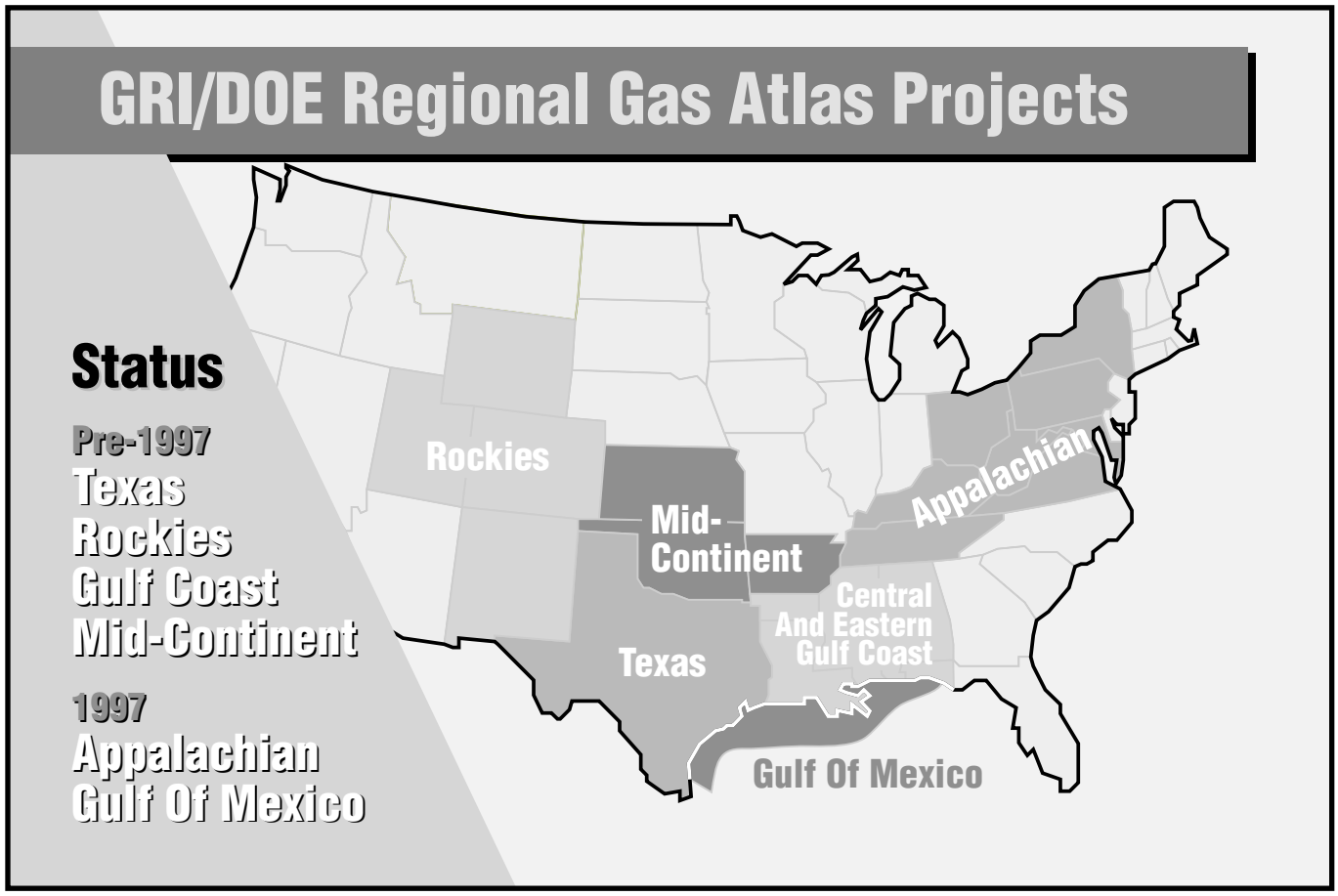
The GASIS Source Directory documents databases and information sources covering a wide range of supply-related topics. The emphasis is on databases of reservoir property, geological, and production data at the well or reservoir level. In general, the databases documented in the Source Directory contain the types of information assembled for the GASIS reservoir database. Over 250 public domain and commercial databases are documented. Data elements include the name of the database, the subject areas covered, the database developer, geographic coverage, contact information, and an abstract. The database can be queried by subject area, geographic area, or developer.

2.1.5 Reservoir Studies

A major component of the GASIS project was a reservoir study project designed to improve the quality and coverage of reservoir level data in major gas producing basins. This research included well log correlation, assignment of reservoir codes to individual gas completions, and determination of representative reservoir properties such as average porosity, pay thickness, gas saturation, and reservoir pressure. A "type well" was selected and documented for each study. The type well is one that has a typical reservoir interval and log response.

The reservoir study effort was designed to obtain information on the major gas producing regions of the lower-48. Basins studied include the Anadarko, Arkoma, East Texas, Arkla, Mid-Gulf Coast, Warrior, Green River, Piceance, Denver, Wind River, Uinta, Overthrust Belt, Powder River, San Juan, and Permian Basins. A total of 1,009 reservoir studies were completed. Within each studied basin, an effort was made to obtain representative information for all major gas plays.

FIGURE 2-2
GRI/DOE REGIONAL GAS ATLAS PROJECTS



2.1.6 Software

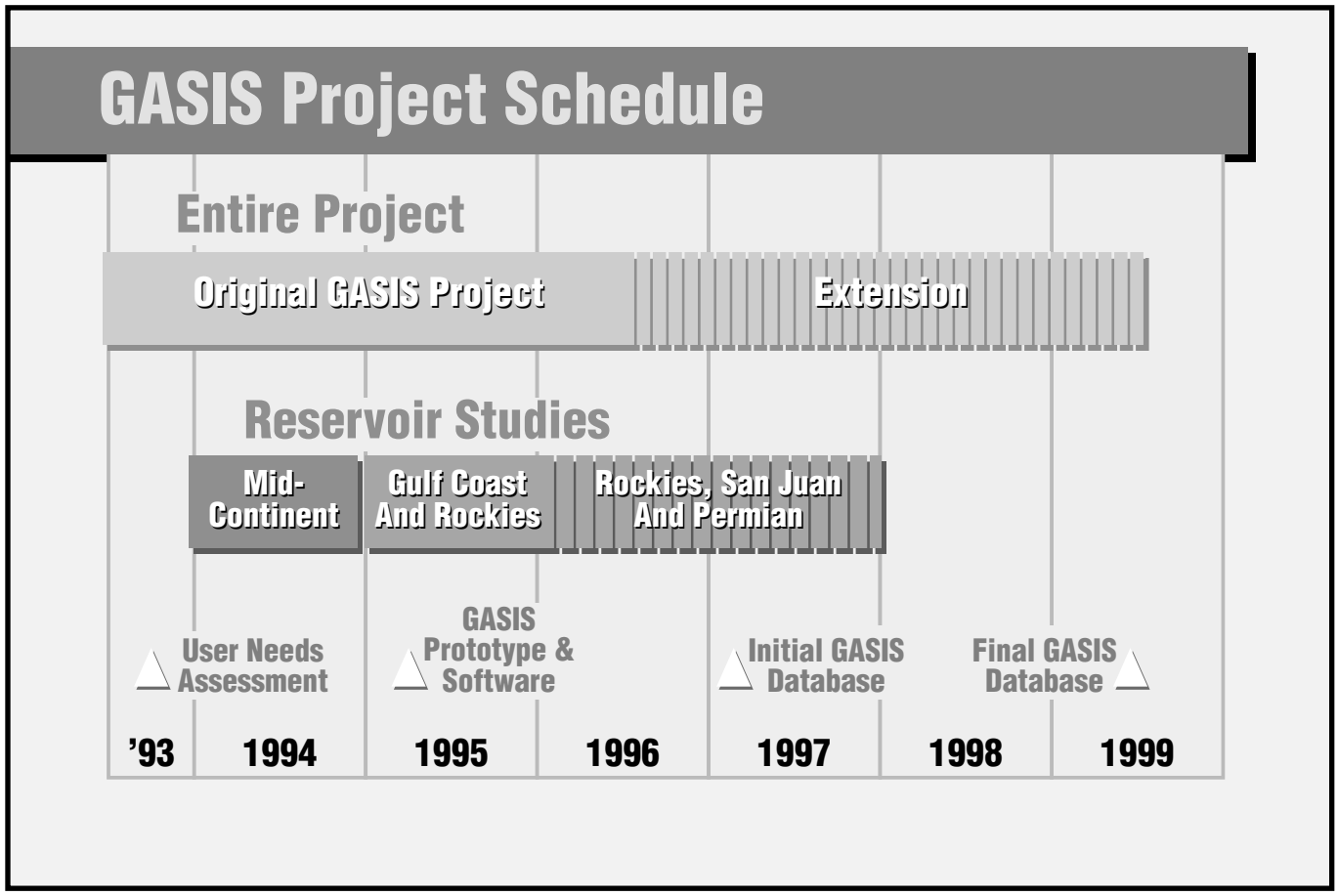
The GASIS project included development of Windows-based (FoxPro) software for database queries and manipulation. The software allows, screen display, query and retrieval, report generation, and exporting of data in standard formats. It also allows graphing of numerical data and viewing of reservoir study type logs. Both the Reservoir Data System and the Source Directory can be queried. The GASIS user is only required to have Windows 95 or Windows 98 to operate the system.

2.2 GASIS SCHEDULE

Figure 2-3 summarizes the GASIS project schedule. The project was initiated in May 1993. In 1995 and 1996 the project was expanded to include additional reservoir studies and data compilation. The project completion date was extended to allow for the incorporation of the offshore and Appalachian gas atlas data, additional production data, and other information.

The initial GASIS project was the User Needs Assessment, which was carried out in 1993 and 1994. Reservoir study work and initial database and software development began in 1994. A prototype of GASIS was developed in 1995. Release 1 of GASIS was published on CD in March of 1997. Release 2 was published in June of 1999.

FIGURE 2-3
GASIS PROJECT SCHEDULE



3. DATABASE DEVELOPMENT

3.1 INTRODUCTION

The primary component of GASIS is the Reservoir Data System, which consists of 19,220 reservoir records containing 185 data fields. The GASIS Reservoir Data System is the first national-scale public domain reservoir database for the U.S. It is a compilation of data from numerous sources and contains a large amount of information that has never before been available at the reservoir level. It incorporates all of the GASIS reservoir study information, including new reservoir and fluid property data and reservoir definition. GASIS also includes information from the regional GRI/DOE gas atlas projects, which created the first reservoir level geological play classification system for the U.S.

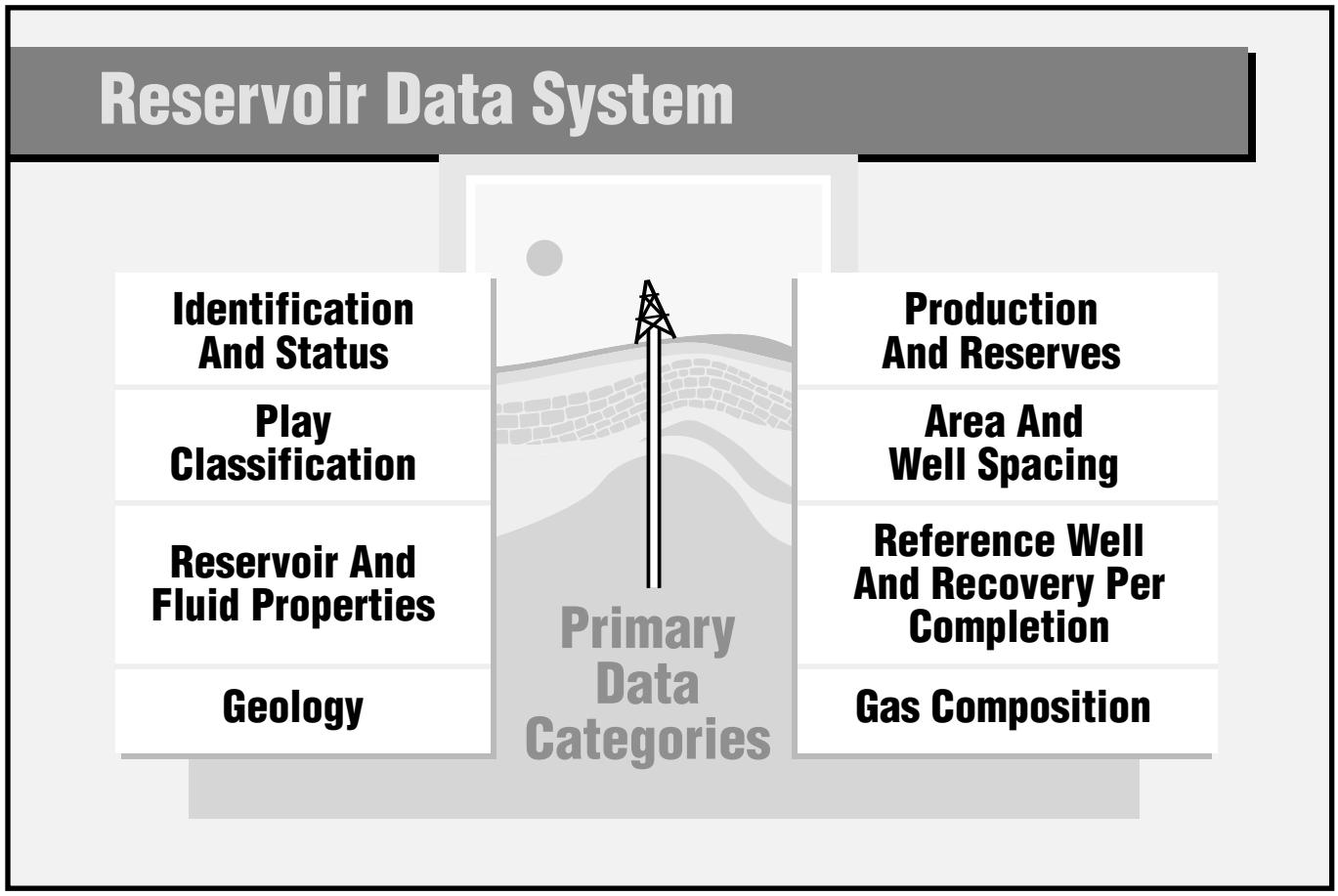
The Reservoir Data System includes all of the onshore and offshore areas included in the GRI/DOE regional gas atlas projects. The coverage area represents the majority of lower-48 production and reserves. The only significant areas of production not included in GASIS are the Michigan/Illinois basins, the Williston Basin of Montana and North Dakota (primarily an oil province), and California. These areas were excluded because they are not covered by gas atlas projects.

Reservoir selection is based upon a minimum cumulative gas production of 10 Bcf through 1996 (5 Bcf in the Rockies as specified for the atlas project). Selection is based upon total gas cumulative production, which includes both gas well gas and oil well or associated/dissolved gas. In the case of the Appalachian and Gulf of Mexico areas, no production criterion was applied and the gas atlas records were used for GASIS development.

3.2 DATA INCLUDED

Figure 3-1 shows the primary categories of data included in the Reservoir Data System. Included are field and reservoir identification and location, producing status, play classification, reservoir and

FIGURE 3-1
RESERVOIR DATA SYSTEM



fluid properties, geologic data, summary production data, and estimated remaining gas reserves and ultimate recovery. Also included are productive area and average gas well spacing, completion level ultimate recovery, a geological type well (for reservoir studies), and gas composition data.

The primary sources of information for the Reservoir Data System are shown in Figure 3-2. These include approximately 1,000 GASIS reservoir studies, selected gas atlas data, Dwight's databases, Gas Research Institute tight gas identification and gas composition data, and information from government agencies. The reservoir study datasets represent the highest quality data source available for GASIS and these received priority in assembling the database. The GRI tight gas database was used to identify low permeability or "tight" reservoirs. GASIS is the first public release of this information, which was originally compiled GRI. The GRI component level gas composition data are also included in GASIS.

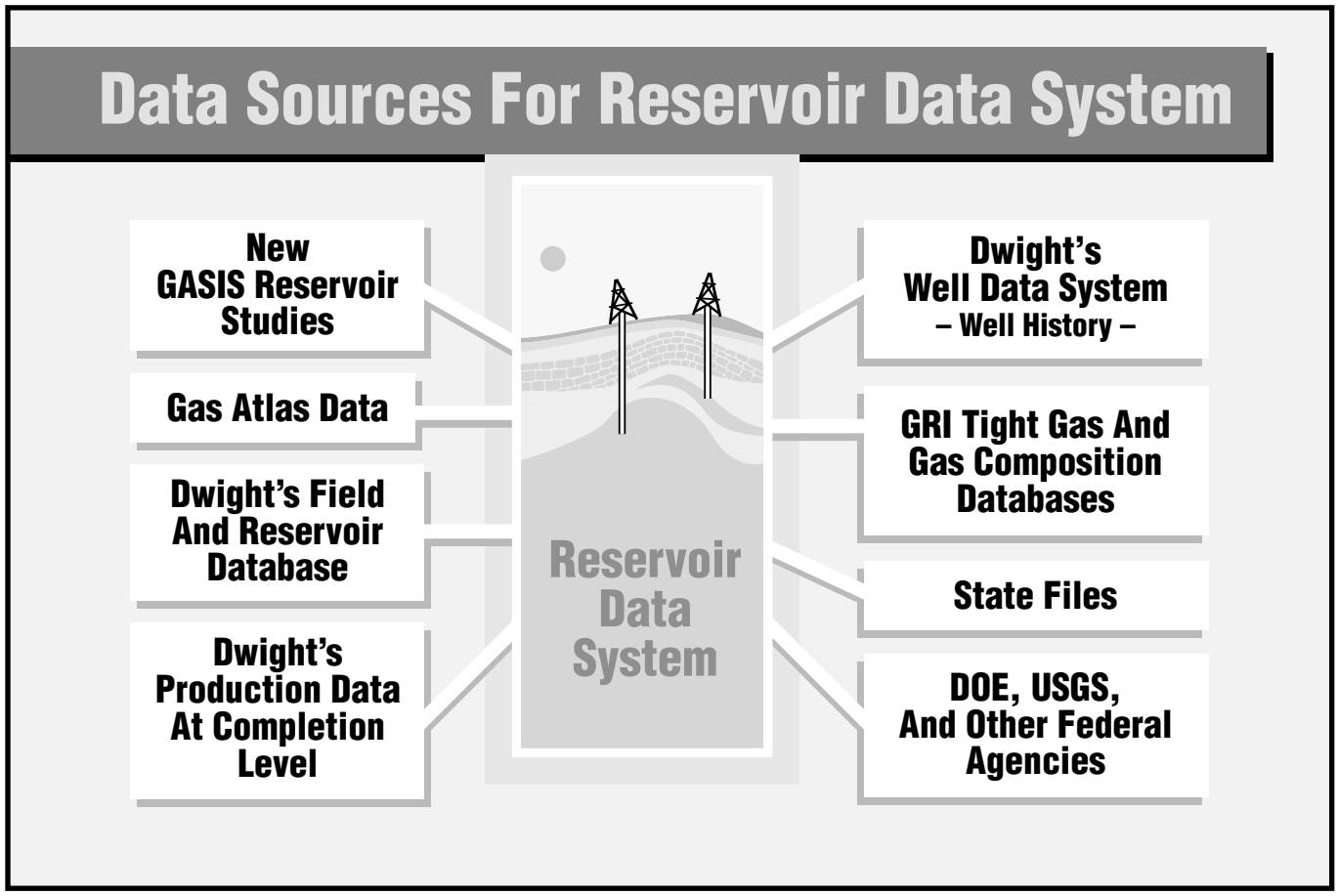
The scope of GASIS goes beyond basic reservoir data. For example, GASIS includes information on the distribution of completion level ultimate recovery. This information was developed from Dwight's gas production database and is a powerful tool in economic evaluation. GASIS also includes updated productive area information, processed from Section-Township-Range information on the completion records.

3.3 ASPECTS OF DATABASE DEVELOPMENT

The following is a listing of the major steps involved in the development of the Reservoir Data System:

- Reservoir selection
  - — Reservoirs were selected for inclusion in the GASIS database.
  - — This involved the application of a minimum cumulative production criterion (10 Bcf of total gas or 5 Bcf in the Rockies). In Appalachia and the Gulf of Mexico, GASIS record selection was defined by the atlas database without the application of a production cutoff.

FIGURE 3-2
DATA SOURCES FOR RESERVOIR DATA SYSTEM



- Processing of regional gas atlas data
  - — Gas Atlas databases were obtained and evaluated. Data elements were converted to GASIS formats.
- Incorporation of reservoir study information
  - — All reservoir study data were incorporated into the database.
- Identification of tight reservoirs
  - — The GRI "tight gas" database was used to identify the GASIS reservoirs that are low permeability.
- Assignment of gas composition data
  - — GRI component level gas composition data were processed for GASIS.
- Development and incorporation of supplemental geological data, including a play level depositional system (depositional environment) classification.
- Identification of cycled/injected gas reservoirs
- Determination of USGS field size classes (1-20)
- Gas reserves and ultimate recovery
  - — Reservoir level reserves and ultimate recoveries were assigned in all areas covered by Dwight's databases. Reserves were estimated at the gas completion level and summed to the reservoir level.
- Ultimate recovery per completion
  - — Completion level ultimate recovery data were used to generate values of mean, median, minimum, and maximum recovery per gas completion.
- Determination of typical (median) recovery well
  - — Completion level ultimate recovery estimates were used to select and document a typical gas recovery well for gas reservoirs.
- Calculation of gas productive area and average spacing
  - — In areas where well location is reported by section-township-range, the gas productive and total productive area of GASIS reservoirs was determined.
- Development of record and data element source codes
  - — Major data sources are tracked in GASIS. Sources include GASIS reservoir studies, Dwight's databases, and the Gas Atlases.
- Automated quality control procedures were applied to identify incorrect data

3.4 USE OF GAS ATLAS DATA

Beginning in the mid-1980s, the Gas Research Institute (GRI) supported an effort to develop a series of "gas atlases" for the lower-48. The concept was to group the significant reservoirs within a producing region into geological "plays" and to publish descriptions of each play and an electronic database of reservoir properties. A play is a grouping of fields or reservoirs with similar characteristics leading to hydrocarbon accumulation. No public domain play classification system had been developed for the U.S. prior to the GRI-supported gas atlas effort. GRI published gas atlases for Texas, the Central and Eastern Gulf Coast, the Mid-Continent, and the Rockies. In the mid-1990s, the Department of Energy also contributed to the gas atlas effort through their support of the Gulf of Mexico and Appalachian atlas projects.

The gas atlas information was a major source of data for GASIS, but there are significant differences in the population of reservoirs included in the gas atlas and in GASIS. This is because reservoir selection for GASIS was primarily based upon evaluation of the Dwight's database. Figure 3-3 shows the reservoir counts for the gas atlas project in comparison to GASIS. With the exception of the Appalachian and Gulf of Mexico atlas regions, GASIS reservoir selection was based upon Dwight's database information. Thus, in some regions, notably the Mid-Continent and Texas, the reservoir counts are very different.

In the case of the Mid-Continent, GASIS includes 880 records in comparison to the 530 records in the gas atlas. The gas atlas database was compiled prior to the GASIS reservoir study effort. Since the GASIS project studied the region extensively and re-defined many reservoirs, the record counts are quite different.

FIGURE 3-3
ATLAS VS. GASIS RESERVOIR COUNTS

Atlas vs. GASIS Reservoir Counts

Area	– Gas Atlas –	– GASIS –
Texas	1,828	3,286
Mid-Continent	530	880
Cent. & E. Gulf Coast	1,349	1,394
Rockies	861	1,058
Appalachia	5,156	2,655
Gulf Of Mexico	9,947	9,947
Total		19,220

In Texas, we determined that the original atlas database excluded a large number of 10+ bcf reservoirs. It is likely that these records were not included because they were never assigned to one of the gas atlas plays.

In the Appalachian Basin, the gas atlas project was our primary source of information. However, the record counts in GASIS are lower because we excluded the very small reservoirs, primarily those containing only one well.

3.4.1 Processing of the Appalachian Atlas Data

The Appalachian gas atlas reservoir database was processed for inclusion in GASIS. The database contains a large number of records for very small reservoirs, and these were excluded from GASIS. A total of 2,655 of the 5,156 gas atlas records are included in GASIS. Multiple processing steps were carried out to convert atlas data to GASIS formats. These included reservoir designation, gas production type, field status, lithology, and depositional system. Codes in the atlas were converted to text for GASIS for play name, state name, producing formation, and geologic age. New data elements were developed for field discovery year, field type, county name, county code, basin name, and basin code. Devonian Shale and tight gas records were identified in the database and "flagged." Gas composition data were also added where available.

3.4.2 Processing of the Gulf of Mexico Atlas Data

The Gulf of Mexico gas atlas data were processed for inclusion in GASIS. The initial publication of the offshore atlas (Miocene and older reservoirs) contained 4,325 records and the second database (Plio-Pleistocene reservoirs) included 5,622 records for a total of 9,947 records. All of these records were included in GASIS. All of the gas atlas data fields were carried over into GASIS, and format adjustments were made where needed. New data elements added for GASIS include field and reservoir status, ultimate gas recovery, gas reserves, and initial GOR.

The records developed by the MMS for the offshore atlas are not "true" reservoir records. MMS developed what were termed "sandbody" records rather than true reservoir records. A sandbody record in many cases is an aggregation of multiple reservoirs that produce from the same interval or

sandbody within a field. No other sources of reservoir level information were available for the development of GASIS, so the gas atlas sandbody records and data were used.

3.5 QUALITY CONTROL PROCEDURES

Extensive quality control checks were applied to the reservoir datasets before inclusion in GASIS. A series of automated quality control checks were applied to identify "outlier" and erroneous data. Both Dwight's and EEA implemented automated quality control procedures. Typical procedures included logic checks, checks for data elements that are required to be present (such as field name), and range checks on numeric data. Questionable data were reviewed and either corrected or deleted.

3.6 COVERAGE OF THE GASIS DATABASE

After finalizing GASIS Release 2, an analysis was carried out to evaluate the coverage of the database relative to the entire population of oil and gas reservoirs. The analysis is included as Appendix C. GASIS record counts and cumulative liquids and gas production were compared to Dwight's TOTL reservoir database, which represents the entire population of reservoirs and cumulative production for non-Appalachian states. In non-Appalachian areas in which the analysis can be carried out, the GASIS database contains records for approximately 47 percent of cumulative liquids production and 76 percent of cumulative total gas production. This analysis excludes Michigan, Illinois, California, North Dakota, and Montana, which are not included in GASIS. These statistics show that the reservoirs included in GASIS represent the majority of cumulative production in the U.S.

4. RESERVOIR STUDIES

4.1 INTRODUCTION

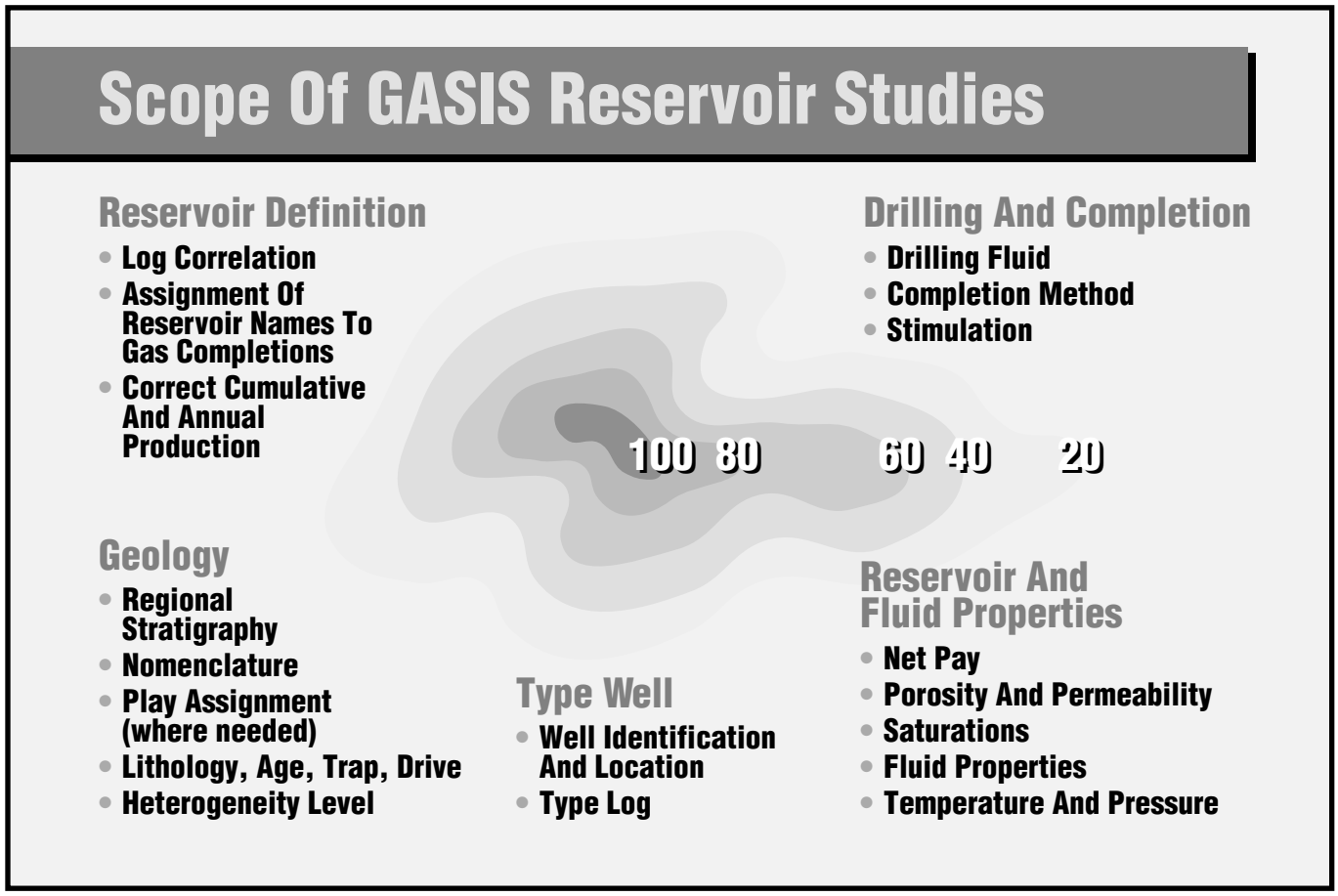
The reservoir study effort was a major component of the GASIS project and was conducted by Dwight's Energydata geological personnel in Oklahoma City. The effort was designed to correct the extensive data problems that were present in existing reservoir databases and to obtain representative reservoir property data for major gas plays. Much of the pre-GASIS reservoir property information in the Mid-Continent region was unreliable, and the coverage of key data items such as porosity and net pay in many areas was poor. The GASIS effort corrected the reservoir definition problems and greatly improved the data coverage in all studied basins.

4.2 SCOPE OF INDIVIDUAL STUDIES

Figure 4-1 shows the scope of the reservoir study project. Projects included reservoir definition, geological interpretation and data collection, reservoir and fluid property data, type well documentation, and other data collection. Reservoir definition work was concentrated in the Mid-Continent, and involved both regional and reservoir-specific log correlation.

The reservoir study effort in the Mid-Continent developed the first accurate and comprehensive reservoir database for the region. Prior to the GASIS project, Mid-Continent database records often did not represent true reservoirs but producing intervals or formations that contained multiple reservoirs. Because of the extremely poor "reservoir definition" (linkage between gas completions and the reservoirs from which they produce), the reservoir property and production data for those records were unreliable and could not be used in engineering or geological analysis. In addition, a large number of pre-GASIS reservoir records had incorrect formation nomenclature and geologic age assignments. This was corrected through the construction of regional stratigraphic cross sections through the Anadarko Basin.

FIGURE 4-1
SCOPE OF GASIS RESERVOIR STUDIES



4.3 COVERAGE BY AAPG BASIN

Figure 4-2 shows the distribution of reservoir studies by AAPG basin. A total of 1,009 GASIS reservoir studies were completed. The project was designed to obtain information on the major gas producing regions of the lower-48. Basins studied include the Anadarko, Arkoma, East Texas, Arkla, Mid-Gulf Coast, Warrior, Green River, Piceance, Denver, Wind River, Uinta, Overthrust Belt, Powder River, San Juan, and Permian Basins. Within each studied basin, an effort was made to obtain representative information for all major gas plays.

The following regions and basins were evaluated:

Mid-Continent

- Anadarko Basin (Western Oklahoma and Texas Panhandle)
- Arkoma Basin (Eastern Oklahoma)

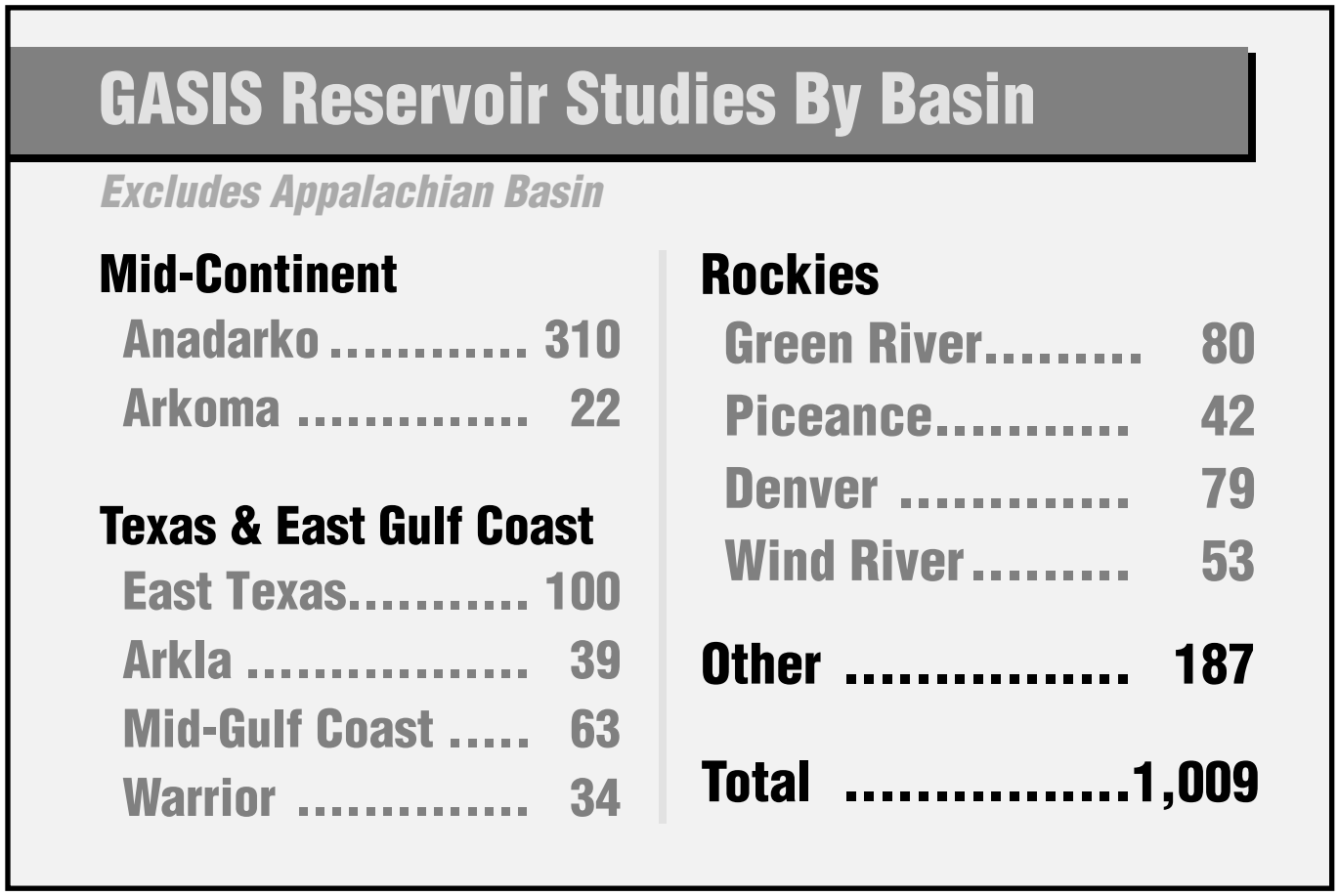
Texas and Central and Eastern Gulf Coast

- East Texas Basin
- Arkla (Northern Louisiana and Southern Arkansas)
- Mid-Gulf Coast Basin (Southern Alabama and Mississippi)
- Warrior Basin (Northern Alabama)

Rockies

- Green River Basin (Southwestern Wyoming)
- Piceance Basin (Northwestern Colorado)
- Uinta Basin (Northeastern Utah)
- Western Overthrust Belt (Western Wyoming and Northeastern Utah)
- Denver Basin (Eastern Colorado)
- Wind River Basin (Central Wyoming)
- Powder River Basin (Northeastern Wyoming)

FIGURE 4-2
GASIS RESERVOIR STUDIES BY BASIN



Other

- San Juan Basin (Northwestern New Mexico)
- Permian Basin (West Texas)

No reservoir study work was conducted in the Gulf of Mexico, since that region was extensively evaluated for the gas atlas project. In the Appalachian Basin, there were no GASIS reservoir studies, but 246 studies were completed for the gas atlas project, and that information is included in GASIS.

A significant portion of the reservoir study effort, especially in the Rockies, was directed toward analysis of low permeability plays and reservoirs. Approximately 270 tight gas reservoir studies (using the FERC tight gas classification) were completed. Major tight formations studied include the Cotton Valley, Travis Peak, Cleveland, Mesaverde, Frontier, Dakota, and Niobrara.

A detailed listing of GASIS reservoir studies is included as Appendix C.

5. SUPPLEMENTAL DATA

5.1 USGS PLAY CLASSIFICATION

The GRI/DOE gas atlas projects grouped reservoirs by play. A "play" is a group of fields or reservoirs with similar attributes. Typically, all of the reservoirs in a play produce from the same formation and were deposited in the same setting or depositional environment. The gas atlas play classification is a key aspect of GASIS.

As part of their 1995 assessment of undiscovered oil and gas resources of the United States, the U.S. Geological Survey defined several hundred lower-48 oil and gas exploratory plays. This play definition is different from that of the atlas project, although there are similarities in most basins. The 1995 USGS assessment of remaining oil and gas potential was published at the play level.

A USGS play code was developed for GASIS and was added to the database. The USGS play code provides an additional tool to group and evaluate reservoirs, and allows linkage to the national assessment of undiscovered oil and gas potential. For example, the analyst can evaluate information on the USGS assessment CD, select a play of interest, and then go to GASIS to see which reservoirs are included in that play.

Both automated and non-automated methods were used to assign USGS play codes to GASIS reservoirs. The automated process was based upon information published by USGS in Open File Report 97-278: "Assignments of U.S. Oil and Gas Reservoirs to U.S. Geological Survey 1995 National Oil and Gas Assessment Plays." In cases where a direct match with the USGS list could not be made, other approaches were used and were based upon formation name, geologic, age, and location information.

Almost 9,000 GASIS records were assigned USGS province codes and play codes. This includes the majority of onshore GASIS records.

5.2 PLAY AND RESERVOIR LEVEL DEPOSITIONAL SYSTEM CLASSIFICATION

A depositional system or depositional environment classification allows reservoirs with similar geology to be grouped and evaluated. Major clastic depositional systems include fluvial, eolian, deltaic, barrier/strandplain, shelf, and basin systems. The GASIS database includes *reservoir level* classifications that were developed for the Rocky Mountain and Appalachian region gas atlases. Unfortunately, reservoir level depositional system classifications were not developed as a part of the other atlas projects (Texas, Mid-Continent, Gulf Coast, and Gulf of Mexico). With the exception of the DOE TORIS oil database, which has a small "overlap" with GASIS, there is no other source of reservoir level depositional system classifications.

Many of the gas atlas plays in Texas and elsewhere were defined on the basis of formation and depositional system (i.e., Frio formation barrier-strandplain system). Where this is the case, it is possible to develop a *play level* depositional system classification, and to assign a code to all reservoirs within the play. This approach was used to develop a play level depositional system for GASIS. All GASIS reservoirs within the play were assigned the same depositional system assignment. Approximately 7,000 GASIS reservoirs were assigned a dominant play level depositional system code using this approach.

The play level depositional system classification is a powerful tool for grouping reservoirs with similar characteristics. This type of information has not previously been available in an electronic database form should see significant applications in industry. This classification system "leverages" the extensive amount of work carried out for the atlas projects to group reservoirs producing from the same interval and depositional environment.

6. GASIS SOFTWARE

The GASIS product includes Windows-based software for database query and manipulation. The software allows query and retrieval, data display, report generation, and exporting of data in standard formats. It also allows graphing of numerical data and viewing of reservoir study type logs. Both the Reservoir Data System and the Source Directory can be accessed and queried.

An advanced query module allows logical operators to be applied to combinations of data fields. For example, the following queries could be specified:

- Reservoirs with cumulative production greater than 50 Bcf in the Green River Basin, and an average depth of less than 10,000 feet.
- Reservoirs below 15,000 feet in Oklahoma, producing from the Arbuckle and having a CO_2 content of greater than 4 percent.
- Cretaceous age reservoirs in the Rocky Mountain atlas region with cumulative production greater than 100 Bcf and a median gas well recovery of more than 5 Bcf.
- Tight gas reservoirs in the onshore Texas Gulf Coast that were discovered after 1980.
- Gulf of Mexico reservoirs in water depths greater than 600 feet.

The query results may be viewed in summary (browse) or detail format, printed, graphed, or exported as a file. The browse format contains one reservoir record per row, for viewing of query results. The detail screens contain all of the data for each reservoir grouped by category. File export options are available for most PC databases and spreadsheets.

Over 900 reservoir study type logs are included in GASIS and may be viewed and printed with the GASIS software. The type logs are accessed by opening the detailed display for a given reservoir study record. Under the “geologic type” well section, there is a button to click to view the type log.

A graphing module is included in GASIS. This feature allows the development of crossplots of any two numeric variables. Examples would be a depth vs. temperature plot for all reservoirs in the Anadarko Basin, or a porosity vs. permeability plot for all Wind River Basin reservoirs below 5,000 feet.

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Appendix A.

GASIS Release 2 Data Elements

	field name	definition	type	width	dec	units
	Field/reservoir identification					
1	LINKA	unique key for reservoir data system	Num	5	0	
2	FLDNAME	DOE/EIA field name	Char	35	0	
3	DOEFLD	DOE/EIA field code	Char	6	0	
4	RESNAME	reservoir name	Char	45	0	
5	R_STUDY	reservoir source (Atlas, Reserv. Study, TOTL)	Char	1	0	A, R, T
6	PLAYNAME	gas atlas geologic play name	Char	140	0	
7	PLAYCOD	gas atlas geologic play code	Char	10	0	
8	SUBPLAYN	gas atlas subplay name	Char	60	0	
9	SUBPLAY	gas atlas subplay code	Char	10	0	
10	USGSPROV	USGS province code	Char	2	0	
11	USGSPLAY	USGS play code	Char	4	0	
12	S_USGSPL	USGS play code source flag (2 codes)	Char	1	0	
13	DWIGHTS	DwightsTOTL, DOGR field and reservoir code	Num	9	0	
14	UNIQID	Dwights TOTL unique key	Char	9	0	
	Field/reservoir location					
15	STATE	state name	Char	15	0	
16	STPOST	two character state postal code	Char	2	0	
17	STCODE	two digit API state code	Char	2	0	
18	COUNTY	county, parish, offshore area	Char	25	0	
19	COCODE	API county code	Char	3	0	
20	DISTRICT	state regulatory district	Char	8	0	
21	BASINNM	AAPG basin name	Char	26	0	
22	BASCODE	AAPG basin code	Char	3	0	
23	ATLASREG	gas atlas region (6 codes)	Char	2	0	
24	LATITUDE	latitude of median well	Num	9	5	degrees
25	LONGITUD	longitude of median well	Num	9	5	degrees
	Reservoir type					
26	RESTYPE	reservoir designation (state agency)	Char	4	0	O, G, OG
27	RTYPEGOR	GOR-based reservoir type	Char	1	0	O, G
28	TIGHT	tight reservoir (or tight formation/area) flag	Char	1	0	y/n
29	CBMETH	coalbed reservoir flag	Char	1	0	y/n
30	SHGAS	Devonian shale reservoir flag	Char	1	0	y/n
31	CYCLED	cycled gas reservoir flag	Char	1	0	y/n
32	GASTYPE	atlas type of gas production	Char	3	0	N, K, A, G
33	PRORATED	prorated reservoir flag	Char	1	0	y/n
34	UNIT	unitized reservoir flag	Char	1	0	y/n
35	CMGLPROD	commingled production flag	Char	1	0	y/n
	Field information & status					
36	FLDSTAT	field status (4 codes)	Char	1	0	P, A, I, C
37	FYRDISC	field discovery year	Num	4	0	
38	FLDTYPE	field type designation (state agency)	Char	3	0	O, G, OG
39	I_CLAS	USGS field size class including growth	Num	2	0	1-20
40	FELEV	reference elevation (sea level datum)	Num	5	0	feet
41	ELEVTYPE	reference elevation type (3 codes)	Char	2	0	KB, GR, DF
42	H2ODEPTH	offshore water depth	Num	5	0	feet

	field name	definition	type	width	dec	units
	Geology					
43	PRODFOR	producing formation name	Char	45	0	
44	ZONE	producing zone or member name	Char	35	0	
45	ERANM	geologic era name	Char	9	0	
46	SYSNM	geologic system name	Char	20	0	
47	SERNM	geologic series name	Char	20	0	
48	GEOLAGE	three digit USGS age code	Char	3	0	
49	GENLITH	general lithology (3 codes)	Char	2	0	
50	S_GENLIT	general lithology source	Char	1	0	
51	SPECLITH	specific lithology of reservoir (10 codes)	Char	24	0	
52	S_SPECLI	specific lithology source	Char	1	0	
53	GENTRAP	general reservoir trap type (3 codes)	Char	5	0	
54	S_GENTRA	general reservoir trap type source	Char	1	0	
55	SPECTRAP	specific trap type (14 codes)	Char	15	0	
56	S_SPECTR	specific trap type source	Char	1	0	
57	DEPENV	depositional environment of reservoir (13 codes)	Char	10	0	
58	S_DEPENV	depositional environment source	Char	1	0	
59	VERHET	vertical heterogeneity type (9 codes)	Char	20	0	
60	S_VERHET	vertical heterogeneity type source	Char	1	0	
61	VHETLVL	vertical heterogeneity level	Char	5	0	low, mod, high
62	S_VHETLV	vertical heterogeneity level source	Char	1	0	
63	HORHET	lateral heterogeneity type (9 codes)	Char	20	0	
64	S_HORHET	lateral heterogeneity type source	Char	1	0	
65	HHETLVL	lateral heterogeneity level	Char	5	0	low, mod, high
66	S_HHETLV	lateral heterogeneity level source	Char	1	0	
67	BIOZONE	gas atlas biozone (Gulf Coast)	Char	6	0	
68	PLAYDEPO	play-level depositional environment (13 codes)	Char	5	0	
	Reservoir status and completion counts					
69	YRDISC	reservoir discovery year	Num	4	0	year
70	STATUS	reservoir status (5 codes)	Char	1	0	
71	PRODCMP	number of gas wells producing in 1996	Num	6	0	
72	HISTCMP	total historical gas wells through 1996	Num	6	0	
73	INACTCMP	=HISTCMP - PRODCMP	Num	6	0	
74	HISTOW	historical oil wells (where available) thru 1996	Num	6	0	
75	HISTOL	historical oil leases (for states by lease) thru 1996	Num	6	0	
76	PRODOW	producing oil wells in 1996	Num	6	0	
	Reservoir area and spacing					
77	PRODAREA	calculated historic area with gas well production	Num	7	0	acres
78	ACRES	published productive area of reservoir	Num	7	0	acres
79	S_ACRES	published productive area source	Char	1	0	
80	CALCSPAC	calculated average GAS well spacing	Num	4	0	acres/well
81	AVGSPAC	predominant allowable gas well spacing	Num	4	0	acres/well
82	S_AVGSPA	allowable gas well spacing source	Char	1	0	
83	MAXSPAC	maximum allowable spacing for reservoir	Num	4	0	acres/well
84	MINSPAC	minimum allowable spacing for reservoir	Num	4	0	acres/well
85	TOTAREA	total oil and gas area	Num	7	0	acres

	field name	definition	type	width	dec	units
	Reservoir parameters					
86	DEPTHTOP	average measured depth to top	Num	5	0	feet
87	S_DEPTH	average reservoir depth source	Char	1	0	
88	AVTHICK	average net pay thickness	Num	6	1	feet
89	MNTHICK	net pay range minimum	Num	6	1	feet
90	MXTHICK	net pay range maximum	Num	6	1	feet
91	S_THICK	data source for net pay	Char	1	0	
92	SIAVTHK	average thickness of gas saturated interval	Num	6	1	feet
93	S_SIAVTH	gas saturated thickness source	Char	1	0	
94	AVPOR	average porosity of pay interval	Num	6	2	%
95	LOPOR	porosity range minimum -net pay	Num	6	2	%
96	HIPOR	porosity range maximum -net pay	Num	6	2	%
97	S_POR	data source for porosity	Char	1	0	
98	AVPERM	average permeability of pay interval	Num	10	4	millidarcies
99	LOPERM	permeability range minimum	Num	10	4	millidarcies
100	HIPERM	permeability range maximum	Num	10	4	millidarcies
101	S_PERM	data source for permeability	Char	1	0	
102	RESTEMP	average reservoir temperature	Num	3	0	degree F
103	S_RESTEM	average reservoir temp data source	Char	1	0	
104	PUBPRES	published initial reservoir pressure (atlas)	Num	5	0	
105	PRESTYP	published initial pressure type (4 codes)	Char	5	0	
106	IPRESTYP	initial reservoir pressure type (3 codes)	Char	2	0	
107	S_IPRES	initial reservoir pressure source	Char	1	0	
108	IPRES	average initial reservoir pressure	Num	5	0	psi
109	IPRESLO	low initial reservoir pressure	Num	5	0	psi
110	IPRESHI	high initial reservoir pressure	Num	5	0	psi
111	BHP	current (1996) bottom hole pressure	Num	5	0	psi
112	WHSIP	current (1996) well head shut-in pressure	Num	5	0	psi
113	GRADIENT	initial reservoir pressure gradient	Num	6	4	psi/ft
114	GEOPRESS	overpressured reservoir	Char	2	0	y/n
115	WATSAT	initial water saturation (Sw)	Num	7	3	%
116	WATSATLO	low initial water saturation (Sw)	Num	7	3	%
117	WATSATHI	high initial water saturation (Sw)	Num	7	3	%
118	S_WATSAT	water saturation data source	Char	1	0	
119	DRIVE	reservoir drive mechanism (6 codes)	Char	11	0	
120	S_DRIVE	drive mechanism source	Char	1	0	
	Gas and fluid properties					
121	GRAVITY	specific gas gravity	Num	8	4	API units
122	S_GRAV	gas gravity source	Char	1	0	
123	LIQGRAV	liquid hydrocarbon gravity	Num	7	2	API gravity
124	S_LIQGRA	liquid hydrocarbon gravity source	Char	1	0	
125	OHM	measured resistivity of produced water	Num	10	4	ohm-meter
126	S_OHM	measured resistivity source	Char	1	0	
127	TRES	temp. of water @ measured resistivity	Num	3	0	degree F
128	S_TRES	temp. of water resistivity source	Char	1	0	
129	SALIN	salinity of produced water	Num	9	2	ppm
130	S_SALIN	salinity of produced water source	Char	1	0	

	field name	definition	type	width	dec	units
	Drilling and evaluation					
131	DRILLFL	predominant drilling fluid used (3 codes)	Char	3	0	
132	INTCASE	intermediate casing typically run	Char	1	0	y/n
133	HORZNTL	horizontal or slant wells in reservoir	Char	1	0	y/n
	Stimulation data					
134	STIM	stimulated reservoir flag	Char	1	0	y/n
135	S_STIM	stimulated reservoir flag source	Char	1	0	
136	STIMTYP	usual stimulation type (3 codes)	Char	5	0	
137	S_STIMTY	usual stimulation type source	Char	1	0	
	Completion data					
138	CMPTYP	typical completion type (5 codes)	Char	3	0	
139	S_CMPTYP	typical well completion type source	Char	1	0	
	Type well data					
140	TWOPWL	geologic type well operator; wellno; wellname	Char	65	0	
141	TWAPI	geologic type well API number	Char	12	0	
142	TWTWP	geologic type well township number	Char	4	0	
143	TWRNG	geologic type well range number	Char	5	0	
144	TWSEC	geologic type well section number	Char	2	0	1-36
145	TWQQ	geologic type well location within section	Char	15	0	
146	INTVTOP	type well top of formation interval	Num	5	0	feet
147	INTVBOT	type well bottom of formation interval	Num	5	0	feet
	Median recovery well (gas reservoirs)					
148	MSERCODE	median well Dwights i.d. (stcode+distcode+sercode)	Char	13	0	
149	MWOPER	median recovery well operator name	Char	24	0	
150	MEDWELL	median recovery well name	Char	36	0	
151	MWAPI	median recovery well API number	Char	12	0	
152	MWTWN	median recovery well township number	Char	4	0	
153	MWRNG	median recovery well range number	Char	5	0	
154	MWSEC	median recovery well section number	Char	2	0	1-36
155	MWQQ	median recovery well location within section	Char	6	0	
156	MWTOP	median recovery well top of completion interval	Num	5	0	feet
157	MWBOT	median recovery well bottom of completion interval	Num	5	0	feet
158	MWCMPYR	median recovery well completion year	Num	4	0	
	Completion recovery					
159	MWNCMP	number of completions evaluated	Num	6	0	
160	MEAN_EUR	mean recovery/completion (estimate)	Num	6	0	MMcf
161	MED_EUR	median recovery/completion (estimate)	Num	6	0	MMcf
162	MIN_EUR	minimum recovery/completion (estimate)	Num	6	0	MMcf
163	MAX_EUR	maximum recovery/completion (estimate)	Num	6	0	MMcf

	field name	definition	type	width	dec	units
	Volumetric data					
164	GASAN	annual gas production (1996)	Num	9	0	MMcf
165	GASCM	cumulative gas production through 1996	Num	10	0	MMcf
166	LIQCM	cumulative liquid hydrocarbon prod. through 1996	Num	10	0	Bbl
167	WATCM	cumulative water production through 1996	Num	10	0	Bbl
168	PUBOGIP	published original gas-in-place	Num	9	0	MMcf
169	S_PUBOGI	data source for gas-in-place	Char	1	0	
170	RUR	estimated remaining reserves (nag)	Num	9	0	MMcf
171	EUR	approximate reservoir ultimate recovery (nag)	Num	9	0	MMcf
172	PRDGOR	cumul. producing gas/oil ratio (GOR)	Num	14	0	scf/bbl
173	INITGOR	initial producing gas/oil ratio (GOR)	Num	14	0	scf/bbl
	Gas composition					
174	METHANE	methane content	Num	8	4	mole %
175	ETHANE	ethane content	Num	8	4	mole %
176	PROPANE	propane content	Num	8	4	mole %
177	BUTANE	butanes content	Num	8	4	mole %
178	PENTANE	pentanes content	Num	8	4	mole %
179	HEXANE	hexanes-plus content	Num	8	4	mole %
180	HSULFID	hydrogen sulfide content	Num	8	4	mole %
181	CARBON	carbon dioxide content	Num	8	4	mole %
182	NITROGN	nitrogen content	Num	8	4	mole %
183	HELIUM	helium content	Num	8	4	mole %
184	OTHER	other components	Num	8	4	mole %
185	HEAT	heating value	Num	4	0	BTU/cf

field name: all data source flags
definition: source of data value
codes: A - gas atlas
R - GASIS reservoir study
T - Dwights TOTL

field name: ATLASREG
definition: gas atlas region
codes: AP - Appalachian
EG - Eastern Gulf Coast
GM - Gulf of Mexico
MC - Mid-Continent
RM - Rocky Mountain
TX - Texas

field name: FLDSTAT
definition: field status
codes: P - producing
A - abandoned
I - inactive
C - combined

field name: GENLITH
definition: general lithology
codes: SC - siliciclastic
CB - carbonate
BO - both SC and CB

field name: GENTRAP
definition: general reservoir trap type
codes: STRUC- structural
STRAT- stratigraphic
COMB - combination

field name: S_USGSPL
definition: USGS play code source flag
codes: O - play code assigned by comparison with USGS OFR 97-28 reservoir database.
E - analysis by EEA using play descriptions, play maps, and stratigraphic columns

field name: GASTYPE
definition: atlas type of gas production
codes: N - non-associated
K - casinghead
A - associated
G - gas well

field name: ELEVTYPE
definition: reference elevation type
codes: KB - kelly bushing
GR - ground
DF - derrick floor

field name: SPECLITH
definition: specific lithology of reservoir (codes)
codes: CONG - conglomerate
SAND - sandstone
SILT - siltstone
SH - shale
CHER - chert
ARK - arkose
DOLO - dolostone
CHLK - chalk
LS - limestone undifferentiated
CARB - carbonate undifferentiated

field name: SPECTRAP
definition: specific trap type
codes:
structural trap types:
AN - anticline/dome
FT - fault
NO - nose
FA - faulted anticline
FN - faulted nose
SD - salt dome
FR - fracture
SC - structural undesignated
stratigraphic trap types:
FC - facies change
UN - unconformity
RF - reef
LP - lateral porosity change
CA - chemical alteration
SR - stratigraphic undesignated

field name: DEPENV
definition: depositional environment of reservoir
codes:
LACUS- lacustrine
PERIT- peritidal
SHSHF- shallow shelf
SHMAR- shelf margin
REEF - reef
SLBAS- slope/basin
BASIN- basinal
EOL - eolian
FLUV - fluvial
ALLUV- alluvial fan
DELTA- delta
STRAN- strandplain
SHELF- shelf

field name: VERHET
definition: vertical heterogeneity type
codes:
DEPO - general depositional heterogeneity
DIAG - diagenetic porosity variation
EROS - erosional discontinuities
FACIES - reservoir facies change
FAULT - faults
FRAC - fractures
NONE - no vertical heterogeneity
STRUC - general structural heterogeneity
UNKN - vertical heterogeneity unknown

field name: HORHET
definition: horizontal heterogeneity type
codes:
DEPO - gen. depositional heterogeneity
DIAG - diagenetic porosity variation
EROS - erosional discontinuities
FACIES - reservoir facies change
FAULT - faults
FRAC - fractures
NONE - no vertical heterogeneity
STRUC - gen. structural heterogeneity
UNKN - vertical heterogeneity unknown

field name: PLAYDEPO
definition: play-level depositional environment
codes:
AFAN- alluvial fan
BASIN- basinal
DELTA- delta
EOLN - eolian
FLUV - fluvial
LACUS- lacustrine
PERIT- peritidal
REEF - reef
SHELF- shelf
SHMAR- shelf margin
SHSHF- shallow shelf
SLBAS- slope/basin
STRAN- strandplain

field name: STATUS
definition: reservoir status
codes:
A - abandoned
C - combined
I - inactive
P - producing
U - unknown

field name: PRESTYP
definition: published initial reservoir pressure type (atlas)
codes:
WHSIP- calc. from wellhead SIP
DST - drillstem test
BHPG - bottom hole gauge SIP
UN - unknown

field name: IPRESTYP
definition: initial pressure type
codes:
FL - wellhead flowing pressure
SI - wellhead shut-in pressure
BH - shut-in bottom hole pressure

field name: DRIVE
definition: reservoir drive mechanism
codes:
GC - gas cap
GS - gravity segregation
SG - solution gas
PD - pressure depletion
WD - water drive
CO - combination

field name: DRILLFL
definition: predominant drilling fluid used
codes:
AIR - air
MUD - mud
OM - oil based mud

field name: STIMTYP
definition: usual stimulation type
codes:
AC - acid
HF - hydraulic fracture
SH - shot

field name: CMPTYP
definition: typical completion type (OH,PER,AJ,SH)
codes:
OH - open hole
PER - cased hole/perforated
AJ - cased hole/abrasi jet
SL - slotted liner
CAS - cased hole/details unknown

Appendix B.

Example Data for a Selected Reservoir With Type Log

DETAIL REPORT - RESERVOIR DATA SYSTEM

FIELD/RESERVOIR IDENTIFICATION

FIELD NAME	BIRCH CREEK
EIA FIELD CODE	065221
RESERVOIR NAME	BEAR RIVER
RESERVOIR SOURCE	R
PLAY NAME	BEAR RIVER FORMATION
PLAY CODE	RMKL-2
SUBPLAY NAME	
SUBPLAY CODE	
TOTL "DWIGHTS"	74100770
TOTL "UNIQID"	490000114
USGS PROVINCE AND PLAYCODE	373705

FIELD/RESERVOIR LOCATION

STATE	WYOMING
POSTAL CODE	WY
API STATE CODE	49
COUNTY	SUBLETTE
COUNTY CODE	035
DISTRICT	
BASIN NAME	GREEN RIVER BASIN
BASIN CODE	535
GAS ATLAS REGION	RM
LATITUDE (DEGREES)	0.00000
LONGITUDE (DEGREES)	0.00000

RESERVOIR TYPE

STATE DESIGNATION	G	*TIGHT GAS*	
COALBED METHANE		*SHALE GAS*	
CYCLED/INJECTED		*ATLAS PROD TYPE*	
PRORATED		*UNITIZED*	
COMMINGLED PRODUCTION		*GOR-BASED RESERVOIR TYPE*	G

FIELD INFORMATION AND STATUS

STATUS	P	*DISCOVERY YEAR*	1957
FIELD TYPE	OG	*USGS SIZE CLASS*	16
ELEVATION (FT)	7115	*ELEVATION TYPE*	KB
WATER DEPTH (FT)	0		

DETAIL REPORT - RESERVOIR DATA SYSTEM

GEOLOGY

FORMATION NAME	BEAR RIVER
ZONE OR MEMBER	
GEOLOGIC ERA	MESOZOIC
GEOLOGIC SYSTEM	CRETACEOUS
GEOLOGIC SERIES	LOWER CRETACEOUS
GEOLOGIC AGE CODE	217
GENERAL LITHOLOGY	SC
SPECIFIC LITHOLOGY	SAND
GENERAL TRAP TYPE	COMB
SPECIFIC TRAP TYPE	FT,LP
DEPOSITIONAL ENVIRONMENT	
VERTICAL HETEROGENEITY	DEPO; DIAG
VERTICAL HETEROGENEITY LEVEL	HIGH
LATERAL HETEROGENEITY	DEPO; DIAG
LATERAL HETEROGENEITY LEVEL	MED
BIOZONE	
PLAY LEVEL DEPOSITIONAL ENVIRONMENT	STRAN

RESERVOIR STATUS AND COMPLETION COUNTS

DISCOVERY YEAR	1957	*STATUS*	P
PRODUCING COMPLETIONS	51	*HISTORICAL COMPLETIONS*	56
INACTIVE COMPL	5	*HISTORICAL OIL WELLS*	0
HISTORICAL OIL LEASES	0	*PRODUCING OIL WELLS*	0

RESERVOIR AREA AND GAS WELL SPACING

CALC GAS PROD AREA (ACRES)	8960	*PUBL PROD AREA (ACRES)*	0
CALC AVG SPACING (ACRES)	160	*AVG SPACING (ACRES)*	0
MAX SPACING (ACRES)	0	*MIN SPACING (ACRES)*	0
TOTAL OIL AND GAS AREA	8960		

RESERVOIR PARAMETERS

DEPTH TOP (FT)	7696	*AVG NET PAY (FT)*	19.6
MIN NET PAY (FT)	10.0	*MAX NET PAY (FT)*	37.0
GAS SATURATED INTVL (FT)	23.8	*AVG POROSITY (%)*	16.00
MIN POROSITY (%)	4.00	*MAX POROSITY (%)*	23.00
AVG PERMEABILITY (MD)	0.1000	*MIN PERMEABILITY (MD)*	0.0000
MAX PERMEABILITY (MD)	0.0000	*RESERVOIR TEMP (F)*	150
PUBL INITIAL PRESS (PSI)	0	*PUBL INIT PRESS TYPE*	
INITIAL PRESS TYPE (PSI)	BH	*INITIAL PRESSURE (PSI)*	4060
LOW INITIAL PRESSURE (PSI)	4060	*HIGH INITIAL PRESSURE (PSI)*	4060
CURRENT BOTTOM HOLE PRESS (PSI)	0	*CURRENT WHSIP (PSI)*	0
INIT PRESS GRAD (PSI/FT)	0.5275	*OVERPRESSURED*	Y
INITIAL SW (%)	66.200	*LOW INITIAL SW (%)*	39.000
HIGH INITIAL SW(%)	89.000	*DRIVE MECHANISM*	PD

GAS AND FLUID PROPERTIES

GAS GRAVITY	0.6100	*LIQUIDS GRAVITY (API)*	50.50
RESISTIVITY (OHM-M)	0.2400	*RESISTIVITY TEMP. (F)*	100
SALINITY (PPM)	19000.00		

DETAIL REPORT - RESERVOIR DATA SYSTEM

DRILLING AND EVALUATION

DRILLING FLUID	MUD	*INTERMEDIATE CSNG*	
HORIZ/SLANT WELL			

STIMULATION DATA

STIMULATED	Y	*STIMULATION TYPE*	AC,HF

COMPLETION DATA

TYPICAL COMPLETION TYPE	PER

TYPE WELL DATA (GAS RESERVOIRS)

OPERATOR,NO.,WELL NAME	CHEVRON OIL COMPANY;94;BIRCH CREEK UNIT
API NUMBER	4903520372
TOWNSHIP	27N
RANGE	113W
SECTION	11
LOCATION	SW NE
TOP OF INTERVAL (FT)	7686
BOTTOM OF INTERVAL (FT)	7875

MEDIAN RECOVERY WELL (GAS RESERVOIRS)

DWIGHTS ID, MEDIAN WELL	2100500077	
OPERATOR	CHEVRON U S A INC	
WELL NAME	BIRCH CREEK UNIT	SE SW
API NUMBER	490352100500	
TOWNSHIP	27N	
RANGE	113W	
SECTION	13	
LOCATION		
TOP OF INTERVAL (FT)	7544	
BOTTOM OF INTERVAL (FT)	7570	
COMPLETION YEAR	1989	

COMPLETION RECOVERY STATISTICS (GAS RESERVOIRS)

NO. OF COMPLETIONS	56	*MEAN EUR/COMP (MMCF)*	1563
MEDIAN EUR/COMP (MMCF)	1085	*MIN EUR/COMP (MMCF)*	73
MAX EUR/COMP (MMCF)	5783		

VOLUMETRIC DATA

ANNUAL GAS PROD (MMCF)	3124	*CUMUL. GAS PROD (MMCF)*	63653
CUMULATIVE LIQUIDS (BBL)	249423	*CUMULATIVE WATER (BBL)*	0
PUBLISHED OGIP (MMCF)	0	*NON-ASSOC RUR (MMCF)*	40998
NON-ASSOC EUR (MMCF)	104651	*CUM. PROD GOR (SCF/BBL)*	255201
INITIAL GOR (SCF/BBL)	0		

GAS COMPOSITION

METHANE (MOLE %)	88.0000	*ETHANE (MOLE %)*	6.7000
PROPANE (MOLE %)	2.7000	*BUTANES (MOLE %)*	1.0000
PENTANES (MOLE %)	0.7000	*HEXANES+ (MOLE %)*	0.2000
H2S (MOLE %)	0.0000	*CO2 (MOLE %)*	0.1000
NITROGEN (MOLE %)	0.7000	*HELIUM (MOLE %)*	0.0200
OTHER (MOLE %)	0.0000	*HEATING VALUE (BTU/SCF)*	1151

Dwights
Energy Data, Software & Information Services

FIELD	RESERVOIR	OPERATOR	WELL #	LEASE	QTR/QTR	LOCATION	API	TOP	BOTTOM
Birch Creek	Bear River	Chevron Oil Company	94	Birch Creek Unit	SW NE	11-27N-113W	49-035-20372	7686	7875

Appendix C.
Coverage of the GASIS Database

GASIS Reservoir Counts and Cumulative Production Coverage by AAPG Basin

		GASIS						*TOTL (Entire population of reservoirs)*			*GASIS Coverage*		
		Reservoir Types				*Cumulative Production*			*Cumulative Production*			*Cumulative Production*	
Basin Code	**Basin Name**	**Oil**	**Gas**	**Unkn**	**Total**	**Liquids (MMB)**	**Gas (Bcf)**	**Reservoirs**	**Liquids (MMB)**	**Gas (Bcf)**	**Reservoirs**	**Liquids**	**Gas**
360	Anadarko Basin	128	712	4	844	2,175	106,575	10,138	5,519	130,586	8.3%	39.4%	81.6%
160	Appalachian Basin	947	1,599	39	2,585	0	10,771	N/A	N/A	N/A	N/A	N/A	N/A
230	Arkla Basin	0	151	0	151	508	17,174	866	4,552	31,477	17.4%	11.2%	54.6%
345	Arkoma Basin	41	103	0	144	1	8,573	1,765	255	12,115	8.2%	0.4%	70.8%
425	Bend Arch	11	37	0	48	826	1,688	4,832	1,461	3,485	1.0%	56.5%	48.4%
520	Big Horn Basin	23	18	0	41	1,258	1,141	436	2,130	1,971	9.4%	59.1%	57.9%
590	Black Mesa Basin	N/A	N/A	N/A	N/A	N/A	N/A	11	20	27	0.0%	0.0%	0.0%
200	Black Warrior Basin	1	44	0	45	2	1,489	427	13	1,710	10.5%	15.0%	87.1%
385	Central Kansas Uplift	2	7	0	9	1	108	5,203	3,028	586	0.2%	0.0%	18.4%
510	Central Montana Uplift	N/A	N/A	N/A	N/A	N/A	N/A	61	244	897	0.0%	0.0%	0.0%
507	Central Western Overthrust	14	15	0	29	319	5,439	66	208	5,442	43.9%	N/A	99.9%
390	Chadron Arch	N/A	N/A	N/A	N/A	N/A	N/A	241	135	0	0.0%	0.0%	0.0%
355	Chautauqua Platform	19	29	0	48	111	1,225	8,236	8,665	4,574	0.6%	1.3%	26.8%
365	Cherokee Basin	N/A	N/A	N/A	N/A	N/A	N/A	779	472	2,511	0.0%	0.0%	0.0%
300	Cincinnati Arch	7	60	1	68	0	30	1	0	125	N/A	0.0%	24.2%
540	Denver Basin	57	34	4	95	314	2,506	2,132	1,032	3,459	4.5%	30.4%	72.5%
260	East Texas Basin	35	258	0	293	7,327	27,664	3,024	9,127	30,760	9.7%	80.3%	89.9%
335	Forest City Basin	N/A	N/A	N/A	N/A	N/A	N/A	294	50	30	0.0%	0.0%	0.0%
420	Fort Worth Syncline	11	32	0	43	110	3,877	1,951	713	4,749	2.2%	15.4%	81.6%
535	Green River Basin	24	178	1	203	553	11,103	1,037	830	12,111	19.6%	66.7%	91.7%
220	Gulf Coast Basin Onshore	244	2,901	0	3,145	7,973	141,449	36,651	27,988	242,249	8.6%	28.5%	58.4%
940	Gulf Of Mexico	3,561	6,386	0	9,947	9,943	122,337	9,947	11,892	139,980	100.0%	83.6%	87.4%
315	Illinois Basin	1	1	0	2	0	190	N/A	N/A	N/A	N/A	N/A	N/A
405	Kerr Basin	N/A	N/A	N/A	N/A	N/A	N/A	3	0	0	0.0%	0.0%	0.0%
450	Las Animas Arch	5	3	0	8	41	123	329	95	128	2.4%	43.5%	96.2%
455	Las Vegas-Raton Basin	0	2	0	2	0	1,011	16	0	15	12.5%	0.0%	N/A
410	Llano Uplift	N/A	N/A	N/A	N/A	N/A	N/A	43	1	3	0.0%	0.0%	0.0%
210	Mid-Gulf Coast Basin	40	108	0	148	1,260	9,979	2,485	3,210	10,720	6.0%	39.2%	93.1%
370	Nemaha Anticline	N/A	N/A	N/A	N/A	N/A	N/A	819	321	36	0.0%	0.0%	0.0%
545	North Park Basin	0	3	0	3	8	678	24	7	165	12.5%	N/A	N/A
400	Ouachita Folded Belt	0	4	0	4	0	70	187	247	198	2.1%	0.1%	35.1%
435	Palo Duro Basin	3	5	0	8	11	716	656	1,540	1,006	1.2%	0.7%	71.2%
585	Paradox Basin	15	23	0	38	379	3,798	245	546	1,614	15.5%	69.4%	235.4%
430	Permian Basin	426	443	2	871	22,919	79,303	12,248	30,751	91,040	7.1%	74.5%	87.1%
595	Piceance Basin	4	58	2	64	897	1,929	354	915	2,153	18.1%	98.0%	89.6%
515	Powder River Basin	49	9	0	58	653	1,617	1,174	1,916	1,829	4.9%	34.1%	88.4%
380	Salina Basin	N/A	N/A	N/A	N/A	N/A	N/A	107	43	0	0.0%	0.0%	0.0%
580	San Juan Basin	17	50	0	67	255	24,370	286	345	24,515	23.4%	73.9%	99.4%
560	San Luis Basin	N/A	N/A	N/A	N/A	N/A	N/A	1	0	0	0.0%	0.0%	0.0%
375	Sedgwick Basin	2	21	0	23	43	1,925	1,825	1,212	2,868	1.3%	3.5%	67.1%
445	Sierra Grande Uplift	0	1	0	1	0	356	N/A	N/A	N/A	N/A	N/A	N/A
350	South Oklahoma Folded Belt	26	56	0	82	615	3,523	2,188	2,370	3,622	3.7%	26.0%	97.3%
415	Strawn Basin	0	4	0	4	0	193	101	2	247	4.0%	10.6%	78.3%
500	Sweetgrass Arch	N/A	N/A	N/A	N/A	N/A	N/A	55	274	872	0.0%	0.0%	0.0%
575	Uinta Basin	18	12	0	30	413	1,620	128	446	1,663	23.4%	92.5%	97.5%
630	Wasatch Uplift	N/A	N/A	N/A	N/A	N/A	N/A	2	0	0	0.0%	0.0%	0.0%
395	Williston Basin	N/A	N/A	N/A	N/A	N/A	N/A	1,214	1,898	2,208	0.0%	0.0%	0.0%
530	Wind River Basin	21	44	4	69	779	2,993	456	1,668	3,198	15.1%	46.7%	93.6%
Total		**5,752**	**13,411**	**57**	**19,220**	**59,694**	**597,540**	**113,044**	**126,141**	**776,945**	**N/A**	**N/A**	**N/A**
Total less Appalachia, etc.		**4,797**	**11,751**	**17**	**16,565**	**59,694**	**586,550**	**113,044**	**126,141**	**776,945**	**14.7%**	**47.3%**	**75.5%**
"GASIS" basins only less Appalachia		**4,797**	**11,751**	**17**	**16,565**	**59,694**	**586,550**	**109,413**	**122,683**	**770,236**	**15.1%**	**48.7%**	**76.2%**

GASIS Reservoir Studies by AAPG Basin

1. By AAPG Basin

Basin Code	Basin Name	Studies
160	Appalachian Basin	246
200	Black Warrior Basin	34
210	Mid-Gulf Coast Basin	63
230	Arkla Basin	39
260	East Texas Basin	100
345	Arkoma Basin	22
350	South Oklahoma Folded Belt	9
355	Chautauqua Platform	21
360	Anadarko Basin	310
375	Sedgwick Basin	1
385	Central Kansas Uplift	1
430	Permian Basin	47
450	Las Animas Arch	5
507	Central Western Overthrust	20
515	Powder River Basin	36
530	Wind River Basin	53
535	Green River Basin	80
540	Denver Basin	79
575	Uinta Basin	19
580	San Juan Basin	24
585	Paradox Basin	3
595	Piceance Basin	42
940	Gulf Of Mexico	1
All basins		**1,255**
Non-Appalachian basins		**1,009**

2. Grouped by Producing Region

	Studies
Mid-Continent	
Anadarko Basin	310
Arkoma Basin	22
South Oklahoma Folded Belt	9
Chautauqua Platform	21
Sedgwick Basin	1
Central Kansas Uplift	1
total	364
E. Texas & East Gulf Coast	
East Texas Basin	100
Arkla Basin	39
Mid-Gulf Coast Basin	63
Black Warrior Basin	34
total	236
Rockies	
Green River Basin	80
Piceance Basin	42
Denver Basin	79
Wind River Basin	53
Las Animas Arch	5
Central Western Overthrust	20
Powder River Basin	36
Uinta Basin	19
Paradox Basin	3
total	337
San Juan	24
Permian	47
Gulf of Mexico	1
Total non-Appalachian	**1,009**

Coverage of GASIS Reservoir Studies by AAPG Basin

Relative to entire GASIS database

		All GASIS Records						*GASIS Reservoir Studies*						*GASIS Resevoir Study Coverage*					
		Reservoir Types				*Cumulative Production*		*Reservoir Types*				*Cumulative Production*		*Reservoir Types*				*Cumulative Production*	
Basin Code	**Basin Name**	**Oil**	**Gas**	**Unkn**	**Total**	**Liquids (MMB)**	**Gas (Bcf)**	**Oil**	**Gas**	**Unkn**	**Total**	**Liquids (MMB)**	**Gas (Bcf)**	**Oil**	**Gas**	**Unkn**	**Total**	**Liquids**	**Gas**
360	Anadarko Basin	128	712	4	844	2,175	106,575	39	267	4	310	286	16,920	30%	38%	100%	37%	13%	16%
160	Appalachian Basin	947	1,599	39	2,585	0	10,771	241	5	0	246	0	50	25%	0%	0%	10%	0%	0%
230	Arkla Basin	0	151	0	151	508	17,174	5	34	0	39	0	0	0%	23%	0%	26%	0%	0%
345	Arkoma Basin	41	103	0	144	1	8,573	0	22	0	22	1	912	0%	21%	0%	15%	91%	11%
425	Bend Arch	11	37	0	48	826	1,688	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
520	Big Horn Basin	23	18	0	41	1,258	1,141	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
200	Black Warrior Basin	1	44	0	45	2	1,489	1	33	0	34	2	657	100%	75%	0%	76%	81%	44%
385	Central Kansas Uplift	2	7	0	9	1	108	1	0	0	1	0	1	50%	0%	0%	11%	17%	1%
507	Central Western Overthrust	14	15	0	29	319	5,439	11	9	0	20	293	5,342	79%	60%	0%	69%	92%	98%
355	Chautauqua Platform	19	29	0	48	111	1,225	5	16	0	21	26	432	26%	55%	0%	44%	23%	35%
300	Cincinnati Arch	7	60	1	68	0	30	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
540	Denver Basin	57	34	4	95	314	2,506	46	29	4	79	212	970	81%	85%	100%	83%	68%	39%
260	East Texas Basin	35	258	0	293	7,327	27,664	9	91	0	100	56	5,578	26%	35%	0%	34%	1%	20%
420	Fort Worth Syncline	11	32	0	43	110	3,877	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
535	Green River Basin	24	178	1	203	553	11,103	6	73	1	80	273	5,547	25%	41%	100%	39%	49%	50%
220	Gulf Coast Basin Onshore	244	2,901	0	3,145	7,973	141,449	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
940	Gulf Of Mexico	3,561	6,386	0	9,947	9,943	122,337	0	1	0	1	0	236	0%	0%	0%	0%	0%	0%
315	Illinois Basin	1	1	0	2	0	190	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
450	Las Animas Arch	5	3	0	8	41	123	3	2	0	5	18	45	60%	67%	0%	63%	43%	37%
455	Las Vegas-Raton Basin	0	2	0	2	0	1,011	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
210	Mid-Gulf Coast Basin	40	108	0	148	1,260	9,979	12	51	0	63	210	3,084	30%	47%	0%	43%	17%	31%
545	North Park Basin	0	3	0	3	8	678	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
400	Ouachita Folded Belt	0	4	0	4	0	70	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
435	Palo Duro Basin	3	5	0	8	11	716	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
585	Paradox Basin	15	23	0	38	379	3,798	0	3	0	3	0	28	0%	13%	0%	8%	0%	1%
430	Permian Basin	426	443	2	871	22,919	79,303	4	41	2	47	250	12,631	1%	9%	100%	5%	1%	16%
595	Piceance Basin	4	58	2	64	897	1,929	3	37	2	42	86	767	75%	64%	100%	66%	10%	40%
515	Powder River Basin	49	9	0	58	653	1,617	28	8	0	36	230	874	57%	89%	0%	62%	35%	54%
580	San Juan Basin	17	50	0	67	255	24,370	6	18	0	24	132	17,602	35%	36%	0%	36%	52%	72%
375	Sedgwick Basin	2	21	0	23	43	1,925	0	1	0	1	0	24	0%	5%	0%	4%	0%	1%
445	Sierra Grande Uplift	0	1	0	1	0	356	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
350	South Oklahoma Folded Belt	26	56	0	82	615	3,523	0	9	0	9	1	79	0%	16%	0%	11%	0%	2%
415	Strawn Basin	0	4	0	4	0	193	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%
575	Uinta Basin	18	12	0	30	413	1,620	13	6	0	19	149	584	72%	50%	0%	63%	36%	36%
530	Wind River Basin	21	44	4	69	779	2,993	15	34	4	53	196	1,278	71%	77%	100%	77%	25%	43%
Total:		**5,752**	**13,411**	**57**	**19,220**	**59,694**	**597,540**	**448**	**790**	**17**	**1,255**	**2,420**	**73,644**	**8%**	**6%**	**30%**	**7%**	**4%**	**12%**
Non-Appalachian		**4,805**	**11,812**	**18**	**16,635**	**59,694**	**586,770**	**207**	**785**	**17**	**1,009**	**2,420**	**73,594**	**4%**	**7%**	**94%**	**6%**	**4%**	**13%**
Studied non-Appalachian basins		**944**	**2,358**	**17**	**3,319**	**39,566**	**313,034**	**207**	**784**	**17**	**1,008**	**2,420**	**73,358**	**22%**	**33%**	**100%**	**30%**	**6%**	**23%**

Appendix D.

Processing of the Appalachian and Gulf of Mexico Gas Atlases

Processing of the Appalachian and Gulf of Mexico Atlas Databases

Appalachian Gas Atlas

- Data from the Appalachian Gas Atlas and (non-GASIS) reservoir studies were processed to create a dataset of 2,655 records for inclusion in GASIS. Record counts in the original atlas versus GASIS are as follows:

State Name	***Atlas Record Count***	***GASIS Record Count***
Kentucky	471	471
Maryland	3	3
New York	155	155
Ohio	535	535
Pennsylvania	670	543
Tennessee	238	238
Virginia	14	14
West Virginia	3,070	696
TOTAL:	**5,156**	**2,655**

- Atlas records for Pennsylvania and West Virginia that were not carried over to GASIS were from very small reservoirs (generally one well). A production volume cutoff was applied to the atlas data records, eliminating these smaller reservoir records.

- Atlas codes were converted to GASIS codes for the following: state code, reservoir type, gas production type, commingled production flag, field producing status, lithology, trap type, depositional environment, reservoir heterogeneity, reservoir status, reservoir stimulation type, and reservoir completion type.

- Atlas codes were converted to full text in GASIS for the following: play name, state name, producing formation name, geologic era name, geologic system name, and geologic series name.

- New data were added to Appalachian atlas records in GASIS, including: field discovery year, field type, county name, county code, AAPG basin name, and AAPG basin code.

- Appalachian region Devonian Shale reservoirs in GASIS were identified and flagged through use of the atlas play and formation name.

- Appalachian region tight reservoirs in GASIS were identified using FERC Form 121 data and were flagged.

- Gas composition information from the Bureau of Mines was added where available.

Gulf of Mexico Gas Atlas

- The Gulf of Mexico Gas Atlas was published in two volumes and was processed for inclusion in GASIS. Only the reservoir data file was included in GASIS. (The atlas included other information that could be used in mapping applications.)

- EEA included all of the gas atlas records in GASIS, since this was the only source of reservoir level information for the region. Other databases, including commercial data only report production for the Gulf of Mexico at the field level and well or completion level. No reservoir level database existed in the public domain prior to the atlas project.

- Data from the Volumes 1 and 2 of the Gulf of Mexico Gas Atlas were processed to create a dataset of 9,947 records for inclusion in GASIS. Each record represents an atlas "sandbody," which may include one or more actual reservoirs. For simplicity, these records may be viewed as reservoir records. Counts of reservoir records by atlas volume are as follows:

Atlas Volume	***Number of Reservoirs***
Volume 1	4,325
Volume 2	5,622
TOTAL:	**9,947**

- Existing atlas data elements processed to the GASIS format include: play code, play name, geologic era name, geologic system name, geologic series name, geologic age codes, lithologies, field names, field codes, state names, state codes, district codes, county names, county codes, basin names, basin codes, field discovery year, field type, reservoir discovery year, reservoir type, reservoir depth, water depth, reservoir drive, net pay, porosity, permeability, reservoir temperature, gas gravity, trapping mechanisms, reservoir pressures, and water saturation.

- New data elements created for the Gulf of Mexico records include: field producing status, reservoir status, original gas-in-place, total gas remaining reserves, total gas ultimate recovery, and initial GOR.

Appendix E.
Gas Atlas Inventories

05/23/94
tables.wq2

DATA ELEMENT COVERAGE OF GAS ATLAS PROJECTS

BY STATE

CATEGORY (EEA)	DATA ELEMENT	ALABAMA	ARKANSAS	FLORIDA	KANSAS	LOUISIANA	MISSISSIPPI	OKLAHOMA	TEXAS
RESERVOIR AND PLAY IDENTIFICATION									
	BIO ZONE	96.2%	38.6%	100.0%		81.5%			
	COUNTY	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	DISCOVERY YEAR	100.0%	100.0%	100.0%	100.0%	92.2%	98.2%	99.2%	99.9%
	FIELD NAME	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	PLAY CODE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	RESERVOIR NAME	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	97.1%
	SUBPLAY	100.0%	82.5%	100.0%	75.2%	97.6%	100.0%	50.8%	13.7%
RESERVOIR AND FLUID PARAMETERS									
	DRIVE MECHANISM	88.5%	75.4%	100.0%	31.4%	20.2%	14.6%	59.7%	38.4%
	RESERVOIR GEOPRESSSURED OR NOT	96.2%	98.3%	100.0%		9.6%	1.8%		62.1%
	GAS GRAVITY	65.4%	15.8%		88.6%	53.8%	3.6%	44.9%	90.8%
	NET PAY (ft)	84.6%	82.5%		74.3%	56.3%	84.6%	49.5%	92.8%
	AVERAGE PERMEABILITY (md)	38.5%	31.6%		28.6%	18.5%	19.1%	20.3%	40.2%
	PERMEABILITY RANGE (md)		79.0%		22.9%	6.6%	63.6%	12.6%	7.9%
	POROSITY (%)	84.6%	93.0%		51.4%	24.9%	85.5%	44.6%	49.2%
	INITIAL RESERVOIR PRESSURE (psi)	84.6%	36.8%		92.4%	13.4%	80.0%	50.3%	37.9%
	INITIAL RESERVOIR TEMPERATURE (F)	73.1%	22.8%		29.5%	8.2%	75.5%	21.8%	38.1%
	TYPE OF GAS	50.0%	98.3%		75.2%	99.4%	28.2%	99.0%	100.0%
	WATER SATURATION (percent)	38.5%	75.4%		37.1%	10.5%	4.6%	21.0%	32.8%
GEOLOGY									
	DEPTH TO TOP OF RESERVOIR (ft)	96.2%	100.0%	100.0%	100.0%	93.4%	91.8%	95.9%	99.8%
	LITHOLOGY	96.2%	100.0%	100.0%	100.0%	99.2%	98.2%	97.4%	99.9%
	TRAP TYPE	88.5%	100.0%	100.0%	54.3%	99.9%	100.0%	69.7%	99.6%
PRODUCTIONI/VOLUMETRIC									
	CUMULATIVE RESERVOIR PRODUCTION	96.2%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	ORIGINAL GAS IN PLACE (MMcf)		22.8%		16.2%	0.6%			21.6%
	PRODUCTION RANGE	96.2%	38.6%	100.0%	100.0%	99.5%	100.0%	99.0%	100.0%
SPACING/ACREAGE									
	RESERVOIR ACREAGE	38.5%	82.5%	50.0%	99.1%	64.8%	90.0%	98.0%	33.5%
	WELL SPACING (acres)	96.2%	79.0%	50.0%	75.2%	46.9%	78.2%	93.6%	100.0%
	TOTAL RECORDS:	26	57	2	105	1,189	110	390	1,828

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DATA ELEMENT COVERAGE OF TEXAS GAS ATLAS

BY DISTRICT

CATEGORY (EEA)	DATA ELEMENT	1	2	3	4	5	6	7B	7C	8	8A	9	10
RESERVOIR AND PLAY IDENTIFICATION													
	BIO ZONE												
	COUNTY	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	DISCOVERY YEAR	100.0%	99.5%	100.0%	100.0%	100.0%		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	FIELD NAME	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	PLAY CODE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	RESERVOIR NAME	97.2%	100.0%	98.9%	99.8%	100.0%	100.0%	86.7%	98.7%	90.2%	52.9%	89.5%	99.3%
	SUBPLAY	44.4%	2.0%	0.3%		56.5%	12.5%	10.0%	38.7%	27.4%	50.0%		52.7%
RESERVOIR AND FLUID PARAMETERS													
	DRIVE MECHANISM	22.2%	28.7%	27.2%	20.1%	43.5%	26.9%	50.0%	73.3%	61.1%	79.4%	36.8%	91.2%
	RESERVOIR GEOPRESSSURED OR NOT	88.9%	21.8%	100.0%	100.0%		1.9%						
	GAS GRAVITY	8.3%	98.0%	97.5%	98.4%	100.0%	96.2%	90.0%	84.0%	73.1%	35.3%	73.7%	97.3%
	NET PAY (ft)	88.9%	98.5%	98.6%	98.0%	97.8%	95.2%	66.7%	86.7%	68.8%	91.2%	68.4%	99.3%
	AVERAGE PERMEABILITY (md)	38.9%	21.8%	32.3%	23.0%	60.9%	43.3%	43.3%	62.7%	59.4%	76.5%	42.1%	87.8%
	PERMEABILITY RANGE (md)	13.9%	9.4%	10.8%	4.6%	30.4%	17.3%	3.3%	8.0%	3.0%	2.9%	5.3%	6.8%
	POROSITY (%)	38.9%	28.2%	45.3%	27.8%	69.6%	51.9%	43.3%	81.3%	74.4%	88.2%	47.4%	96.6%
	INITIAL RESERVOIR PRESSURE (psi)	16.7%	21.8%	28.9%	18.5%	54.4%	32.7%	50.0%	73.3%	63.3%	82.4%	36.8%	86.5%
	INITIAL RESERVOIR TEMPERATURE (F)	27.8%	14.9%	28.6%	14.4%	45.7%	27.9%	76.7%	81.3%	72.2%	79.4%	63.2%	91.2%
	TYPE OF GAS	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	WATER SATURATION (percent)	13.9%	16.3%	23.2%	13.0%	28.3%	25.0%	36.7%	66.7%	58.6%	85.3%	42.1%	91.2%
GEOLOGY													
	DEPTH TO TOP OF RESERVOIR (ft)	94.4%	100.0%	99.4%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	LITHOLOGY	94.4%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	TRAP TYPE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	76.7%	100.0%	100.0%	100.0%	100.0%	100.0%
PRODUCTIONI/VOLUMETRIC													
	CUMULATIVE RESERVOIR PRODUCTION	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	ORIGINAL GAS IN PLACE (MMcf)	30.6%	23.3%	16.7%	18.7%	30.4%	13.5%	46.7%	42.7%	24.4%	11.8%	21.1%	24.3%
	PRODUCTION RANGE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
SPACING/ACREAGE													
	RESERVOIR ACREAGE	13.9%	20.3%	20.4%	14.6%	43.5%	26.9%	56.7%	66.7%	55.1%	73.5%	47.4%	92.6%
	WELL SPACING (acres)	100.0%	100.0%	100.0%	100.0%	97.8%	100.0%	100.0%	100.0%	100.0%	85.3%	100.0%	100.0%
	TOTAL RECORDS:	36	202	353	547	46	104	30	75	234	34	19	148

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DATA ELEMENT COVERAGE OF ROCKY MOUNTAIN GAS ATLAS (Does not include all elements)

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ELEMENT	WY	CO	UT	NM	ALL
Biozone	0.0%	0.0%	0.0%	0.0%	0.0%
County	100.0%	100.0%	100.0%	100.0%	100.0%
Discovery Year	99.3%	100.0%	100.0%	100.0%	100.0%
Field Name	100.0%	100.0%	100.0%	100.0%	100.0%
Play Name	100.0%	100.0%	100.0%	100.0%	100.0%
Reservoir Name	100.0%	100.0%	100.0%	100.0%	100.0%
Subplay	0.0%	0.0%	0.0%	0.0%	0.0%
Drive Mechanism	99.3%	94.2%	100.0%	94.5%	96.5%
Geopressure	0.0%	0.0%	0.0%	0.0%	0.0%
Gas Gravity	63.8%	85.1%	79.7%	59.0%	66.9%
Net Pay	95.6%	85.1%	81.3%	84.3%	88.2%
Average Permeability	61.7%	66.2%	56.3%	34.6%	51.3%
Permeability Range	25.5%	24.7%	23.4%	11.9%	--
Porosity	87.9%	85.7%	73.4%	85.2%	85.4%
Initial Res. Pressure	92.6%	72.1%	76.6%	85.8%	85.0%
Initial Res. Temp.	98.7%	28.6%	46.9%	71.5%	71.3%
Type of Gas	100.0%	100.0%	100.0%	100.0%	100.0%
Water Saturation	10.7%	60.4%	32.8%	48.8%	36.6%
Depth	99.3%	96.1%	100.0%	99.7%	99.0%
Lithology	99.7%	100.0%	100.0%	97.7%	99.0%
Trap Type	99.3%	96.1%	100.0%	95.9%	98.0%
Cumulative Production	100.0%	100.0%	100.0%	99.7%	100.0%
Original Original Gas in Place	0.0%	0.0%	0.0%	0.0%	0.0%
Prod. Range	0.0%	0.0%	0.0%	0.0%	0.0%
Reservoir Acreage	98.3%	83.8%	98.4%	100.0%	96.4%
Spacing	76.2%	90.9%	95.3%	100.0%	89.5%
Number of Records	298	154	64	344	860 *

* Does not include 1 Arizona record.

Appendix F.

Supplemental Geological Data

Processing of Supplemental Geological Data for The GASIS Reservoir Data System

Assignment of USGS Play and Province Codes to GASIS Reservoirs

- The USGS has developed a play classification system that is different from the gas atlas system
- USGS play and province codes were assigned to GASIS reservoir records through automated and manual methods.
- An automated matching process was run on non-Appalachian region GASIS records and data in the *USGS Open File Report 97-278: Assignments of U.S. Oil and Gas Reservoirs to U.S. Geological Survey 1995 National Oil and Gas Assessment Plays*. This matching process involved comparisons based on state name, county name, AAPG basin name, DOE/EIA field code, field name, formation names, and reservoir names.
- USGS play codes were also assigned to non-Appalachian region GASIS records based on USGS play name and formation name.
- Additional assignments were made based upon other information in the GASIS reservoir record (ex: geologic age, depth, lithology, field type, reservoir type, atlas play name, trap type, tight flag, shale gas flag).
- USGS play outlines were mapped to compare counties covered by plays to the geographic location of GASIS records. This allowed some additional matching.

Assignment of Play-Level Depositional Environments to GASIS Reservoirs

- A play-level depositional environment code was developed and applied to GASIS reservoir records.
- Play descriptions in the hardcopy GRI/DOE atlases were studied to determine the dominant depositional environment for the play. This was facilitated by the fact that the atlas plays were generally stratigraphically (rather than structurally) defined.
- Reservoir-level depositional environment assignments were used where available to supplement the play descriptions. The Rocky Mountain and Appalachian atlases have play level classifications.
- Maps showing depositional environment types and play outlines were available in the hardcopy atlases. These maps were examined and used to supplement the information gathered from the other research.
- Play-level codes were then applied to all GASIS records assigned to these gas atlas plays.

Appendix G.

GASIS User Survey Report

DOE "GASIS" RESERVOIR DATA SYSTEM: USER NEEDS ASSESSMENTS AND RECOMMENDATIONS

Prepared for:

U. S. DEPARTMENT OF ENERGY
Morgantown Energy Technology Center

Prepared by:

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September 14, 1994

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1. INTRODUCTION

1.1 INTRODUCTION

The Department of Energy's Morgantown Energy Technology Center (METC) is supporting a three year effort to construct a national database of geological, engineering, and summary production information for U.S. oil and gas reservoirs. The reservoir database will be the primary component of the Gas Information System ("GASIS"), and will combine previously compiled public domain data, newly acquired and interpreted data, and newly released data into a single database with over 18,000 reservoir records. Each reservoir record is expected to contain approximately 187 individual data items. The GASIS database will be made available to industry on CD-ROM for PC applications.

Energy and Environmental Analysis (EEA) of Arlington, Virginia is the prime contractor on the project, and is working with Dwight's Energydata and several consultants. Dwight's field and reservoir database group in Oklahoma City is the primary group involved in the GASIS project.

The primary goal of the database development effort is to create a national oil and gas reservoir database for use by DOE/METC for supply technology assessment and evaluation of alternative natural gas research strategies. GASIS data will be used by DOE/METC as input for a personal computer-based national supply and demand model that is currently under development. DOE/METC data needs encompass a broad array of information, including geological data, reservoir properties, gas and fluid properties, summary production data, drilling and completion data, stimulation data, rock mechanics data, and coalbed gas reservoir data. While several of these data types have been previously compiled electronically in some form, no existing database contains all of the required information.

The other major goal of the project is to promote the development of domestic gas resources by improving the coverage and availability of public domain reservoir information nationally for the

oil and gas industry and research community. Public domain information available to industry in the above data categories is either non-existent, has never been compiled, or has never been compiled nationally.

The GASIS project can be viewed as an extension of the large-scale GRI/DOE Gas Atlas projects, which have developed a series of regional atlases and electronic datasets for oil and gas reservoirs in major producing areas of the U.S. The GASIS database will greatly improve upon the Gas Atlas databases by combining regional data into a national database, by expanding the scope of data coverage for each reservoir, and by collecting a large amount of new data.

The GASIS project represents more than a national compilation of existing data. GASIS includes a large-scale geological research effort designed to improve the coverage and quality of reservoir information in selected areas. The reservoir study effort is being conducted by Dwight's Energydata personnel and includes regional and field level log correlation, log analysis, data collection, and geological interpretation. This research will result in a dramatic improvement in the quality of reservoir information in the studied areas, especially those with "reservoir definition" problems, such as the Mid-Continent.

A User Needs Assessment was conducted to obtain input on the content and design of GASIS from all major sectors of the gas industry. The results are documented in this report and have been incorporated into our recommendations. While GASIS is primarily being developed to address the needs of DOE for modeling and technology assessment, the industry priorities and recommendations documented here have been used as a guide to ensure that GASIS includes the information that is most useful to industry, and that the software portion of GASIS allows efficient manipulation of the data.

1.2 USER NEEDS ASSESSMENT

1.2.1 Goals of Assessment

The primary goals of the User Needs Assessment were:

- to determine potential applications for GASIS in each industry sector;

- to determine industry priorities for data categories and data elements;
- to evaluate software and data exchange issues;

Secondary goals of the assessment were:

- o evaluate the status and characteristics of currently available non-proprietary field and reservoir data
- to obtain information on sources of data that could be used for GASIS

1.2.2 Scope of the Assessment

The assessment was based upon in-person interviews with representatives of major oil companies, independents, pipelines, service companies, and financial institutions. To provide a format for discussion and documentation, a survey form was created. The form was mailed to the participant before the interview, and each person was asked to review the questions and issues before the meeting. The major components of the form and survey are described below:

Potential GASIS Applications

Each participant was asked to discuss potential applications for GASIS for his organization or group. To guide the discussion, a matrix was included showing our expected applications by user group.

Current Sources of Data

Each participant was asked to discuss the primary sources of production and engineering data that are used by his organization. Included were purchased or licensed data, public domain data, and proprietary data. The participant was asked to describe shortcomings with current data sources, including coverage, availability, and quality.

Priorities by Region

Regional priorities for GASIS data collection and research efforts were discussed.

Priorities for Data Elements

The list of 154 originally proposed GASIS data elements was presented to each participant, who was asked to prioritize the categories of information and individual data elements for inclusion in GASIS. The participant was also asked to indicate which
numeric data should be included as a range of values rather than an average for the reservoir.

Software and Data Exchange Requirements

The final portion of the survey was designed to evaluate software and format issues. Discussion areas included recommended search and retrieval capabilities, data export formats, and desirability of the CD-ROM medium.

1.3 SUMMARY OF RESULTS OF SURVEY

1.3.1 Potential GASIS Applications

The GASIS database will be the most complete non-proprietary collection of oil and gas reservoir information available, and will be an excellent source of information for planning, analysis, and research. GASIS will be used for play analysis, modeling and forecasting, resource studies, market assessment, and technology assessment. Because it will be provided on CD-ROM with its own search and retrieval and export software, GASIS will be easy to obtain and use.

Producers have the widest range of potential applications of all the surveyed groups. As a stand-alone database, GASIS will be used by both planning and exploration groups to perform statistical and economic studies of geological plays or other reservoir subsets. Majors and large independents will also use selected GASIS data to complement existing proprietary regional or national databases. When used in this manner, GASIS data are expected to be applied to more sophisticated applications including supply modeling, reservoir simulation and technology assessment.

Planning groups at gas pipeline companies are interested in evaluating gas supply developments, both nationally and in their supply areas. They are expected to use GASIS for reserve and resource studies and economic studies.

Energy lending groups will use GASIS to evaluate oil and gas reservoir studies and economic studies submitted in support of lending applications.

Service firms and equipment manufacturers will use GASIS to evaluate the potential market for new equipment or technologies.

Research organizations and government agencies will use GASIS for technology market assessment and national supply modeling. GASIS would provide a tool to assess the potential impact of improved recovery technologies in areas such as hydraulic fracturing and geologically directed infill drilling. GASIS would also provide valuable data to prioritize research efforts in gas processing, drilling, and completion technologies.

1.3.2 Data Priorities and Software Recommendations

The highest industry data priorities are reservoir engineering data, geological parameters, status information, and gas and fluid properties. Full field and reservoir identification and location information are critical. The database should incorporate uniform field and reservoir codes that will allow linkage to other commercial and in-house data.

Search and retrieval software are very important, especially for users with limited access to commercial database packages. The search and retrieval system should allow the user to query the database and retrieve records meeting specified criteria. Retrieved records could be printed or exported as a file. Data export from GASIS is critical and should be in the form of an ASCII flat file, which is the most universal format. Graphical data such as type logs or cross sections would be desirable but are not a priority.

2. USER GROUPS AND POTENTIAL GASIS APPLICATIONS

2.1 INTRODUCTION

A major goal of the User Needs study was to interview representatives of all major sectors of the U.S. gas industry and research community. The intent was to include major and independent producers, state and federal agencies, pipelines, research organizations, banks, service companies, associations and equipment manufacturers.

All of these industry groups are either current or potential users of oil and gas reservoir data.

2.2 PROFILE OF SURVEYED ORGANIZATIONS

Forty-five organizations were interviewed between August 1993 and January 1994. Over 85 individuals participated in the interviews.

The following table shows the distribution of interviews by potential user group:

Major producer	6
Independent producer	10
Pipeline Co.	3
Marketer	3
Financial Institution	5
Service Company	1
Gas Research Institute	1
DOE/EIA	1
USGS	1
State Geological Survey	1
State Regulatory Agency	1
Minerals Management Service	2
Geological and Engineering Consultant	7
Association	3
Total	45

About one-third of the organizations interviewed were companies engaged in exploration and production. The only groups on our original list of potential users not covered were local distribution companies, universities, and equipment manufacturers. These groups are not

considered major potential users of GASIS, although local distribution companies are expected to be somewhat more involved in gas supply issues in the future because of structural changes in the pipeline industry over recent years that have resulted in more LDC responsibility to manage supply.

2.3 GASIS APPLICATIONS BY USER GROUP

2.3.1 Introduction

A discussion of potential applications for GASIS was included in the User Needs Assessment to provide DOE with a better understanding of the use and potential benefits of this type of information within each industry sector. The survey results will be used to prioritize data collection activities and to better design the GASIS database.

GASIS will be used both as a stand-alone database and as a supplemental source of data for commercially licensed or in-house datasets. In stand-alone applications, GASIS data will be accessed on CD-ROM and manipulated with the included search and retrieval software. As a supplemental data source, GASIS data will be used to improve the data coverage of reservoir parameters (such as net pay or porosity) and to add data elements or types of data that are unique to GASIS. Unless otherwise stated, the applications described in this section are for GASIS as a stand-alone database.

2.3.2 Specific Applications by Group

Figure 2-1 summarizes potential GASIS applications by user group. The following section describes in more detail how GASIS data would be used:

DOE/METC

GASIS data will be used by DOE/METC for supply technology assessment and evaluation of alternative natural gas research strategies. GASIS data will be used to develop input files for a personal computer-based national supply and demand model that is currently under development (the GSAM model).

Figure 2-1
POTENTIAL GASIS APPLICATIONS BY USER GROUP

Applications	User Group (see below)										
	1	2	3	4	5	6	7	8	9	10	11
Exploration, play analysis	X					X	X	X	X		X
Reservoir simulation	X				X		X	X	X		
Reserve estimation	X	X	X	X		X	X	X	X	X	X
Drilling program design	X										
Well stimulation design	X				X	X			X		
Property acquisition	X	X		X					X		
Resource assessment	X	X				X	X	X	X		
Facilities design	X			X					X		
Planning and marketing	X	X			X	X	X				
Deliverability estimates	X	X	X	X		X	X		X	X	X
Gas processing design	X	X			X	X			X		
Regulatory analysis	X	X				X	X		X	X	X
Research and training	X	X			X	X	X	X	X		

User groups:

1. Producers
2. Pipelines and LDC's
3. Marketers
4. Financial Institutions
5. Service companies
6. Gas Research Institute
7. DOE
8. USGS, MMS, and state geologic surveys
9. Geological and engineering consultants
10. State regulatory agencies
11. Associations

Producers

Producers use commercial oil and gas reservoir engineering and production data extensively as an integral part of their business. The larger companies all have access to commercial electronic data. Our survey indicated that the GASIS database would serve both as a source of supplemental data to these users and as a stand-alone database for various types of analyses.

Producers will use GASIS data in a wide range of applications. Primary applications of GASIS as a stand-alone database include play analysis (historical discoveries and attributes), planning (economic analysis, modeling, and forecasting), resource assessment and characterization, and reserve and ultimate recovery studies. When combined with extensive in-house and commercial data sources, GASIS data will be used in more sophisticated applications including reservoir simulation, well stimulation design, and drilling program design.

Small and medium-size independents are expected to use the GASIS database more than majors, because the smaller organizations generally have less access to national or regional data.

Natural Gas Pipelines and LDC's

Pipelines and LDC's will primarily use GASIS for reserve and deliverability estimation, planning and marketing, gas composition analysis. Planning groups with interstate pipelines will use GASIS as a source of data for industry forecasting and resource studies.

Marketers

Marketers will primarily use GASIS for reserve and deliverability estimates by play or geographic area.

Financial Institutions

Banks will use GASIS as a source of information to help evaluate the engineering and economic data and analyses submitted to them by consultants. While they have access to commercial production and well completion data, lenders have indicated that they would use GASIS for "reasonableness checks" on reserve and deliverability estimates and reservoir and fluid

properties. Play level evaluation of reserves, recoveries, deliverability, and engineering parameters would be an important application.

Service Companies and Equipment Manufacturers

Service firms and manufacturers of gas processing and other equipment are expected to use GASIS to evaluate the potential market for new equipment or technologies.

Gas Research Institute

GRI has a need for a reservoir database to help assess the potential impact on industry of technology development. GASIS will provide a tool to assess the potential impact of drilling and completion technologies, improved recovery technologies, gas processing technologies, and other areas of research. GRI is expected to use GASIS data in support of national and regional modeling and forecasting work.

USGS, MMS, and State Geologic Surveys

Primary applications include play analysis, resource characterization and assessment, statistical studies, reserve estimates, and economic analysis.

Geological and Engineering Consultants

Primary applications include reservoir evaluation, analog studies, play analysis, economics, reserve estimates by play or area, and reservoir simulation (combined with other data).

Associations

These groups typically perform national or regional statistical studies and evaluate industry activity and technology developments. GASIS data would be used in these types of studies. The primary types of GASIS data used would be production, reserves, recovery estimates, well counts, and status information.

State Regulatory Agencies

State conservation commissions are expected to use the database to support rulings related to well spacing, unitization, and other matters, and to evaluate reserves and deliverability.

Universities (not interviewed in survey)

Petroleum Engineering and Geology departments are expected to use GASIS data for reservoir and play studies.

3. CURRENT SOURCES OF DATA FOR U.S. OIL AND GAS RESERVOIRS

3.1 INTRODUCTION

A goal of the User Needs study was to document the major data sources currently being used by industry to evaluate domestic oil and gas reservoirs. This information is intended to help prioritize GASIS data collection, avoid duplication of effort where public domain data have been compiled by others, and identify additional sources of data for GASIS.

The User Needs review of data sources did not include an evaluation of the specific content, availability, and cost of each data source. That level of documentation is encompassed by the Source Directory portion of GASIS, which is currently under development. This chapter presents only general information about major sources.

Because GASIS will be a reservoir level database, our primary interest in the User Needs study was identification of data sources for oil and gas production, geological, and engineering data at the reservoir level. However, because much of the information available is reported by well or completion, we also discussed well level databases.

For this report, data have been classified as commercial, public domain, or proprietary. Commercial data are those data available from vendors such as Dwight's or Petroleum Information. Public domain data include state filings and printed matter that are available from not-for-profit organizations such as state agencies. Proprietary data are in-house databases developed by agencies or private companies that are not publicly available.

3.2 COMMERCIAL DATABASES

3.2.1 Introduction

There are three major vendors of oil and gas production and engineering data for the United States: Dwight's Energydata (Dwight's), Petroleum Information (P.I.), and Nehring and

Associates (NRG). All three vendors offer a field and reservoir geologic, engineering, and production database. Dwight's and P.I. also offer databases containing gas well and oil lease production and well tests. Oil and gas production data are assembled from public domain data reported by state or federal agencies. In some cases, vendors have a more complete production history than is available in digital format from the states, because the vendor has keyed the old production records. A variety of sources have been used for geological and engineering data, including data published in field compilations assembled by regional geological societies.

The field and reservoir databases offered by Dwight's and P.I. trace their roots to the Petroleum Data System (PDS). The PDS was originated at the University of Oklahoma in 1968 as a comprehensive field and reservoir database for resource assessment work. A significant portion of the early PDS development was funded by the Federal Government. Dwight's and P.I. began developing their own products from the PDS in the early 1980's when development at the University of Oklahoma stopped. The PDS is actually the umbrella name for several oil and gas databases. The two PDS databases that are pertinent to GASIS are the field and reservoir geologic, engineering, and production database (TOTL) and the gas analysis file (GANL). Other PDS files include data such as secondary and enhanced recovery projects, oilfield brine analyses, and crude oil analyses.

Dwight's and P.I. also offer well history databases. These databases generally incorporate the information reported on state well completion forms such as formation tops, and may also contain scouting information gathered by the vendor.

In the mid 1970's, the Department of the Interior (DOI) funded research by the Rand Corporation on Significant Oil and Gas Fields of the United States. The data compiled for DOI served as the basis for the NRG database when Nehring Associates was established in the early 1980's. Since that time, the database has been updated and expanded from the original DOI research.

Vendors add value by integrating data from several sources, keying hardcopy data, regularly updating their databases, and packaging the data in more convenient formats such as CD-ROM.

Commercial databases can be usually be purchased in a variety of printed and magnetic formats or accessed on-line. Custom retrieval and programming services are also offered.

3.2.2 Dwight's Energydata

Dwight's Petroleum Data System (DPDS) consists of several files with primary emphasis on field and reservoir level data. The TOTL file contains annual and cumulative production, location, geologic, and engineering data for fields and reservoirs in 31 states and the OCS. Dwight's has developed reserve estimates for the TOTL file called Estimated Future Recoverables (EFR). Other DPDS files include natural gas composition, crude oil analyses, enhanced recovery data, and brine analyses.

Dwight's Oil and Gas Reports (DOGR) contain monthly production histories for non-Appalachian wells and leases. In addition to monthly gas and liquids production, cumulative production, location, identification, and gas well pressure test data are provided.

Dwight's Well Data System (WDS) is their well permit and drilling history database. Complete historical coverage is available for the Rocky Mountain states and Kansas.

3.2.3 Petroleum Information

P.I.'s Petroleum Data System (PDS) is comprised of several files. The TOTL file contains field and reservoir geologic, engineering, and oil and gas production history data. P.I.'s PDS also includes related files such as natural gas composition, brine analyses, and crude oil analyses.

P.I. also offers a historical production database for non-Appalachian producing states. This database contains monthly oil and gas production, cumulative production, location, identification, and well test information for gas well completions and oil leases.

The Well History Control System (WHCS) is P.I.'s comprehensive drilling and completion database for the United States. This system contains completion records for more than 2.2

million wells.

3.2.4 NRG Associates

NRG markets the Significant Oil and Gas Fields of the United States database. This database contains production history, recovery history, geologic, and engineering data for selected United States fields and reservoirs. The focus of the NRG file is fields of 1 million BOE or more, and reservoirs of 500,000 BOE or more. A key part of this database is a proprietary system of geologic play identification.

3.3 PUBLIC DOMAIN DATABASES

3.3.1 Gas Atlas Databases

DOE and GRI have developed a series of regional gas atlases and databases for major producing areas of the United States. The Gas Atlas projects emphasize geologic classification of major gas reservoirs by play. The reservoirs are selected on the basis of cumulative production. The atlases contain a variety of maps, cross-sections, logs, and narrative. Geologic and engineering parameters are presented in a standard tabular format. Four atlases have been completed to date: Texas, Central and Eastern Gulf Coast, Mid-Continent, and Rocky Mountain. Appalachian and Northern Gulf of Mexico (OCS) atlases are in progress.

The data contained in the atlas tables have been compiled into databases on diskettes that accompany the printed material. The Texas, Eastern Gulf Coast, and Mid-Continent databases contain approximately twenty basic geologic and engineering data elements corresponding to the tables published in the atlases. The Rocky Mountain Atlas database has 130 data elements covering a variety of data not present in the other published atlases. Examples of information unique to the Rocky Mountain atlas include coalbed methane data and gas composition data.

3.3.2 Other Public Domain Electronic Data

State and federal agencies have computerized three basic types of information: gas and liquids production, well completion history data and well test data. Allowable or proration data and gas composition data are also computerized in some states. The specific types of data available in

digital format, and the completeness of historical coverage, vary from state to state. While the details of the various agency data systems are beyond the scope of this report, examples are discussed below to illustrate the types of databases.

Many of the major producing states have compiled gas well production data electronically, although the amount of historical coverage varies between states. The Oklahoma, Texas, and the OCS (MMS) databases were mentioned during the survey. Gas production from gas wells is generally tracked by well completion, while oil and casinghead gas are reported by lease in most states. For example, in Texas, the gas production database contains monthly production for each individual gas well completion; however, oil production is reported by lease.

Well completion or "well header" information have been computerized in several areas including Colorado, Louisiana, Oklahoma, Texas, and the OCS. These databases typically contain contains well names, API numbers, locations, drilling dates, tops, test, and status information keyed from state completion forms.

Some deliverability test data have been computerized as well. The Texas form G-10 gas well test data are available on tape back through 1977. Well test data include pressure measurements, daily rates, gravities, and estimated potential.

An electronic database of gas composition data has been compiled by the U.S. Bureau of Mines and is publicly available. This database consists of wellhead and pipeline gas samples from most areas of the United States, and from several foreign countries. A sample consists of location and identification data, and mole percent concentrations of all common hydrocarbon and non-hydrocarbon gas components.

3.3.3 Public Domain Printed Material

A tremendous amount of reservoir data are available in state files in hardcopy form. Data are in the form of well logs, completion reports, and pressure and deliverability tests. Well logs are the primary source of data for geologic correlation and determination of parameters such as net pay

and porosity.

Completion reports include information such as location, operator, spud date and completion date, formation tops, tested intervals, and test recoveries.

State regulatory agencies require operators to periodically obtain pressure and deliverability data on producing wells. This information is available in hardcopy form in state files and is available electronically through vendors.

Other public domain hardcopy sources for reservoir data include state unitization hearing files, regional geological society field and reservoir compilations, DOE and Gas Research Institute reports, FERC form-121 (tight gas) applications, and Minerals Management Service publications.

3.4. PROPRIETARY DATA

3.4.1 In-House Databases

Operators interpret geologic and engineering data in the course of evaluating, developing, and managing their properties. The larger companies have built databases to preserve these data. Data types include production data, test data, formation tops, electronic well logs, engineering parameters, deliverability tests, lat/long data, and drilling and completion data. Most larger companies use Geographic Information Systems to manage this type of data.

3.4.2 MMS Databases

The Minerals Management Service performs engineering and geologic evaluations of OCS reservoirs in support of the Maximum Effective Rate Program (allowables). The MMS has built a proprietary database (FRRE) from the data supplied by operators with their MER applications. Apparently, some of the non-confidential data from the FRRE database will be incorporated into the Northern Gulf of Mexico gas atlas. The MMS maintains other electronic data which are not proprietary. These data include completion level production data, lease, platform, and lat/long location information.

3.5 SHORTCOMINGS OF AVAILABLE DATA

Inadequate coverage of basic engineering parameters, inaccuracies, and lack of proper reservoir definition in some regions were cited as problems with publicly available reservoir data. The lack of standard content, reporting definitions, and codes was said to make combining or reconciling data from different sources difficult. The costs of locating, assembling, keying from hardcopy, standardizing, and quality checking are obstacles to the use of hardcopy data. Some data are distributed in inconvenient formats such as magnetic tape.

Lack of reservoir definition and reservoir production data in the Mid-Continent and South Louisiana regions is a serious shortcoming of existing data. Since gas production is reported for individual well completions, reservoir production is the sum of completion level production. Areas with reservoir definition problems are those in which the linkage between completions and reservoirs is unknown or inadequately known. Without proper reservoir definition, reservoir level production is unknown, and the assignment of reservoir parameters using published data is often uncertain.

The Appalachian region is of course the most problematic area of the country for data availability. This is the oldest producing area of the U.S., and operators have generally not been required to report production and test information to state agencies. In most states, production data are not generally available at either the well or reservoir level. Most of the Appalachian states have some production and/or well history information on recent wells.

3.6 HOW GASIS WILL ADDRESS THESE SHORTCOMINGS

GASIS will address the issue of poor data coverage of geological and engineering parameters in two basic ways. First, the GASIS database will combine the best available information from a number of different sources. This will result in more complete coverage of the types of information (such as net pay and porosity) that are commonly included in reservoir databases. Second, the GASIS reservoir study project will collect an entire suite of geological and engineering data on several hundred studied reservoirs. This will be new data that has not been available in any other compilation.

The GASIS project will use standard definitions for all data elements, and will make the necessary conversions for each major data source used. In addition, GASIS will include standardized field and reservoir codes to allow linkage to commercial and other data sources.

Resolution of reservoir definition problems in key areas will be addressed by the GASIS reservoir study project. A major portion of the project will be directed at the reservoir definition problem in the Mid-Continent. This effort will result in both the proper allocation of gas production to reservoirs and the collection of a large amount of new data.

Finally, the GASIS project will incorporate quality control procedures and algorithms to identify erroneous or questionable data.

4. DATA PRIORITIES AND RECOMMENDATIONS

4.1 INTRODUCTION

This chapter documents the results of the data priority portion of the survey and gives our recommendations for the data categories and data elements to be included in GASIS.

As stated earlier, DOE/METC data needs for modeling have the highest priority for GASIS development. The data priorities documented here are those expressed by the industry participants of the User Survey. They represent only one aspect of what must be considered in developing our recommended data element list. Factors that must be considered include:

- the database concept of GASIS (scope, reporting level, etc.)
- DOE/METC data needs
- industry priorities and recommendations
- available data sources
- level of effort required to collect the data

The GASIS database concept defines the general types of information that must be included, the reporting level (individual reservoir), and the scope of coverage (geographic coverage and which reservoirs to include). This concept was defined by DOE in the original proposal and has not changed in any substantial way.

DOE/METC data needs are defined in broad terms by the types of data that were included in the original list of data elements (discussed in section 4.2). This original list included a broad array of data types, including geological data, reservoir properties, gas and fluid properties, drilling data, completion data, stimulation data, and rock mechanics data. The broad scope of data types in the original list defines a need for information on all major aspects of reservoir characterization. These broad data needs are indicative of the anticipated scope of potential DOE supply research areas.

Data availability is a major consideration. Some of the data types on the original DOE list (such as certain information on rock mechanics) do not have identified available data sources for any significant number of reservoirs. Much of the information in areas such as this exists in company files. In general, data elements with no identified sources have been omitted from the list. The understanding is that they can be re-inserted as sources are identified.

Level of effort involved to collect certain information is a major factor. While many of the original data elements currently reside in electronic or hardcopy compiled form, some do not. For example, gas-in-place numbers are almost non-existent in our available databases. Generation of new estimates of gas-in-place at the reservoir level would involve a large amount of data processing and interpretation.

Despite these limitations, our proposed GASIS data element list includes most of the data elements that were originally proposed, as well as quite a few new ones. Generally, data elements that are being dropped are those for which there is no identified data source or those whose collection is beyond the scope of the current project.

Finally, the data priorities documented in this chapter are priorities of survey respondents for the content of the GASIS database. The overall GASIS project includes a large-scale supplemental research and data collection effort, primarily consisting of the geological field and reservoir studies being conducted by Dwight's Energydata. The supplemental research effort was not specifically addressed by the User Needs study and is not dealt with in this report. However, the results of the User Needs study have been used to help determine the types of supplemental information that are being collected on each studied reservoir.

4.2 POTENTIAL TYPES OF DATA FOR GASIS

The original list of proposed data elements for GASIS was developed by DOE and includes identification, status, engineering, geology, and production information. Table 4-1 is the list of data elements included in the User Needs study. Most of these data elements were taken from the original DOE list, while some were added by EEA. The elements added by EEA were

primarily identification and status information that we felt was necessary to properly identify and locate each reservoir and to link to other databases. The following text summarizes the types of data included under each category:

- Field and Reservoir Identification - includes field and reservoir name, field and reservoir codes, play name and code, basin name and code, and location information.
- Reservoir - General - includes type of gas, unconventional gas identification, reservoir discovery year, average depth, surface elevation, water depth.
- Field status - includes producing status of field, field size, field type, pipeline system.
- Geology - includes formation name, geologic age, lithology, area of closure, trap type, depositional environment, heterogeneity, fracture identification.
- Reservoir Status - includes producing status of reservoir, well counts, productive area, allowable spacing.
- Reservoir parameters - includes net and gross pay thicknesses, porosity, permeability, temperature, initial pressure, water saturation, and drive mechanism.
- Fluid properties - includes gas/oil ratio, condensate ratio, gas gravity, compressibility, BTU (heat) content, gas gravity, water resistivity.
- Drilling and Evaluation - includes drilling, logging, and testing practices, horizontal or slant well identification.
- Stimulation - includes usual stimulation type, pressures, injection rates, and proppant information.
- Completion - includes usual completion type, perforation size and type, completion equipment.
- "Reference well" data - includes flow potential, production, and ultimate recovery information for a "reference" or "typical" well in the reservoir.
- Volumetric Data - includes cumulative and annual gas production, reserves, ultimate recovery, gas-in-place, gas cycling volumes, recovery factor.
- Gas processing - includes gas composition, processing method, pipeline specifications for delivery pressures, CO_2, H_2S, water, natural gas liquids, and heat content.
- Rock properties - includes, mechanical rock properties, pore pressure, stratigraphic column, mineral composition, and matrix density.
- Coalbed methane data - includes coalbed thickness, rank, gas content, desorption data.

TABLE 4-1
ORIGINAL DATA ELEMENTS

Category	GASIS Data Element	Full (F), or partial (P) Gas Atlas coverage
Field/reservoir i.d.	field name	F
	DOE field code	
(All of these items are expected to be included in GASIS)	reservoir name	F
	reservoir code	
	state	F
	state code	
	county	F
	county code	
	district	F
	AAPG basin name	
	AAPG basin code	
	geologic play name (from atlas)	F
	geologic play code	P
	section-township-range	
	OCS block and number	
	subplay name (from atlas)	P
	biozone (from atlas)	
Reservoir - general	associated vs non-assoc. gas	F
	tight gas (y/n)	
(All of these items are expected to be included in GASIS)	coalbed methane (y/n)	
	shale gas flag (y/n)	
	reservoir discovery year	F
	average reservoir depth (ft)	F
	surface elevation (ft)	
	average subsea depth (ft)	
	offshore water depth (ft)	

Category	GASIS Data Element	Full (F), or partial (P) Gas Atlas coverage
Field status	field status (prod, SI, abd, stor)	P
	field discovery year	
	field type (oil or gas)	
	USGS field size class	
	oldest formation penetrated	P
	depth of deepest well in field (ft)	
	gas pipeline system (name)	
	current market area for production	
Geology	formation name (standardized)	
	zone or member name	
	geologic age (system and series)	
	geologic age code	
	lithology	F
	reservoir trap type	F
	structure type	
	area of closure (acres)	P
	geologic play name	P
	depositional environment (play level)	P
	heterogeneity type (depos, fracs, etc)	P
	heterogeneity class or level	
	reservoir continuity class	P
	natural fracture spacing	
	reservoir facies	
Reservoir status	reservoir status (prod,SI,abd.,stor)	
	year of reservoir status data	
	no. producing gas wells, (yr)	P
	no. producing oil wells, (yr)	
	no. shut in/temp abandon wells, (yr)	
	no. plugged/abandoned wells, (yr)	P
	proven productive area (acres)	P
	average well spacing (acres)	P
	allowable spacing (acres)	
	commingled production (y/n)	P

TABLE 4-1
ORIGINAL DATA ELEMENTS
(Continued)

Category	GASIS Data Element	Full (F), or partial (P) Gas Atlas coverage
Reservoir parameters	net pay thickness (ft)	P
	gross productive interval (ft)	
	average porosity (%)	P
	source of porosity data	P
	porosity range (%)	
	porosity-ft of net pay	P
	avg. horiz. permeability (md)	P
	horiz. perm range (md)	P
	vert. permeability (md)	P
	source of permeability data	
	init. reservoir temp. (deg.F)	P
	initial reservoir pressure (psi)	P
	current reservoir pressure (psi)	P
	date of current pressure data (mo./yr)	P
	pressure gradient (psi/ft)	P
	geopressure (y/n)	P
	gas column (ft)	
	formation vol. factor	
	water saturation (%)	P
	gas saturation (%)	P
	drive mechanism.	P
Fluid properties	initial GOR (scf/bbl)	
	lease condensate ratio (bbl/MMcf)	
	gas gravity	P
	gas compressability	
	condensate gravity	
	Btu content (gas)	P
	Resistivity (Rw) of formation water	P

Category	GASIS Data Element	Full (F), or partial (P) Gas Atlas coverage
Drilling and evaluation	drilling practices (typical)	
	drilling fluid (typical)	
	horizontal or slant wells (y/n)	
	log types (typical)	P
	well test practices (typical)	
	logging practices (typical)	
Stimulation	usual stimulation type	
	typical breakdown pressure	
	typical casing pressure	
	typical injection rates	
	typical fluid pad amount	
	typical proppant quantity	
	typical proppant type	
	typical treatment time	
	instantaneous shut-in pressure	
Completion	typical completion type	P
	typical perfs per well	
	typical perf. interval (ft)	
	typical perf. size, type	
	completion equipment description	
Reference well data	reference well name and number	
	reference well location	
	init. open flow potential	
	final open flow potential	
	test type for flow potential	
	maximum annual production (MMcf)	
	estimated ultimate recovery (MMcf)	

TABLE 4-1
ORIGINAL DATA ELEMENTS
(Concluded)

Category	GASIS Data Element	Full (F), or partial (P) Gas Atlas coverage
Volumetric data	annual gas prod. (sel. yrs) (MMcf/yr)	
	cumulative gas production (MMcf)	F
	cumulative cond. production (Bbl)	
	cumulative water production (Bbl)	
	year for cumulative production data	
	cumulative gas cycling volume (MMcf)	
	original gas-in-place (MMcf)	P
	remaining gas in place (calc.) (MMcf)	P
	remain. gas reserves (MMcf)	P
	year for reserve estimation	
	data source for remaining reserves	
	ultimate recovery (MMcf)	P
	recovery factor (% of OGIP)	P
Gas processing	wellhead gas composition (by component)	
	gas processing method	
	processing cost estimate (calc $/mcf)	
	min. pipeline delivery pres. (psi)	
	max. pipeline delivery pres. (psi)	
	pipeline NGL specifications	
	pipeline heating minimum (Btu/cf)	
	max. CO2 allowable to pipeline (%)	
	max. H2S allowable to pipeline (ppm)	
	max. pipeline water content	
Rock properties	elastic modulus	
	Poissons ratio	
	tensile strenth	
	compressive strength	
	fracture toughness	
	cohesive strength	
	avg. rock pore pressure (psi)	
	stratigraphic wellbore column desc.	
	lithostatic gradient (psi/ft)	
	approx. mineral composition	
	reservoir matrix density	
Coalbed methane data	coalbed thickness (ft)	
	coal rank	
	coalbed gas content (cf/ton)	
	coalbed desorption data	
	cap. pressure data	
	mineable coal seam (y/n)	

4.3 DATA PRIORITIES

Determination of data priorities for the GASIS Reservoir Data System was the primary goal of the User Needs study. The objective was to evaluate both the types of data and the individual data elements that should be included. Secondarily, we wanted to obtain recommendations on which data elements should be reported as a range of values, rather than as an average value for the reservoir.

During each interview, the entire list of potential data elements was evaluated. Respondents were asked to determine which data elements or categories should or should not be included in GASIS. They were not asked to rank elements in order of priority, but to recommend either inclusion or exclusion from GASIS. Data priorities were determined by summing the positive and negative responses for each element. Priorities were evaluated for five categories of potential GASIS users.

4.3.1 Priorities by Data Category

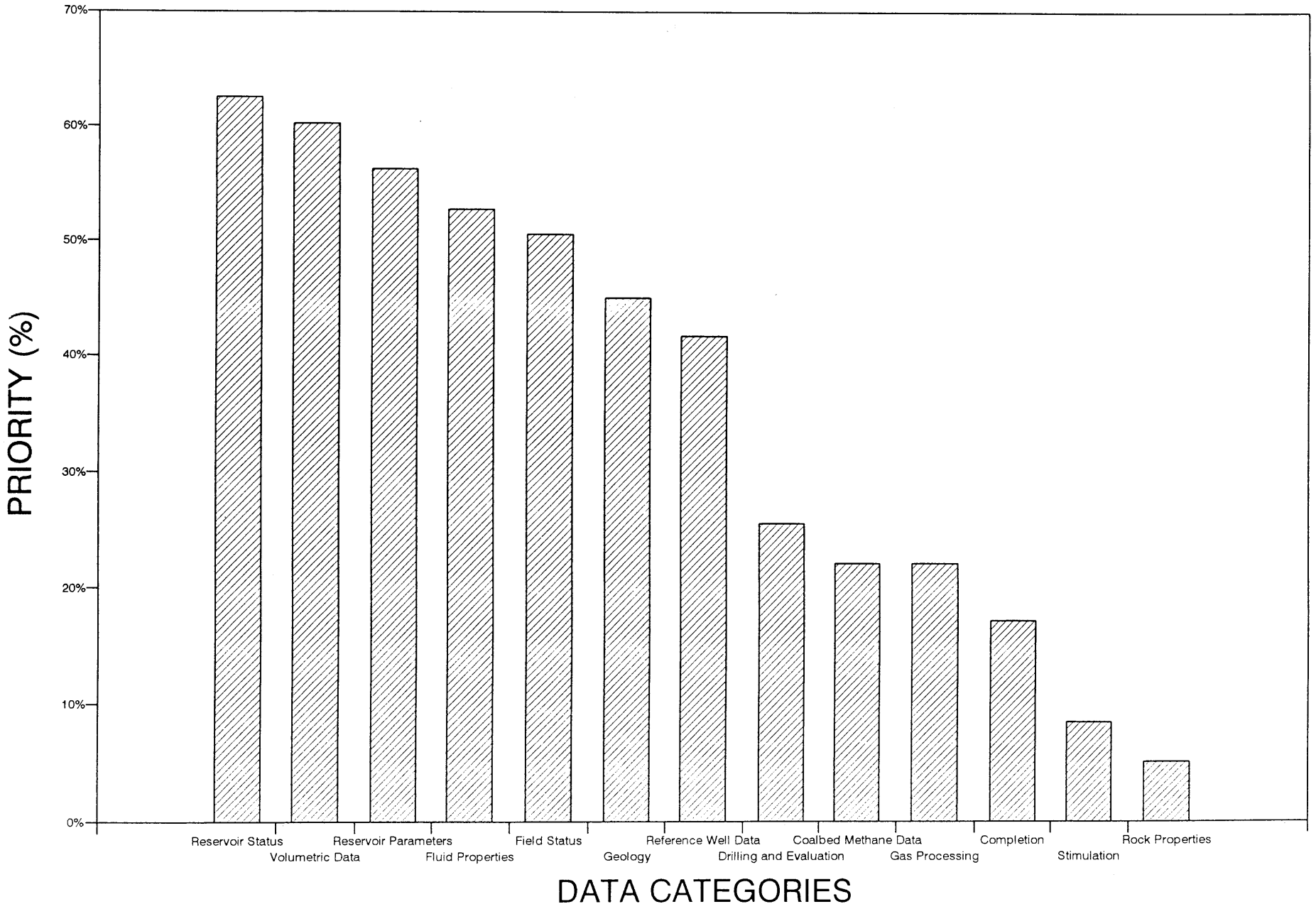
Figure 4-1 summarizes priorities by data category using the recommendations of all respondents. Data categories are ranked from highest to lowest. The percentage plotted on the vertical axis is the percentage of positive responses to the data elements within each group. Responses were tabulated for the 13 categories shown. Excluded were the first two groups listed above containing reservoir identification, location, and descriptive information ("Field and Reservoir Identification" and "Reservoir - General").

The purpose of presenting this chart is to show the general importance assigned to various types of data. The precise ranking of these categories is not important.

The highest priority categories are reservoir status, volumetric (production) data, reservoir engineering data, gas and fluid properties, field status and information, geological parameters, and reference well information. Ranked lower in priority were drilling and evaluation, coalbed methane, gas processing, and completion data. The lowest priority categories were stimulation data and rock properties.

FIGURE 4-1

GASIS PRIORITIES BY DATA CATEGORY
(ALL USER GROUPS)



It should be emphasized that the data shown in Figure 4-1 are based upon a summation of the responses to all potential data elements in each category. Thus, if a category contains many data items that were not considered important, the entire category would be shown as having low priority. As an example, the overall "stimulation" category is shown as having a low priority. However, as will be discussed below, identification of stimulated reservoirs (one of the elements in this category) is given a relatively high priority.

Most potential users consider the reservoir engineering parameters and basic geological parameters as the most important components of the GASIS database. Especially critical are the data elements allowing estimation of reservoir volume. Most users also agreed that the geological play definition will be extensively used for reservoir analog development.

Field and reservoir status is given a high priority because this category allows an analyst to evaluate the producing status and number of wells in a reservoir or play. Some basic information on field size and type would allow evaluation of the nature of the fields in which the GASIS reservoirs occur.

The volumetric data category, including cumulative production, estimated reserves, and ultimate recovery, was rated as a very important component. The gas atlas projects have generally included only cumulative production, which can be used only as a coarse measure of reservoir size. Estimated ultimate recovery (cumulative production plus reserves) is much more valuable for evaluation of reservoir size distribution, discovery trends, and economic analysis.

A reference well section is important because it allows identification of the producing interval in a specific well, and provides a basis for estimating development economics.

Most respondents indicated that the GASIS database should not include an extensive amount of quantitative drilling, stimulation, and completion data because this information generally has limited usefulness at the reservoir (rather than the well) level. While an interest was expressed in

summary information for these categories, most respondents recommended avoiding a large effort to quantify historical practices.

4.3.2 Priorities by User Group

Figure 4-2 shows the analysis of priorities by potential user group. The sequence of data categories is the same as in the previous figure. Within each data category, the priorities of each of the five potential user groups are shown. The chart shows that all five user groups generally rated the first seven data categories shown as the most important. An exception to this is the low priority placed on "reference well data" by the major producers. (This result probably reflects the fact that large companies generally have access to commercial well-level databases). Figure 4-2 also shows that the independents placed a higher priority on drilling and completion data than other users.

4.3.3 Priorities by Data Element

Figure 4-3 shows the prioritization of individual data elements. The horizontal axis shows the percentage of positive responses to each data item. The data elements are shown in the order in which they appeared on the survey form. The following section explains why certain elements in each category are given low or moderate priority. In the discussion, "low priority" is 0 - 29 percent on Figure 4-3, "moderate priority" is 30 - 49 percent, and "high priority" is 50 percent or more.

Field Status

USGS field size class was only of moderate interest because it is a processed (and interpreted) value. Information on the gas pipeline system is of interest but would involve a substantial effort to obtain and is time dependent. Market area is also difficult to determine.

Geology

Depositional environment and heterogeneity and continuity information are highly interpretive. Because of this, they are not considered a high priority by many users. Despite this, most users would want us to include the classifications from the gas atlas projects. Heterogeneity type is

FIGURE 4-2

GASIS PRIORITIES BY DATA CATEGORY AND USER GROUP

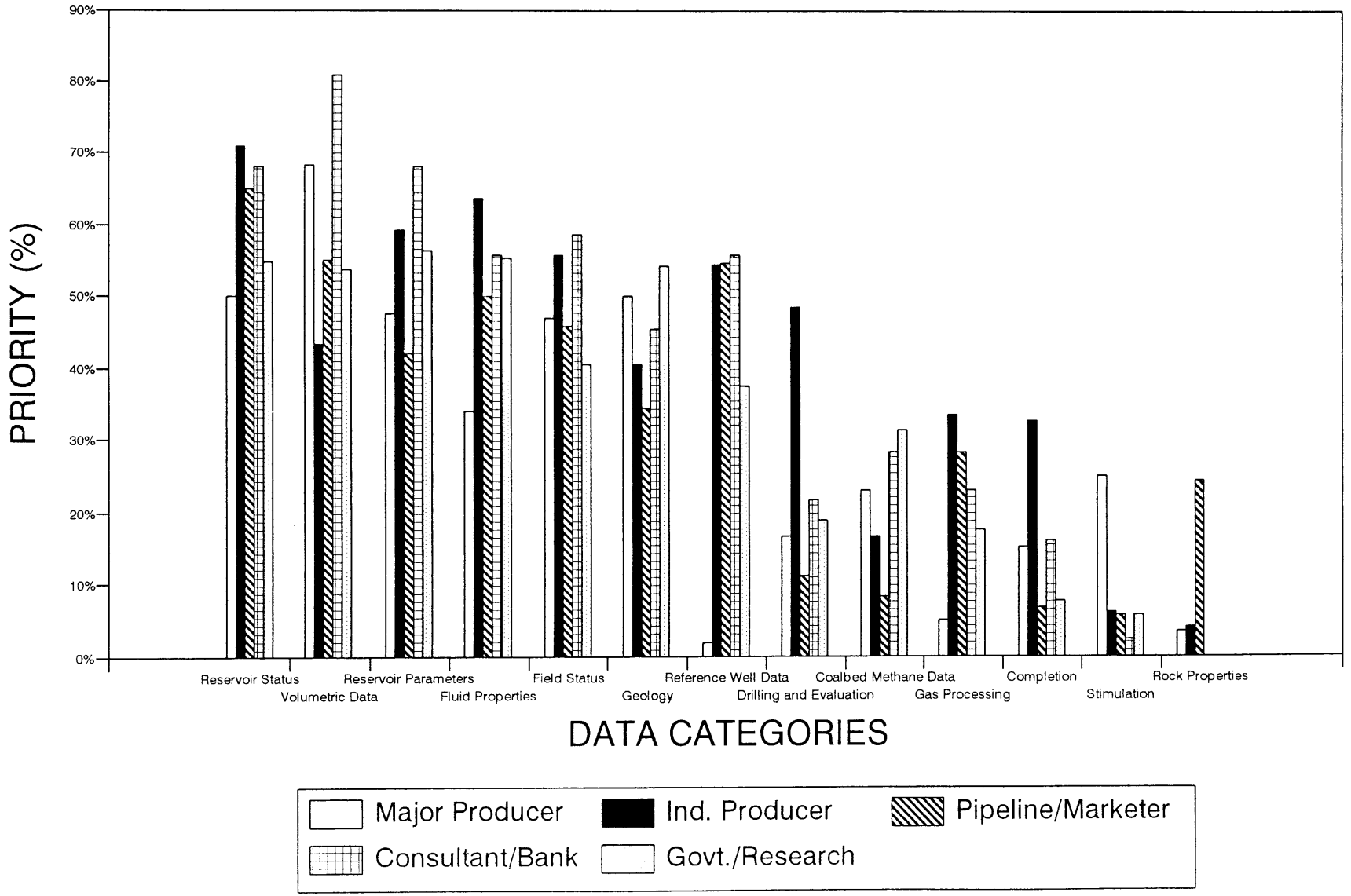


FIGURE 4-3

USER PRIORITIES FOR DATA ELEMENTS

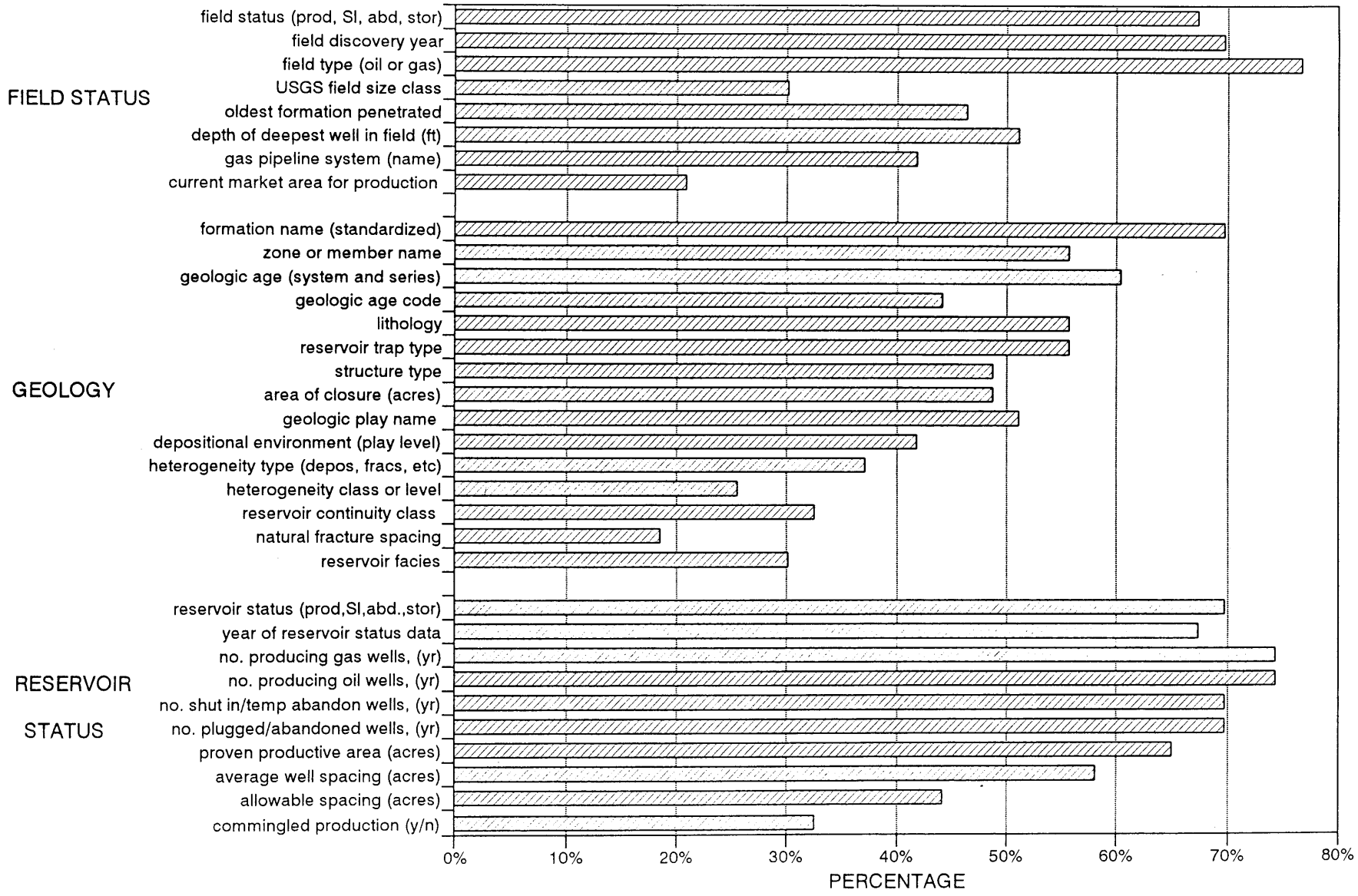


FIGURE 4-3 (Continued)

USER PRIORITIES FOR DATA ELEMENTS

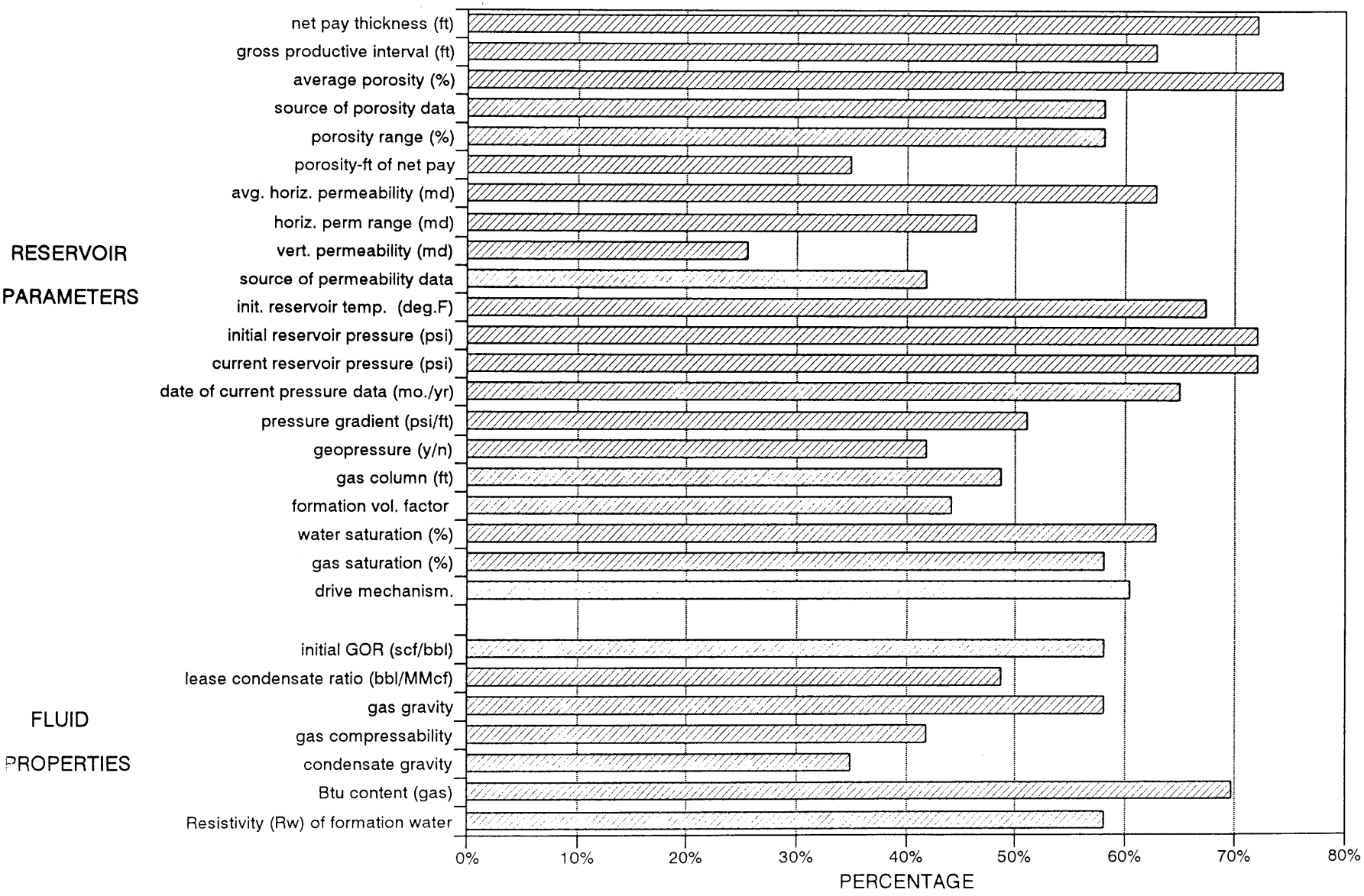


FIGURE 4-3 (Continued)

USER PRIORITIES FOR DATA ELEMENTS

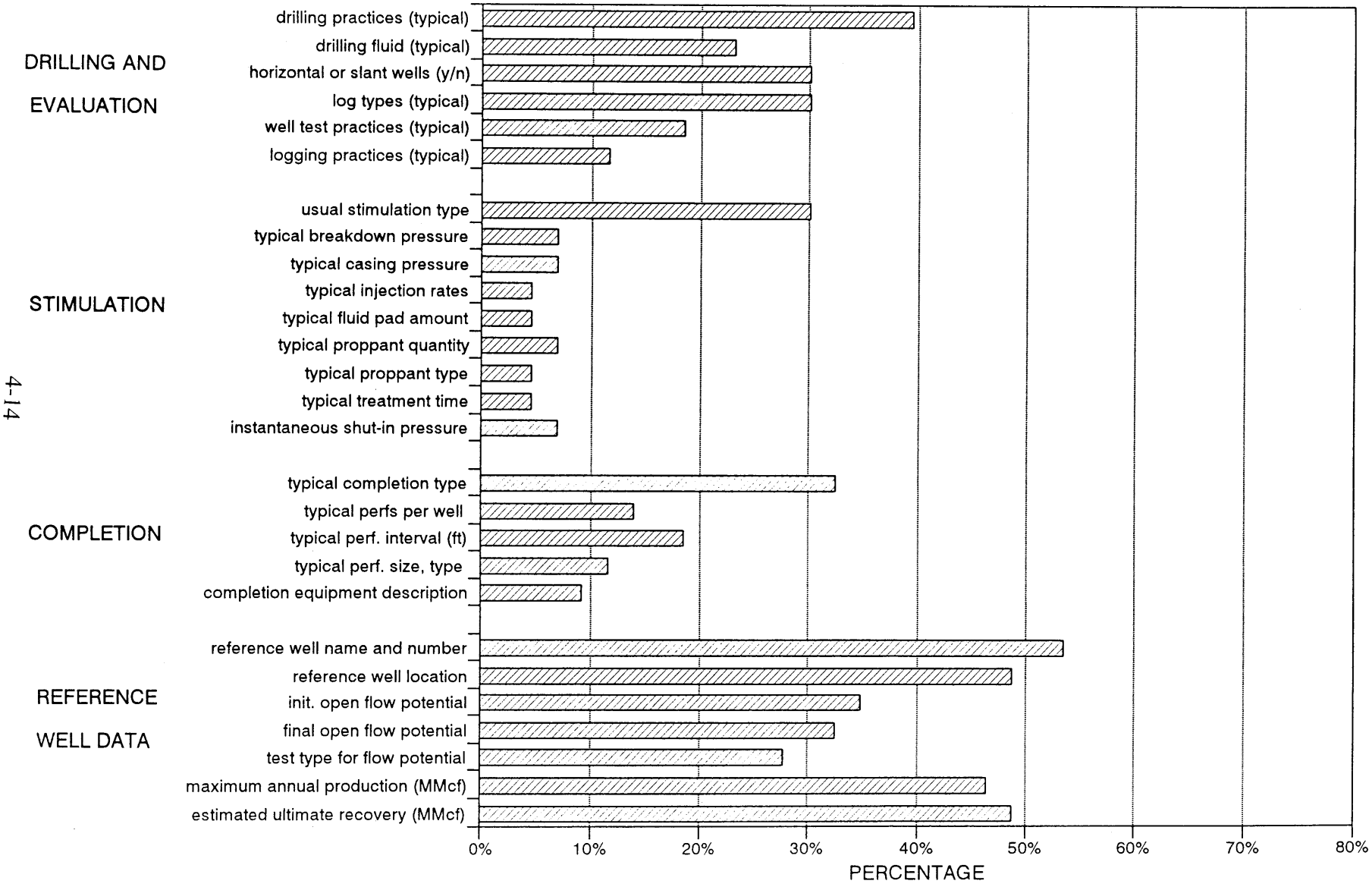
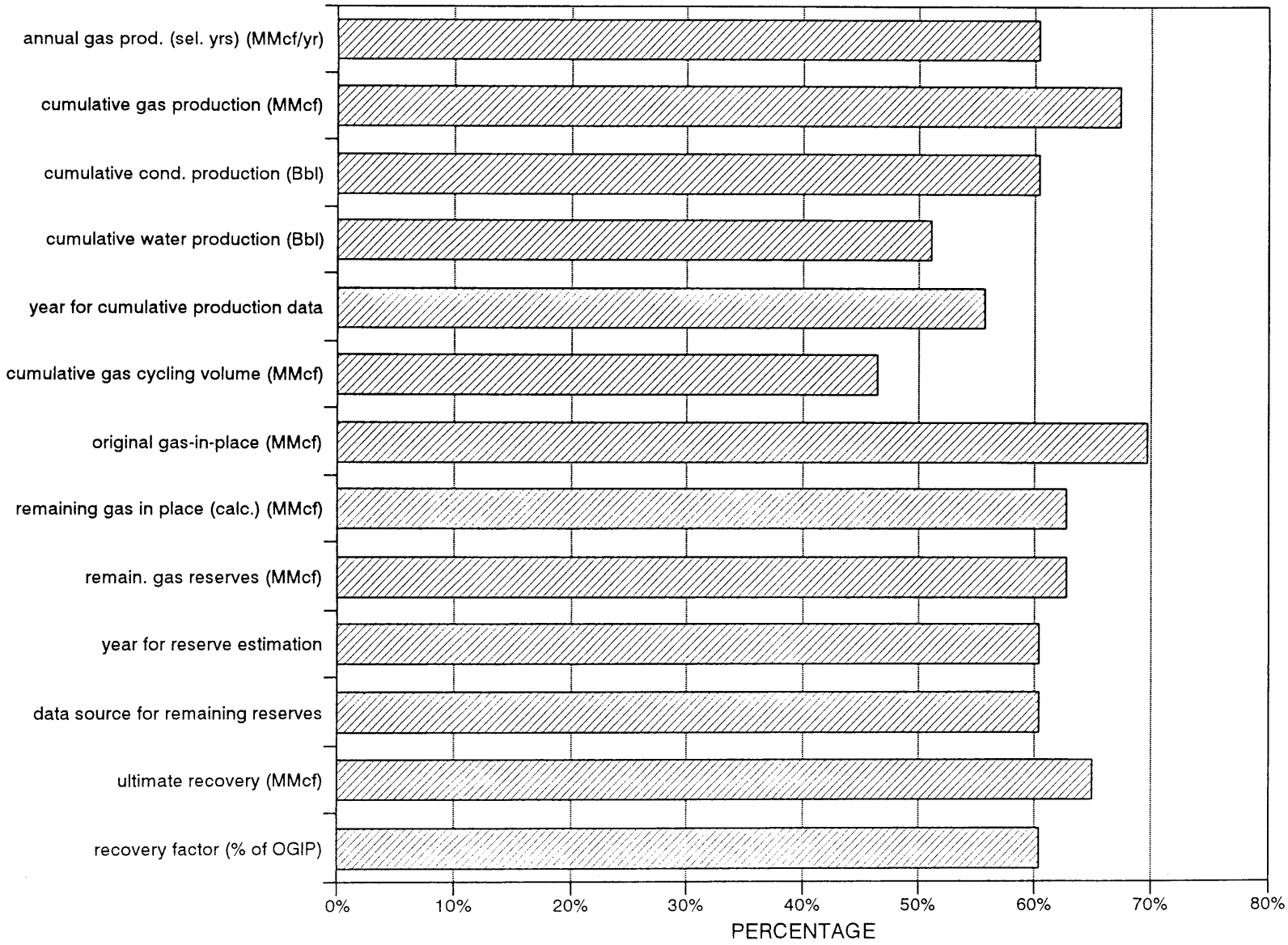


FIGURE 4-3 (Continued)

USER PRIORITIES FOR DATA ELEMENTS



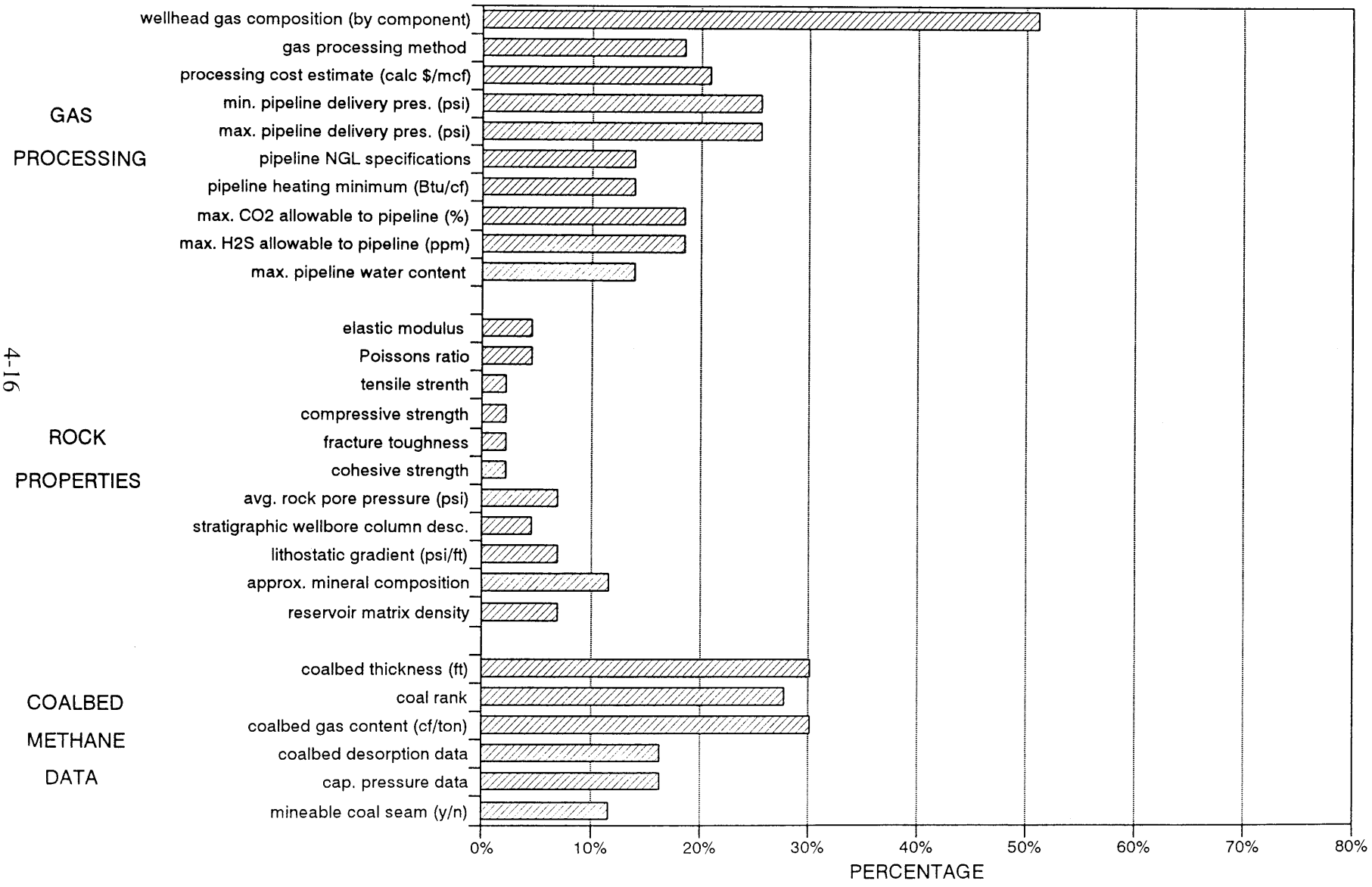
4-15

VOLUMETRIC DATA

G-40

FIGURE 4-3 (Concluded)

USER PRIORITIES FOR DATA ELEMENTS



considered less interpretive than heterogeneity class (or level). Reservoir facies was not covered by the gas atlas projects and is highly interpretive. Fracture spacing information is assigned a low priority because there is no known publicly available data source. Natural fracture spacing is very difficult to estimate in the subsurface.

Reservoir Status

The commingled production flag was rated as a relatively low priority. This variable is an indication of which reservoirs have production commingled with gas from other reservoirs.

Reservoir Parameters

Porosity-feet of net pay was assigned a moderate priority because it is a calculated value and therefore is not as useful as a measured value. Vertical permeability was given a low priority because there is no good data source.

Fluid Properties

Most of these are high priority elements.

Drilling and Evaluation, Stimulation, and Completion

As mentioned above, these categories were generally assigned relatively low priorities because this information has limited utility at the reservoir level, and the assignment of "typical" values would be interpretive and time-consuming to collect. Data elements with the lowest priorities were the quantitative elements, such as "typical breakdown pressure." However, the chart shows that there was a significant amount of interest the inclusion of summary information (the initial element) for each category.

Reference Well Data

Information on flow potential was considered less useful than maximum production or ultimate recovery estimates for the reference well.

Volumetric Data

Essentially all data elements proposed in this category were high priority.

Gas Processing

Detailed information on pipeline specifications was not considered useful for GASIS. Reasons cited include the difficulty of collecting the data at a relevant point on the pipeline (gathering system), and the time dependency of the data. As for gas processing, the major plants and their capacities are public information, but there is no known source of available data linking fields and reservoirs with processing facilities or processing method.

Rock Properties

All elements were given a low priority because they are not commonly used and because there is no known available data source. The primary groups using this type of data are government and industry research labs and service companies such as Halliburton. It may be possible to obtain some of this information from government labs or major oil companies.

Coalbed Methane Data

Interest was expressed in the development of a separate coalbed methane database using information from GRI. EEA is currently evaluating the nature of available data. This type of aggregated information would be of greatest value for research, modeling, and planning groups.

4.3.4 Regional priorities

The survey section on regional priorities was included to help us prioritize supplemental data collection activities, especially the reservoir studies. As expected, producers almost exclusively indicated high priorities for the regions in which they are active. While this information is of interest, it was decided not to tabulate these results, because they are highly dependent upon the specific list of companies surveyed. If a decision were made to prioritize some aspect of GASIS research on the basis of industry activity, it would be possible to use drilling statistics or other data.

Ideally, we wanted obtain input on regional database shortcomings that could be addressed by GASIS. One federal agency recommended an emphasis on data for the Appalachian basin because of the poor current state of oil and gas reservoir data in that area. Because of the severe data difficulties in this area however, we do not believe that a large GASIS effort in this basin (beyond incorporating the atlas data) would be worthwhile.

Other problematic regions for reservoir database development include South Louisiana, Oklahoma, and Kansas. Reservoir definition is a severe problem in these areas and will be addressed to the extent possible through GASIS reservoir studies or automated methods.

4.4 RECOMMENDED DATA ELEMENTS AND ORGANIZATION

4.4.1 General Recommendations

Identification and Linkage

GASIS should include all of the identification and location data that we can reasonably report. This should include reservoir codes from the major commercial data vendors.

Historical versus "Point in Time" Data

It is recommended that GASIS be developed as a static or "point in time" database, with all time dependent data reported only for a reference year.

Oil and Gas Production Data

Only summary oil and gas production data should be included. This will include cumulative production data and one year of annual data.

Field and Well Level Data

A minimal amount of information should be reported at the field or well level. GASIS should include almost exclusively reservoir level data.

Measured versus Interpreted Data

Interpreted data in GASIS should be minimized. However, interpreted data (such as depositional environment) that has already been collected by the gas atlases or elsewhere should be included.

Supplemental data collection efforts, including GASIS reservoir studies will emphasize measured data. The methodology for newly interpreted data must be documented.

Reserves and Ultimate Recovery

Reserves for each gas reservoir will be estimated using either a production decline method or a reserve-to-production ratio method.

4.4.2 Recommended Data Elements

Table 4-2 is the listing of recommended data categories and elements for the Reservoir Data System. The table includes the category name, data element name, definition, units, and best current data sources. Also included is an indication of the data elements to be collected in the reservoir studies and the data elements for which a data source will be reported.

There are 150 data elements in 19 categories shown on the table. When combined with 37 data source elements, there are currently 187 total entities.

4.5 CHANGES TO THE ORIGINAL DATA ELEMENT LIST

All significant changes to the original data element list are documented in Table 4-3. In general, data elements that have been removed from the original DOE list are those for which there is no known source of information, or for which the effort required to collect, process, or interpret the information was determined to be beyond the scope of the current project. New data elements include enhanced identification and location information, status information, geological information, reservoir parameters, a geologic type well section, and completion recovery statistics.

4.5.1 New Data Elements

Field and Reservoir Identification, Location, Type and Status

- Unique GASIS reservoir code. Will allow better manipulation of GASIS records and data.
- Commercial vendor codes. Will allow for linkage of GASIS data and commercial reservoir data.

TABLE 4-2
RECOMMENDED DATA ELEMENTS

GASIS DATA ELEMENTS

09/06/94

Category	GASIS Data Element (* = GASIS reservoir study element) (# = data source will be tracked)	Definition	Units	Best Sources
Field/reservoir identification	field name	DOE field name		TOTL "FIELD"
	field code	DOE field code		TOTL "FLDCODE"
	reservoir name	reservoir name		TOTL "RESERV"
	GASIS reservoir code	unique GASIS code		NEW GASIS CODE
	gas atlas play name	gas atlas geologic play name		TOTL,ATLAS
	play code	gas atlas geologic play code		ATLAS
	subplay name	gas atlas subplay name		ATLAS
	subplay code	gas atlas subplay code		ATLAS
	Dwight's reservoir code	Dwight's reservoir code		TOTL, DOGR
	other vendor reservoir code	other vendor reservoir code		vendors
Field/reservoir location	state	state name		TOTL "STATE"
	state postal code	two character state postal code		TOTL "STCODE"
	API state code	two digit API state code		"DWIGHTS"
	county	county, parish, offshore area		TOTL "COUNTY"
	county code	API county code		TOTL "COCODE"
	district	state regulatory district		TOTL "REGDIST"
	basin name	AAPG basin name		TOTL "GEOBASIN"
	basin code	AAPG basin code		TOTL "BASCODE"
	latitude	field latitude	degrees	from Atlas as available
	longitude	field longitude	degrees	from Atlas as available
Reservoir type	reservoir designation	state reservoir designation (O, G, OG)		TOTL
	atlas gas type	gas type (non-assoc., assoc., casinghead)		ATLAS
	cycled gas reservoir	cycled gas reservoir	y/n	ATLAS
	unitized reservoir	unitized reservoir	y/n	ATLAS
	prorated reservoir	prorated reservoir	y/n	ATLAS
	tight gas reservoir flag	tight reservoir (or tight formation/area) flag	y/n	EEA/GRI database
	coalbed methane flag	coalbed reservoir flag	y/n	TOTL "CBMETH," DOGR
	shale gas flag	Devonian shale reservoir flag	y/n	ATLAS

TABLE 4-2
RECOMMENDED DATA ELEMENTS
(Continued)

07/22/94

Category		GASIS Data Element (* = GASIS reservoir study element) (# = data source will be tracked)	Definition	Units	Best Sources
Field information and status		field status	field status (producing, abandoned, inactive)		TOTL (multiple categories)
		field discovery year	field discovery year		TOTL "YRDISC"
		field type	field type designation (state agency)		TOTL "OIL", "GAS", "ASSOC"
		USGS field size class	USGS field size class including growth	1-20	EEA
	*	reference elevation	reference elevation (sea level datum)	feet	TOTL "FELEV"
	*	reference elevation type	reference elevation type		res. studies
		categories:			
		- kelley bushing	KB		
		- ground	GR		
		- derrick floor	DF		
		offshore water depth	offshore water depth	feet	ATLAS, MMS
Geology		formation name	producing formation name		TOTL "PRODFOR"
		zone or member name	producing zone or member name		TOTL "ZONE"
		geologic era	geologic era name		TOTL "ERANM"
		geologic system	geologic system name		TOTL "SYSNM"
		geologic series	geologic series name		TOTL "SERNM"
		geologic age code	three digit USGS age code		TOTL "GEOLAGE"
	#	general lithology	general lithology of reservoir		R.M. ATLAS, specific lithologies
		- siliciclastic	SC		
		- carbonate	CB		
	* #	specific lithology	specific lithology of reservoir		ATLAS, TOTL ".LITHOL" ".CHEM"
		- conglomerate	CONG		
		- sandstone	SAND		
		- siltstone	SILT		
		- shale	SH		
		- chert	CHER		
		- arkose	ARK		
		- siliciclastic undiff.	SILI		
		- carbonate mudstone	MDST		
		- carbonate wackestone	WACK		

TABLE 4-2
RECOMMENDED DATA ELEMENTS
(Continued)

07/22/94

Category	GASIS Data Element (* = GASIS reservoir study element) (# = data source will be tracked)	Definition	Units	Best Sources
	- carbonate packstone	PACK		
	- carbonate grainstone	GRAN		
	- carbonate boundstone	BOUN		
	- dolostone	DOLO		
	- chalk	CHLK		
	- limestone undifferentiated	LS		
	- carbonate undifferentiated	CARB		
	- coal	COAL		
	* # general reservoir trap type	general reservoir trap type		ATLAS, TOTL
	- structural	STRUC		ATLAS, TOTL
	- stratigraphic	STRAT		ATLAS, TOTL
	- combination	COMB		ATLAS, TOTL
	* # structural trap type	structural trap type		ATLAS, TOTL
	- anticline/dome	A		ATLAS, TOTL
	- fault	F		ATLAS, TOTL
	- nose	N		ATLAS, TOTL
	- faulted anticline	FA		ATLAS, TOTL
	- faulted nose	FN		ATLAS, TOTL
	- salt dome	SD		ATLAS, TOTL
	- fracture	FR		ATLAS, TOTL
	- structural undesignated	SC		ATLAS, TOTL
	* # stratigraphic trap type	stratigraphic trap type		ATLAS, TOTL
	- facies change	FC		ATLAS, TOTL
	- unconformity	U		ATLAS, TOTL
	- reef	R		ATLAS, TOTL
	- lateral porosity change	LP		ATLAS, TOTL
	- chemical alteration	CA		ATLAS, TOTL
	- stratigrapic undesignated	SR		ATLAS, TOTL

TABLE 4-2
RECOMMENDED DATA ELEMENTS
(Continued)

GASIS DATA ELEMENTS

07/22/94

Category		GASIS Data Element (* = GASIS reservoir study element) (# = data source will be tracked)	Definition	Units	Best Sources
	#	depositional environment	depositional environment of reservoir		ATLAS (Rockies, other?)
		- lacustrine	LACUS		
		- peritidal	PERIT		
		- shallow shelf	SHSHF		
		- shelf margin	SHMAR		
		- reef	REEF		
		- slope/basin	SLBAS		
		- basinal	BASIN		
		- eolian	EOL		
		- fluvial	FLUV		
		- alluvial fan	ALLUV		
		- delta	DELTA		
		- strandplain	STRAN		
		- shelf	SHELF		
	* #	vertical heterogeneity type	vertical heterogeneity type		reservoir studies
		- shale beds			
		- laminations			
		- carbonate beds			
		- tight streaks			
		- diagenetic porosity variation			
		- fractures			
	* #	vertical heterogeneity level	vertical heterogeneity level (high, mod. low)		reservoir studies
	* #	lateral heterogeneity type	lateral heterogeneity type		reservoir studies
		- reservoir facies changes			
		- primary porosity variation			
		- diagenetic porosity variation			
		- erosional discontinuities			
		- faults			
		- fractures			

TABLE 4-2
RECOMMENDED DATA ELEMENTS
(Continued)

07/22/94

Category		GASIS Data Element (* = GASIS reservoir study element) (# = data source will be tracked)	Definition	Units	Best Sources
	* #	lateral heterogeneity level	lateral heterogeneity level (high, mod., low)		reservoir studies
		biozone	gas atlas biozone (Gulf Coast)		ATLAS
Reservoir status and completion counts		reservoir discovery year	reservoir discovery year	year	TOTL, DOGR
		reservoir status	reservoir status (producing, inactive)		TOTL
		producing gas completions	number of completions producing in 1994		DOGR
		total historical gas completions	total historical gas completions		DOGR
		inactive gas completions	number of inactive completions in 1994 includes shut in and abandoned)		TOTL, DOGR
Reservoir area and spacing		gas well productive area	historic area with gas well production (640 basis)	acres	DOGR (non-Texas), calculated
	#	published productive area	published productive area of reservoir	acres	ATLAS
		average gas well spacing	calculated average well spacing through 1994	acres/well	DOGR, calculated
	* #	allowable gas well spacing	predominant allowable spacing for reservoir	acres/well	reservoir studies, ATLAS
	*	allowable gas well spacing (high)	maximum allowable spacing for reservoir	acres/well	reservoir studies
	*	allowable gas well spacing (low)	minimum allowable spacing for reservoir	acres/well	reservoir studies
Reservoir parameters	* #	average reservoir depth	average measured depth to top	feet	res. studies, TOTL "DPTHTOP," ATLAS
	* #	average net pay thickness	average net pay thickness	feet	res. studies, TOTL, ATLAS
	* #	minimum net pay thickness	net pay range minimum	feet	res. studies, TOTL "MNTHICK"
	* #	maximum net pay thickness	net pay range maximum	feet	res. studies, TOTL "MXTHICK"
	* #	gas saturated thickness	avg. thickness of gas saturated interval	feet	res. studies, TOTL "SIAVTHK"
	* #	average porosity	average porosity of pay interval	%	res. studies, TOTL "AVPOR," ATLAS
	* #	minimum porosity	porosity range minimum -net pay	%	res. studies, TOTL "LOPOR,"
	* #	maximum porosity	porosity range maximum -net pay	%	res. studies, TOTL "HIPOR"

TABLE 4-2
RECOMMENDED DATA ELEMENTS
(Continued)

07/22/94

Category		GASIS Data Element (* = GASIS reservoir study element) (# = data source will be tracked)	Definition	Units	Best Sources
	#	average permeability	average permeability of pay interval	millidarcies	TOTL "AVPERM," ATLAS
	#	minimum permeability	permeability range minimum	millidarcies	TOTL "LOPERM"
	#	maximum permeability	permeability range maximum	millidarcies	TOTL "HIPERM"
	* #	avg. reservoir temperature	avg. reservoir temperature	degree F	res. studies, TOTL "RESTEMP," ATLAS
	#	published initial res. pressure	published initial res. pressure	psi	TOTL "ORIPRES," ATLAS
	#	published initial res. pressure type	published initial res. pressure type		ATLAS
		- calc. from wellhead SIP	WHSIP		
		- drillstem test	DST		
		- bottom hole gauge SIP	BHPG		
		- unknown	UN		
		average initial res. pressure	average initial res. pressure (DOGR)	psi	DOGR calculated
		average current reservoir pres.	average current (1994) reservoir pres.(DOGR)	psi	DOGR calculated
		initial reservoir pres. gradient	initial reservoir pres. gradient (DOGR pres. data)	psi/ft	calculated
	* #	initial water saturation	initial water saturation (Sw)	%	res. studies, TOTL "H2OSAT," ATLAS
	#	drive mechanism.	reservoir drive mechanism		TOTL, ATLAS
		- gas cap	GC		
		- gravity segregation	GS		
		- solution gas	SG		
		- pressure depletion	PD		
		- water drive	WD		
		- combination	CO		

TABLE 4-2
RECOMMENDED DATA ELEMENTS
(Continued)

GASIS DATA ELEMENTS

07/22/94

Category		GASIS Data Element (* = GASIS reservoir study element) (# = data source will be tracked)	Definition	Units	Best Sources
Gas and fluid properties	#	gas gravity	specific gas gravity	API units	TOTL "NGSGRAV" "AGSGRAV"
	#	liquid hydrocarbon gravity	liquid hydrocarbon gravity	API gravity	DOGR, TOTL
	* #	measured resistivity of produced water	measured resistivity of produced water	ohm-meter	res. studies, TOTL "OHM"
	* #	temp. of water @ measured resistivity	temp. of water @ measured resistivity	degree F	res studies, TOTL "TRES"
	* #	salinity of produced water	salinity of produced water	ppm	res studies, TOTL "SALIN"
Drilling and evaluation	*	drilling fluid	predominant drilling fluid used		well history data, res. studies
		- air	- AIR		
		- mud	- MUD		
		- oil based mud	- OM		
	*	intermediate casing	intermediate casing typically run	y/n	well history data, res. studies
		horizontal or directional wells	horizontal or directional wells in reservoir	y/n	TOTL "HRZNTL"
Stimulation data	* #	stimulated reservoir flag	indication of reservoir stimulation	y/n	res. studies, well history data
	* #	usual stimulation type	usual stimulation type		res. studies, RM Atlas
		- acid	- AC		
		- hydraulic fracture	- HF		
		- shot	- SH		
Completion data	* #	typical well completion type	predominant well completion method		res. studies, RM Atlas
		- open hole	- OH		
		- cased hole/perforated	- PER		
		- cased hole/abrasi-jet	- AJ		
		- slotted liner	-SL		
Type well data (gas reservoirs)	*	type well operator	geologic type well operator name		reservoir studies
	*	type well name	geologic type well name and number		reservoir studies
	*	type well API number	geologic type well API number		reservoir studies
	*	type well township	geologic type well township number		reservoir studies
	*	type well range	geologic type well range number		reservoir studies
	*	type well section	geologic type well section number	1-36	reservoir studies

TABLE 4-2
RECOMMENDED DATA ELEMENTS
(Continued)

GASIS DATA ELEMENTS

07/22/94

Category	GASIS Data Element (* = GASIS reservoir study element) (# = data source will be tracked)	Definition	Units	Best Sources
	* type well location	geologic type well location within section		reservoir studies
	* type well formation interval	formation interval in type well (meas. depth)	feet	reservoir studies
	- top of formation interval	- top of formation containing reservoir	feet	reservoir studies
	- base of formation interval	- base of formation containing reservoir	feet	reservoir studies
Median recovery well (gas reservoirs)	median well operator	median recovery well operator name		DOGR calculated (selected well)
	median well name	median recovery well name		DOGR calculated (selected well)
	median well API number	median recovery well API number		DOGR calculated (selected well)
	median well township	median recovery well township number		DOGR calculated (selected well)
	median well range	median recovery well range number		DOGR calculated (selected well)
	median well section	median recovery well section number	1-36	DOGR calculated (selected well)
	median well location	median recovery well location within section		DOGR calculated (selected well)
	median well interval	completion interval in median recovery well	feet	DOGR calculated (selected well)
	median well completion year	completion year of median recovery well	yr	DOGR calculated (selected well)
Completion recovery statistics (gas reservoirs)	number of completions evaluated	number of completions evaluated	no	DOGR (calculated)
	mean recovery/completion	mean recovery/completion (estimate)	MMcf	DOGR (calculated)
	median recovery/completion	median recovery/completion (estimate)	MMcf	DOGR (calculated)
	minimum recovery/completion	minimum recovery/completion (estimate)	MMcf	DOGR (calculated)
	maximum recovery/completion	maximum recovery/completion (estimate)	MMcf	DOGR (calculated)

GASIS DATA ELEMENTS

TABLE 4-2
RECOMMENDED DATA ELEMENTS
(Continued)

07/22/94

Category		GASIS Data Element (* = GASIS reservoir study element) (# = data source will be tracked)	Definition	Units	Best Sources
Gas Volume Data (gas reservoirs)		annual gas production	annual gas production (1994)	MMcf	TOTL
		cumulative gas production	cumulative gas production through 1994	MMcf	TOTL
		cumulative liquid hydrocarbon prod.	cumulative liquid hydrocarbon prod. through 1994	Bbl	TOTL
		cumulative water production	cumulative water production through 1994	Bbl	TOTL
		liquid hydrocarbon ratio	initial producing liq. hydrocarbon ratio	bbl/MMcf	calculated
	#	published original gas-in-place	published original gas-in-place	MMcf	ATLAS
		non-assoc. gas reserves	estimated remaining gas reserves (1994)	MMcf	EEA calculated value
		non-assoc. ultimate recovery	cumulative production plus est. reserves	MMcf	EEA calculated value
Gas Volume Data (oil reservoirs)		annual assoc./diss. gas production	annual assoc./dissolved gas production (1994)	MMcf	TOTL
		cumulative assoc./diss. gas production	assoc./dissolved gas production through 1994	MMcf	TOTL
		initial gas/oil ratio	initial gas/oil ratio	cf/bbl	TOTL
Gas composition (field/formation)		methane	methane content	mole %	GRI/EEA Database
		ethane	ethane content	mole %	GRI/EEA Database
		propane	propane content	mole %	GRI/EEA Database
		butane	butane content	mole %	GRI/EEA Database
		pentane	pentane content	mole %	GRI/EEA Database
		hexane-plus	hexane-plus content	mole %	GRI/EEA Database
		H2S	H2S content	mole %	GRI/EEA Database
		CO2	CO2 content	mole %	GRI/EEA Database
		Nitrogen	Nitrogen content	mole %	GRI/EEA Database
		Helium	Helium content	mole %	GRI/EEA Database
		other	other components	mole %	GRI/EEA Database
		heating value	Heating value	BTU/cf	GRI/EEA Database

GASIS DATA ELEMENTS

TABLE 4-2
RECOMMENDED DATA ELEMENTS
(Continued)

07/22/94

Category	GASIS Data Element (* = GASIS reservoir study element) (# = data source will be tracked)	Definition	Units	Best Sources
Coalbed methane database	Field name	Field name		USGS, USBM, GRI DATA
(proposed separate database)	Reservoir name	Reservoir name		USGS, USBM, GRI DATA
(producing fields)	AAPG basin name	AAPG basin name		USGS, USBM, GRI DATA
	thickness of coal interval	thickness of coal interval		USGS, USBM, GRI DATA
	average net coalbed thickness (ft)	average net coalbed thickness (ft)	feet	USGS, USBM, GRI DATA
	number of producing seams	number of producing seams		USGS, USBM, GRI DATA
	average depth to top coal	average depth to top coal	feet	USGS, USBM, GRI DATA
	average vitrinite reflectance	average vitrinite reflectance	%Ro	USGS, USBM, GRI DATA
	apparent coal rank	apparent coal rank		USGS, USBM, GRI DATA
	coalbed gas content (cf/ton)	coalbed gas content (cf/ton)	cf/ton	USGS, USBM, GRI DATA
	number of coalbed completions	number of coalbed completions		DOGR (EEA)
	cumulative gas production	cumulative gas production	MMcf	DOGR (EEA)

TABLE 4-3

RECOMMENDED CHANGES TO ORIGINAL DATA ELEMENT LIST

Original Category	New Elements	Removed Elements	Comments on Removed Elements
Field/reservoir identification and location	Unique GASIS reservoir code	Section-township-range	Included in Median Recovery Well section
	Commercial vendor codes	OCS block number	Included with field name
	Latitude/longitude of median well		
Reservoir-general	Atlas gas type		
	Cycled gas reservoir		
	Unitized reservoir		
	Prorated reservoir		
Field information and status		Oldest formation penetrated	Could determine through processing
		Depth of deepest well	Could determine through processing
		Gas pipeline system	Beyond the scope of GASIS
		Market area for production	Beyond the scope of GASIS
Geology	Separate elements for era, system, and series	Structure type	Covered by trap type
	General lithology	Reservoir continuity class	Covered by heterogeneity
	General trap type	Natural fracture spacing	No data source
	Depositonal environment-reservoir	Reservoir facies	Covered by depositional environment
	Vertical heterogeneity type and level	Depositional environment-play level	Sometimes included in play name
	Lateral heterogeneity type and level	Heterogeneity type and level	Now reported as "vertical" or "lateral" heterogeneity type and level

TABLE 4-3
(Continued)

RECOMMENDED CHANGES TO ORIGINAL DATA ELEMENT LIST

Original Category	New Elements	Removed Elements	Comments on Removed Elements
Reservoir status	Total historical gas completions	Number of producing oil wells	Only available by lease
	Inactive gas completions	Number of plugged and abandoned wells	Now included with inactive completions
	Gas well productive area (calculated)		
	Average gas well spacing (calculated)		
	Allowable spacing (high)		
	Allowable spacing (low)		
Reservoir parameters	Minimum and maximum net pay	Porosity-feet of pay	Calculated value
	Gas saturated thickness	Vertical permeability	No significant data source
	Published initial pressure type	Geopressure flag	Covered by pressure gradient
	Average initial pressure (calculated)	Gas column height	No compiled source
	Average current pressure (calculated)		
Gas and fluid properties	Temperature for water resistivity		
	Salinity of produced water		
Drilling and evaluation	Drilling fluid type	Typical drilling practices	No compiled source
	Intermediate casing flag	Typical log types	No compiled source
		Typical logging practices	No compiled source
		Typical well test practices	No compiled source
Stimulation	Stimulated reservoirs flag	All except usual stimulation type	No compiled source

TABLE 4-3
(Continued)

RECOMMENDED CHANGES TO ORIGINAL DATA ELEMENT LIST

Original Category	New Elements	Removed Elements	Comments on Removed Elements
Completion		All except typical well completion type	No compiled source at reservoir level
Reference well (now Type Well)	Operator Formation interval	Initial open flow potential Final open flow potential Test type for flow potential Maximum annual production	Geologic Type Well category does not include flow potential or recovery
Median recovery well (new category)	All		
Completion recovery statistics (new category)	All		
Volumetric Data		Cumulative gas cycling volume Remaining gas-in-place Recovery factor	Poor data sources Current G.I.P. data too poor Current G.I.P. data too poor
Gas Composition		All except gas composition and heating value	
Coalbed methane database	Field name Reservoir name AAPG Basin name Average net coalbed thickness Number of producing seams Average depth Vitrinite reflectance Number of completions Cumulative gas production	Description data Capillary pressure data Minable coal seam	Scope and content of coalbed database has not yet been finalized

TABLE 4-3
(Concluded)

RECOMMENDED CHANGES TO ORIGINAL DATA ELEMENT LIST

Original Category	New Elements	Removed Elements	Comments on Removed Elements
Rock Properties		All	No compiled source has been identified. Category will be included if source is identified

- Latitude/longitude. The lat/long of a selected well in the reservoir will enhance the capabilities of displaying information from GASIS
- Atlas gas type. The "BEG" atlas projects have classified reservoirs as non-associated, associated gas, gas well associated gas, and casinghead gas. This is different from the Dwight's classification.
- Cycled, unitized, and prorated reservoir flags. This information will come from the atlas projects.

Geology

- General lithology. A processed element using the specific lithology data.
- General trap type. A processed element using the specific trap data.
- Depositional environment (reservoir). This is available from the Rocky Mountain atlas.
- Vertical heterogeneity type and level. This will be included in the reservoir studies.
- Lateral heterogeneity type and level. Included in the reservoir studies.

Reservoir Status, Completion Counts, Reservoir Area, and Spacing

- Total historical gas completions. Determined using Dwight's database
- Inactive gas completions. Determined using Dwight's database.
- Gas well productive area (calculated). The sum of the productive sections (square miles) in the reservoir.
- Average gas well spacing (calculated). Calculated from the area and number of historical completions.
- Allowable spacing (high and low). Included in the reservoir studies.

Reservoir Parameters and Fluid Properties

- Minimum and maximum net pay. Included in the reservoir studies.
- Gas saturated thickness. Included in the reservoir studies.
- Published initial pressure type. Taken from the atlas datasets where available
- Average initial and current pressure (calculated). A method will be developed to determine or estimate the initial and current pressures from the information in Dwights database.
- Temperature for water resistivity. Included in the reservoir studies and taken from the Dwights database.

- Salinity of produced water. Taken from the Dwights database.

Drilling and Evaluation, Stimulation, and Completion

- Drilling fluid type. Included in the reservoir studies.
- Intermediate casing flag. Included in the reservoir studies.
- Stimulated reservoir flag. To be developed using automated database methods.

Reference Well

- Geological type well data. A type well will be selected for each studied reservoir.
- Median recovery well data. Identification of the "typical" recovery well in the reservoir, based upon GASIS reserve and recovery estimates.

Completion Recovery Statistics

- Completion recovery statistics. Determined using GASIS reserve estimates and statistical methods.

Coalbed Methane

- Coalbed methane data. Information at the reservoir level for selected coalbed gas reservoirs.

4.5.2 Data Elements Removed from GASIS

Field and Reservoir Identification, Location, Type, and Status

- Section-township-range information for reservoir - This information is now provided for the Median Recovery Well
- OCS Block Number - Now included with field name
- Oldest formation penetrated - The information we have on this is not current. Obtaining current information would require processing and it was determined this would not be within the scope of the project.
- Depth of deepest well - Same explanation as Oldest Formation (see above)
- Gas pipeline system - This is beyond the scope of the current project.
- Market area for production - This is beyond the scope of the project.

Geology

Structure type - This is now covered by reservoir trap type

Reservoir continuity class - Continuity refers to the same property as heterogeneity, which is included in GASIS

Natural fracture spacing - No significant source of compiled information is available.

Reservoir facies - This is covered by Depositional Environment, which comes from the Rocky Mountain and possibly other atlases.

Depositional environment (play level) - This information is not currently compiled. To collect it would require a geological review and interpretation of the gas atlas writeups and is considered beyond the scope of the current project. We have included depositional environment at the reservoir level where data are available (Rockies)

Heterogeneity type and level - This is now reported as "vertical" or "lateral" heterogeneity in the GASIS reservoir studies.

Reservoir Status

- Number of producing oil wells - This is available at the lease level only, not at the reservoir level.
- Number of plugged and abandoned wells (completions) - With the Dwights production databases, we cannot differentiate plugged and abandoned completions from shut-in completions. It is possible to estimate the number of each by looking at the length of time the wells have been inactive. In the database, we will report "inactive completions."

Reservoir Parameters and Fluid Properties

- Porosity-feet of net pay - This is a calculated value
- Vertical permeability - There is no significant data source for this information.
- Geopressure flag - This information is covered by Pressure Gradient
- Gas column height - There is no compiled data source. This would require new research/interpretation. Possible to estimate using subsea depths of completions.

Drilling and Evaluation, Stimulation, and Completion

- Typical drilling practices - There is no compiled source of this information at the reservoir level. A great deal of information is available at the well level and would have to be interpreted. GASIS reservoir studies are covering some types of drilling information.
- Typical log types and practices - No compiled sources at reservoir level, as above.

- Typical well test practices - No compiled sources at reservoir level, as above.

Reference Well Data

- Open flow potentials - The reference well category has been replaced with the Median Recovery Well section.

Volumetric Data

- Cumulative gas cycling volume - There are data sources for some of this information, but they are incomplete and it was determined that working with this information was not part of the current project.

Gas Processing and Composition

- Gas processing method - no compiled information available
- Pipeline delivery pressures and specifications - no compiled information available

Rock Properties

- Mechanical rock properties (such as compressive strength, etc.) - No compiled information at the reservoir level is available. An effort will be made in determine data availability of well level information.

Coalbed Methane

- The scope and content of the coalbed database has not been finalized.

5. GASIS SOFTWARE AND DATA EXCHANGE ISSUES

5.1 INTRODUCTION

The goal of this part of the user survey was to seek recommendations on software and data exchange capabilities for GASIS. The GASIS software development will be driven by user needs, for use with current technology available to all sizes of company. Survey participants were asked about the software and hardware they currently use, the importance of several possible GASIS features, and the convenience of the CD-ROM format. This section presents a detailed review of the responses, followed by recommendations.

5.2 USER NEEDS ASSESSMENT

5.2.1 Current Industry Database Management Software

Over 25 software packages were cited during the surveys. Lotus and Excel were the most common spreadsheet applications, while Paradox and dBASE were the most common database management systems. Applications ranged from the unsophisticated off-the-shelf packages on PCs to the more sophisticated proprietary systems on mainframe computers. The major companies supported the full range of hardware and software from PCs to the mainframe; some smaller organizations had only PCs with basic software. Besides spreadsheets and database systems, the types of software used included reservoir analysis software, geologic database systems, mapping packages, geographic information systems, client-server databases, and statistical applications. Access, Arc/INFO, Aries by Garrett, Vision by Dwight's, FoxPro, GeoGraphix, Grapher, Gypsy, Ogre by Cook, Oracle, PEP, Quattro Pro, Production Analyst by OGCI, SAS, Surfer, and Sybase were all mentioned during the survey. A few organizations also had their own proprietary software. DOS was the most common PC operating system; the MS-Windows environment was also common.

5.2.2 Current Industry Computer Hardware

Hardware selection is as varied as the software and ranges from the mainframe to the IBM PC/XT. Work stations, 386s, 486s, Macs, DEC and IBM Minis and mainframes are all used. Many companies had Local Area Networks with work stations. One large company uses a CD-ROM Server networked to their users. Most had access to CD-ROM Readers for the PC applications. Many users had access to the Dwight's CD-ROM databases and to Dwight's Vision on-line software. Many others had access to Petroleum Information's on-line software for well and production data.

5.2.3 Query and Reporting Capabilities for GASIS

Query, display, and report capabilities are necessary for GASIS to function as a stand-alone reference system. Without these capabilities, manipulation and analysis of GASIS data would require the use of separate database management software. While many potential GASIS users have access to commercial database software, survey participants agreed on the need for GASIS software to make the data more accessible and more widely used.

Some survey participants would use the GASIS CD-ROM exclusively as a stand-alone tool to query, display, and print reports. Others plan to use separate software to manipulate the data, but need to subset the GASIS data prior to exporting.

Most participants felt that basic query and reporting capabilities would be adequate. The software should allow the retrieval of database records using criteria applied to most of the data elements. Conditional criteria could be applied to numeric data elements. Basic reporting capabilities would include the generation of standardized listings of the records retrieved.

More sophisticated capabilities such as custom report generation were not considered necessary because most users would do this with commercial software.

5.2.4 Exporting Data From GASIS

Participants unanimously said data export from GASIS was very important. In general, ASCII Fixed and ASCII Delimited Formats would be acceptable. The ASCII Delimited Format includes field "delimiters" which allow data to be imported directly into spreadsheets without having to parse the data into columns. The Lotus (.WK1) and dBASE (.DBF) formats were also suggested. One participant felt ASCII was satisfactory but that direct transfer is best. Most of the software packages cited in the survey have the capability to import and export many formats including Lotus (.WK1), dBASE (.DBF), ASCII Fixed, and ASCII Delimited.

5.2.5 GASIS Format and Operating System

Almost all participants agreed that distribution of GASIS would be convenient on a CD-ROM, accessible by a PC/MS-DOS system. The CD-ROM format has a number of significant benefits when compared to traditional magnetic media. CD-ROM has a very high data capacity (equivalent to hundreds of floppy disks). Also, because the data remain on the CD, hard drive capacity limitation is not a problem. CD-ROM readers are less expensive and easier to use than sequential access tape drives.

5.2.6 Potential Graphical Data

Graphical information in a GASIS database is of interest to industry, but not a priority. Some types of scanned graphics are of interest, such as type logs and structure maps. A type log would be especially useful for reservoirs where there is uncertainty about the producing interval. Several suggested that a stratigraphic chart or column for each major basin or area would be very useful. Interviewees felt the graphics in the Gas Atlases should not be replicated. Several participants felt that the inclusion of graphics would not be worth the effort.

5.3 RECOMMENDATIONS

The basic guideline should be to design the product so all users can benefit - from the small independent who has limited resources to the integrated major using sophisticated systems.

5.3.1 Query and Reporting Capabilities

A key function of GASIS is the ability to search the database and select records for display, print, or export based on user criteria. The query capabilities will be powerful and easy to use. A menu-driven front end to the database engine will allow users to perform retrievals based on almost any of the data elements. A user will not need to know a language such as SQL to query the database.

Two types of screen display will facilitate inspection of records retrieved by a query. A summary screen display (one record per row) will enable the user to quickly browse through query results; a detail screen display (one data field per row) will allow on-screen inspection of every data element in the selected records.

Options for printed reports will also include detailed and summary styles. The summary report will be a tabular listing of reservoirs limited to data elements such as play, state, county, field, reservoir and depth. The detailed report will list every data element, and will be laid out in an attractive format with descriptive labels for all elements. The format of the reports will be fixed. Generation of custom reports will require the user to export GASIS data to other software packages.

5.3.2 Exporting Data from GASIS

Even though Lotus, Excel, Paradox, and dBASE are the most widely used applications, there are too many other packages used to provide a specific, direct transfer format for each. Therefore, it is recommended that two data export formats be available in GASIS: 1) an ASCII Fixed Format File (a text file) and 2) an ASCII Delimited File. These two ASCII formats can be directly imported by most packages.

EEA will also incorporate Lotus and dBASE export formats if this can be done with a reasonable effort.

5.3.3 GASIS Format and Operating System

GASIS should be distributed on CD-ROM for PC applications, and the software should be developed for MS-Windows. MS-Windows is currently used by many companies, and is likely to be the prevalent PC environment when GASIS is released in 1996. MS-Windows applications are generally easier to learn and operate than DOS applications. If a DOS version of GASIS is deemed necessary for compatibility with systems not able to run Windows, a simplified version of the application could be developed.

5.3.4 Graphical Data

Graphical data are not currently planned. However, if such information is included in GASIS in the future, the highest priority is a "type log" for those reservoirs included in the reservoir study project. The type log would show the reservoir interval in the "type well" selected for each reservoir study. The well name and location and producing interval would be identified. Other graphical data for future consideration include maps showing play outlines and the location of each reservoir, and a typical stratigraphic column for each play or selected area.

Appendix H.

Reservoir Study Summaries and Recommendations

GASIS PROJECT DOCUMENTATION REPORT

Contract Number: DE-AC21-93MC28139

February 1996

Gasis Project Documentation Report

The GASIS project has encompassed portions of 6 states and consists of 60 plays, 320 fields, and 539 reservoirs. For the purpose of this report, each GASIS Project Region has been separated according to how it was evaluated and is discussed based upon the unique parameters for that study area. The separate GASIS Project Regions are as follows:

Midcontinent Anadarko Basin of Oklahoma
Midcontinent Arkoma Basin of Oklahoma
Chatauqua Platform of Oklahoma
Texas District 10 - Texas Panhandle
East Texas - Districts 5 & 6
North Louisiana
Eastern Gulf Coast - Alabama and Mississippi
Greater Green River Basin of Wyoming

Play/Field/Reservoir selection criteria

The criteria used to select plays, fields, and reservoirs were applied uniformly throughout all the GASIS study areas. However, problems encountered with data availability, data coverage, and the ability to conduct cost effective reservoir studies varied by region. Although reservoir definition problems seem to be omnipresent, the degree of the problem varied significantly by reservoir (ultimately effected the play) and by region. Play/Field/Reservoir selection criteria were used at each scale to ultimately determine which plays should/could be evaluated. The availability and use of Dwight's Well Data, Production Data, and Petroleum Reservoirs Data allowed for the implementation of computers to determine the feasibility of certain reservoir studies. All GASIS size fields were evaluated prior to play selection. A computation containing cumulative production, total historic producing wells, and total historic wells since 1970 was a preliminary screen for field and play selection.

Dwight's used several criteria to select **plays** for reservoir evaluation. The criteria included:

Significance of Play (cumulative production)
: Plays with large cumulative production were given a priority status for reservoir evaluation.

Existing Atlas coverage of play
: Plays with most reservoir parameters missing were given a priority status (most beneficial to GASIS). Plays with data believed to be unreliable were also given a high priority.

Anticipated reservoir definition problems
: Plays with obviously vague reservoir definitions were given priority. Some plays would not be feasible under the budget constraints because of extreme reservoir definition problems therefore, they were omitted.

Tight Gas Plays

Tight gas plays were given a priority as requested by DOE

Estimated undiscovered reserves (future benefit)

Plays with substantial estimated undiscovered reserves were given a priority status. This criteria was based on under-explored geographical area. Dwight's felt this criteria was critical to future DOE applications for the GASIS database and for general industry acceptance.

Estimated play representation

The proportion of fields amenable to field studies was used as a criteria. High percentage plays were given priority.

Model Capacity

Dwight's placed a high priority on those for which statistically valid model data could be generated from a summary of the fields evaluated in the play.

Time effectiveness (cost)

The cost effectiveness of field studies in the play and relative impact on the GASIS database was the primary criteria used to select all potential plays.

Dwight's used several criteria to select **fields** for reservoir evaluation. The criteria included:

Significance of field (cumulative production)

Fields with large cumulative production were given priority status for reservoir evaluation.

Field well population (well count)

Fields with small total well counts were given priority status for reservoir evaluation. Some fields had too many wells to cost effectively evaluate versus the potential information gained.

Existing Atlas field data

Fields missing most of the reservoir parameters were given a priority status (most beneficial to GASIS). Fields with data judged unreliable were also given a high priority.

Anticipated reservoir definition problems

Fields with obviously vague reservoir definitions were given priority. Fields with suspect reservoir names were also given a priority status. However, some fields were not feasible under the budget constraints because of extreme reservoir definition problems therefore, they were omitted.

Tight Gas Plays

Tight gas fields were given a priority as requested by DOE.

Estimated reserves (future benefit)

Fields estimated to contain substantial reserves were given a priority status. This criteria included future infield drilling (development) potential. Dwight's felt these criteria were crucial to future DOE applications of the GASIS database and for general industry utilization.

Estimated well representation

The proportion of wells amenable to field studies was used as a criteria. Fields having a low percentage of usable wells were omitted from the list of potential studies.

Fields having multiple reservoirs were given a priority.

Fields having a majority of their wells drilled since 1965 were typically prioritized because density-porosity data was usually available. Fields having no recent logs were usually omitted.

Model Capacity

Dwight's placed a high priority on those fields for which reliable and statistically valid play data could be generated from a summary of the field data. It was the original intent of Dwight's to provide field data from which model data could be generated. The model data could then be used to replace missing reservoir parameters in other Atlas (or GASIS) fields within the play. Furthermore the model data could be used to test the reliability of the Atlas data prior to using for GSAM models.

Time effectiveness (cost)

The cost effectiveness of reservoir studies in a field and relative impact on the GASIS database was the primary criteria used to select all potential fields.

Dwight's used several criteria to select **reservoirs** for evaluation. The criteria included:

Significance of reservoir (cumulative production)

Reservoirs with large cumulative production were given priority status for reservoir evaluation.

Reservoir well population (well count)

Reservoirs with small total well counts were given priority status for reservoir evaluation. Some reservoirs had too many wells to cost effectively evaluate versus the potential information gained.

Existing Atlas reservoir data

Reservoirs missing most of the reservoir parameters were given a priority status (most beneficial to GASIS). Reservoirs with data judged unreliable were also given a high priority.

Reservoirs with obviously vague reservoir definitions were given priority. Reservoirs with suspect reservoir names were also given a priority status. However, some reservoirs were not feasible under the budget constraints because of extreme reservoir definition problems, therefore, they were omitted.

Tight Gas Plays

Tight gas reservoirs were given a priority as requested by DOE.

Estimated reserves (future benefit)

Reservoirs with substantial estimated reserves were given a priority status. This criteria included future infield drilling (development) potential. Dwight's felt these criteria were crucial to future DOE applications of the GASIS database and for general industry utilization.

Estimated well representation

The proportion of wells amenable to reservoir studies was a critical criteria. Reservoirs having a low percentage of usable wells were omitted from the list of potential studies. A usable well needed to have electric logs and scout tickets available as well as a known production history.

Model Capacity

Dwight's placed a high priority on those fields for which reliable and statistically valid play data could be generated from a summary of the reservoir data. It was the original intent of Dwight's to provide reservoir data from which model data could be generated. The model data could then be used to replace missing reservoir parameters in other Atlas (or GASIS) reservoirs within the play. Furthermore the model data could be used to test the reliability of the Atlas data prior to using for GSAM models.

Time effectiveness (cost)

The cost effectiveness of reservoir studies in a field and relative impact on the GASIS database was the primary criteria used to select all potential reservoirs.

Midcontinent Anadarko Basin of Oklahoma

The Midcontinent Anadarko Basin of Oklahoma is essentially the western half of Oklahoma. However, the true Anadarko Basin is much larger and spans across portions of three states. The structural elements that combine to make up the true Anadarko Basin and Shelf region are the Nemaha Uplift on the eastern edge, the Amarillo-Wichita Uplift to the south, the Cimarron Arch, Apishapa Uplift, and Las Animas Arch to the west, and the Central Kansas Uplift and Pratt Anticline to the north. The Anadarko Basin gently grades into the Hugoton Embayment of western Kansas and the boundary is essentially indistinguishable. Due to the enormity of the Anadarko Basin, only the Oklahoma portion was studied for this portion of the GASIS Project. The Kansas and Texas areas will be studied as funding becomes available.

The GASIS Project included reservoir characterization studies conducted within 15 of the 16 plays defined by the Atlas of Major Midcontinent Gas Reservoirs. These plays are as follows, with the plays subject to this study marked with an asterisk (*):

Permian [PM] Plays:

*PM-7 Wolfcampian Platform Dolostone - Amarillo-Wichita Uplift, Oklahoma

PM-8 Wolfcampian Shallow Marine Carbonate - Hugoton Embayment, Kansas and Oklahoma

*PM-9 Lower Permian Sandstone - Southern Oklahoma Folded Belt

Pennsylvanian [PN] Plays:

*PN-13 Pennsylvanian Alluvial-Fan and Fan-Delta Siliciclastics - Anadarko Basin, Oklahoma

*PN-12 Virgilian Deltaic Sandstone - Anadarko Basin, Oklahoma

*PN-16 Virgilian Shallow-Shelf Limestone - Hugoton Embayment, Kansas and Oklahoma

*PN-17 Missourian Shallow-Marine Sandstone - Anadarko Basin, Oklahoma

*PN-19 Des Moinesian Fluvial-Deltaic Sandstone and Shallow-Marine Limestone - Anadarko Basin, Oklahoma

*PN-21 Atoka Marine Sandstone - Anadarko Basin, Oklahoma

*PN-9 Morrow Sandstone - Anadarko Basin and Hugoton Embayment, Kansas and Oklahoma

*PN-26 Springer Marine Sandstone - Anadarko Basin, Oklahoma

Mississippian [MS] Plays:

*MS-4 Lower Chester Shallow-Marine Sandstone and Sandy Carbonate - Hugoton Embayment and Anadarko Basin, Kansas and Oklahoma

*MS-5 Upper Chester Shallow-Marine Carbonate - Anadarko Basin and Hugoton Embayment, Kansas and Oklahoma

*MS-6 Meramec-Osage Fractured Carbonate - Anadarko Basin, Oklahoma

Lower Paleozoic [SD and OR] Plays:

*SD-5 Siluro-Devonian Shallow-Marine Carbonate - Anadarko Basin, Oklahoma

*OR-5 Cambro-Ordovician Structures - Anadarko and Ardmore Basins, Oklahoma

Within the 15 plays studied, a total of 53 Fields involving 166 reservoirs were characterized.

Play Selection

Determination of which plays and fields to characterize were subject to several selection criteria:

1) Significance of play production.

2) Discovery date of the field. Old fields are notorious for poor and inconsistent data.

3) Number of wells drilled within a field since 1970. This increases the probability that a porosity tool was run in the borehole.

4) Availability of both resistivity and porosity surveys for a significant number of wells within a specific field. Both surveys are required to properly characterize the reservoir.

5) Play representation. A significant number of the fields must be available so that a statistically sound representation of the play can be characterized.

6) Reservoirs classified as tight gas reservoirs were given priority over reservoirs not classified as tight gas.

Play selection was designed to include a statistically significant, representative sample throughout the study area, both geographically and stratigraphically. In the Midcontinent Anadarko Region, the only play that was not characterized was Play PM-8. This play is the Chase Group of the Hugoton Embayment. It is so large and extensive that it accounts for 25% of the Midcontinent gas production. The prolific nature, areal extent, and potential stratigraphic complexity would require separate funding to adequately characterize the PM-8

Play. All other plays of the Midcontinent region were characterized.

Data Availability

The staff of Dwight's Energydata thoroughly researched the data availability, both quantity and quality, for the Midcontinent Anadarko Basin area. The Oklahoma City Geological Society Library, located in Oklahoma City, had the best and most complete log coverage for the study area. Virtually every log, except the ones not yet released, was available to the Dwight's staff. Scout tickets indicating completion, as well as re-completion information, were also available for all logs used in the study. Data for the Midcontinent Anadarko Basin is easily accessed and is in excellent condition.

Allocation Problems

Allocation problems in the Midcontinent Anadarko Basin region were significant. The producing formation is defined and reported by the operator of the well. There is no standard to which operators are held to correctly define the producing formation. Due to this lack of a standard, the formation names can end up as vague, elusive, or incorrect.

The first process that the Dwight's geological staff had to perform on each field that had 10 BCF cum production or greater reservoir was to create a grid work of stratigraphic correlations that could be applied to each producing horizon to ensure consistent and precise reservoir allocations throughout the field. This process was then gradually spread throughout the entire study area to be sure that reservoirs of a given age and/or formation in one field are the same age and/or formation in the next field. In this way a consistent, concise, and correct data base has been established for the GASIS characterization studies.

Virtually every Pennsylvanian, Mississippian, and Lower Paleozoic play had re-allocations. Approximately 40% of all the wells in the study area were re-allocated to a new reservoir. Some of these re-allocations resulted in the production for that well to change to a new and different play. In some fields this process would eliminate the Atlas identified 10 BCF reservoir and create a completely new, re-allocated 10 BCF reservoir of a different play designation. Because a GASIS type log was defined for each reservoir study, the actual producing interval can be reviewed. (See the GASIS Type Log Book)

Play Assignments

It is important to note that the above process enabled the Dwight's geological staff to identify 60 reservoirs that had not been assigned to Atlas plays and assign them the appropriate play code. The re-allocation process is a critical step in the GASIS field studies that can result in the identification of new GASIS size reservoirs and/or the removal of some reservoirs from a GASIS classification.

Future

Future work in the Midcontinent Anadarko Basin should include large amounts of effort on the PM-8 Play, the Wolcampian Shallow Marine Carbonate - Hugoton Embayment, KS and OK. This huge gas field has accounted for over 25% of the gas produced from the Midcontinent Anadarko Basin. Its age of discovery and size will make it a difficult task to undertake.

Less that 10% of the Morrow Play (PN-9) was evaluated. This play contains approximately 7 TCF of gas reserves, making it the second largest play in the Midcontinent Region. Additionally, a newly defined play, the Springer Carbonates, was created by recent advances in the allocation process due to the regional stratigraphic grid work. The Springer Carbonates contain about 1.2 TCF of proven recoverable reserves. The Midcontinent Anadarko Basin studies did not include any fields or reservoirs within this play. Studies in the Midcontinent region did not include OK Panhandle reservoirs.

The Kansas portion of the Midcontinent Anadarko Basin has been largely ignored to date. The reason for this is data availability. There is only one good source for Kansas data and it is the Kansas Geological Society Library in Wichita, Kansas. This is a "for profit" organization. The data are expensive to obtain compared to the other areas worked to date. Also, the data is in large scale, "field print" log format. These make regional correlations more difficult due to size, and log reproduction costs more expensive.

Recommendations

It is highly recommended that additional studies be conducted in the Midcontinent Region. Other than Texas and Louisiana, Oklahoma typically has more wells drilled than any other5 states combined. There exists considerable future potential for gas discoveries. Studies should include: A) Springer Carbonate Play, B) Permian Carbonates [PM-8], C) Additional Morrow studies, and D) Oklahoma Panhandle studies.

Midcontinent Arkoma Basin of Oklahoma

The Midcontinent Arkoma Basin of Oklahoma is the southern extension of the Chatauqua Platform shelf facies as it grades into the Arkoma Basin. The true Arkoma Basin covers portions of both Oklahoma and Arkansas. The structural elements that make up the Arkoma Basin are the Chatauqua Platform to the north and west, the Ouachita Mountain Uplift and Thrust belt to the south, and the Ozark Uplift to the northeast. The eastern limits are where the Ozark Uplift and the Ouachita Mountains converge. Due to the size of the Arkoma Basin only the Oklahoma portion was studied for this segment of the GASIS Project. The Arkansas Arkoma Basin will be studied as funding becomes available.

The GASIS Project included reservoir characterization studies conducted within all 6 of the plays defined by the Atlas of Major Midcontinent Gas Reservoirs. These plays are as follows:

Pennsylvanian [PN] Plays:

- PN-20 Des Moinesian Fluvial-Deltaic Sandstone - Arkoma Basin, Oklahoma and Eastern Kansas
- PN-22 Atoka Channel Submarine-Fan, and Transgressive Sandstone - Arkoma Basin, Oklahoma and Arkansas
- PN-23 Morrow Nearshore, Shallow-Marine Sandstone - Arkoma Basin, Oklahoma and Arkansas
- PN-24 Thrusted Spiro-Wapanucka Sandstone and Limestone - Arkoma Basin, Oklahoma
- PN-25 Morrow (Wapanucka) Shallow-Marine Carbonate - Arkoma Basin, Oklahoma

Lower Paeozoic [OR] Plays:

- OR-6 Lower Paleozoic Fault Blocks - Arkoma Basin, Oklahoma and Arkansas

Within the 6 plays of the Arkoma Basin a total of 18 fields involving 31 reservoirs were characterized.

Play Selection

Determination of which plays and fields to characterize were subject to several selection criteria:

1) Significance of play production.

2) Discovery date of the field. Old fields are notorious for poor and inconsistent data.

3) Number of wells drilled within a field since 1970. This increases the probability that a porosity tool was run in the borehole.

4) Availability of both resistivity and porosity surveys for a significant number of wells within a specific field. Both surveys are required to properly characterize the reservoir.

5) Play representation. A significant number of the fields must be available so that a statistically sound representation of the play can be characterized.

6) Reservoirs classified as tight gas reservoirs were given priority over reservoirs not classified as tight gas.

Play selection was designed to include a statistically significant, representative sample throughout the study area, both geographically and stratigraphically.

Data Availability

The staff of Dwight's Energydata thoroughly researched the data availability, both quantity and quality, for the Midcontinent Arkoma Basin of Oklahoma. The Oklahoma City Geological Society Library, located in Oklahoma City, had the best and most complete log coverage for the study area. Virtually every log, except the ones not yet released, was available to the Dwight's staff. Scout tickets indicating completion, as well as re-completion information, were also available for all logs used in the study. Data for the Midcontinent Arkoma Basin is easily accessed and is in excellent condition.

Allocation Problems

Allocation problems in the Midcontinent Arkoma Basin region were significant. The producing formation is identified and reported by the operator of the well. There is no standard to which operators are held to correctly define the producing formation. Due to this lack of a standard, the formation names can end up as vague, elusive, or incorrect altogether.

The first process that the Dwight's geological staff had to perform on each field that had 10 BCF cum production or greater reservoir was to create a grid work of stratigraphic correlations that could be applied to each producing horizon to ensure consistent and precise reservoir allocations throughout the field. This process was then gradually spread throughout the entire study area to be sure that reservoirs of a given age and/or formation in one field are the same age and/or formation in the next field. In this way a consistent, concise, and correct data base has been established for the GASIS characterization studies.

Virtually every Pennsylvanian and Lower Paleozoic play had re-allocations. Approximately 20% of all the wells in the study area were re-allocated to a new reservoir. Some of these re-

allocations resulted in the production for that well to change to a new and different play. In some fields this process would eliminate the Atlas identified 10 BCF reservoir and create a completely new, re-allocated 10 BCF reservoir of a different play designation. Because a GASIS type log was defined for each reservoir study, the actual producing interval can be reviewed. (See the GASIS Type Log Book)

Play Assignments

In the Midcontinent Arkoma Basin the above re-allocation process resulted in one reservoir that was changed to a different play.

Future

The Midcontinent Arkoma Basin is a large, prolific, predominantly gas prone basin that should have more reservoir characterization studies. Even though all the plays have representative characterization studies, the size of the Arkoma Basin suggests that a additional comprehensive studies should be conducted.

The Arkansas portion of the Arkoma Basin has not been studied at all and would require a separate research project of its own.

Chatauqua Platform of Oklahoma

The Chatauqua Platform (CP) of Oklahoma is essentially the northeastern quarter of Oklahoma. The structural elements that define the Chatauqua Platform are the Nemaha Uplift to the west, the McClain County Fault to the south, the Cherokee Basin of Kansas to the north, the Ozark Uplift to the northeast, and the Arkoma Basin to the southeast.

The Atlas of Major Midcontinent Gas Reservoirs does not attempt to distinguish the Chatauqua Platform from either the Anadarko Basin or the Arkoma Basin. It has arbitrarily assigned play classifications from either basin to the various reservoirs from the Chatauqua Platform. The geological staff at Dwight's Energydata were of the opinion that the reservoirs of the Chatauqua Platform can be assigned play classifications that designate them as specific Chatauqua Platform plays. The plays are defined as follows:

Pennsylvanian [PN] Plays:

MCPN-34 Des Moinesian Sandstone - Chatauqua Platform, Oklahoma

MCPN-36 Atokan Sandstone - Chatauqua Platform, Oklahoma

MCPN-38 Morrowan Sandstone - Chatauqua Platform, Oklahoma

Within the three plays studied, a total of 7 fields involving 13 reservoirs were characterized.

Play Selection

Determination of which plays and fields to characterize were subject to several selection criteria:

1) Significance of play production.

2) Discovery date of the field. Old fields are notorious for poor and inconsistent data.

3) Number of wells drilled within a field since 1970. This increases the probability that a porosity tool was run in the borehole.

4) Availability of both resistivity and porosity surveys for a significant number of wells within a specific field. Both surveys are required to properly characterize the reservoir.

5) Play representation. A significant number of the fields must be available so that a statistically sound representation of the play can be characterized.

6) Reservoirs classified as tight gas reservoirs were given priority over reservoirs not classified as tight gas.

Play selection was designed to include a statistically significant, representative sample throughout the study area, both geographically and stratigraphically. Nine of the eleven fields studied incorrectly appear in the Gas Atlas in either the Anadarko or Arkoma Basins. The Dwight's geological staff defined the plays and assigned the fields the new play codes for the Chautauqua Platform.

Data Availability

The staff of Dwight's Energydata thoroughly researched the data availability, both quantity and quality, for the Chatauqua Platform area. The Oklahoma City Geological Society Library, located in Oklahoma City, had the best and most complete log coverage for the study area. Virtually every log, except the ones not yet released, was available to the Dwight's staff. Scout tickets indicating completion, as well as re-completion information, were also available for all logs used in the study. Data for the Midcontinent Anadarko Basin is easily accessed and is in excellent condition.

Allocation Problems

Allocation problems in the Chatauqua Platform region were significant. The producing formation is defined and reported by the operator of the well. There is no standard to which operators are held to correctly define the producing formation. Due to this lack of a standard, the formation names can end up as vague, elusive, or incorrect altogether.

The first process that the Dwight's geological staff had to perform was to create a grid work of stratigraphic correlations that could be applied to each producing horizon to ensure consistent and precise reservoir allocations throughout the field. This process was then gradually spread throughout the entire study area to ensure that reservoirs of a given age and/or formation in one field were the same age and/or formation in the next field. In this way a consistent, concise, and correct data base has been established for the GASIS characterization studies.

Virtually every Pennsylvanian, Mississippian, and Lower Paleozoic play had re-allocations. Approximately 40% of all the wells in the study area were re-allocated to a new reservoir. Some of these re-allocations resulted in the production for that well to change to a new and different play. In some fields this process would eliminate the Atlas identified 10 BCF reservoir and create a completely new, re-allocated 10 BCF reservoir of a different play designation. Because a GASIS type log was defined for each reservoir study, the actual producing interval can be reviewed. (See the GASIS Type Log Book)

Play Assignments

It is important to note that the above process enabled the Dwight's geological staff to identify reservoirs that had not been assigned to Atlas plays and assign them the appropriate play code. The re-allocation process is a critical step in the GASIS field studies that can result in the identification of new GASIS size reservoirs and/or the removal of some reservoirs from a GASIS classification. In the Chatauqua Platform completely new and different play designations were defined by the Dwight's staff for all reservoirs characterized.

Future

Probably considered by many to be an oil prone area, the Chatauqua Platform has many 10 BCF gas reservoirs that are interspersed throughout the oil fields. It would be of interest to the GASIS Project to note that even in mature oil plays there are 10 BCF gas reservoirs that are still being developed. These reservoirs should be characterized to demonstrate their existence to the industry at large. Interestingly, some of these gas reservoirs are just now being developed because the gas market and/or gas transportation system were not in place when the original oil development took place. Now that markets are available the gas reservoirs are being exploited.

Texas District 10 - Texas Panhandle

Texas District 10, which is the Texas Panhandle, is the area that is north and east of the Amarillo Uplift, west of the Dalhart Basin and Cimarron Arch, and bounded by the State of Oklahoma. This region is the western portion of the Anadarko Basin as it extends from northwestern Oklahoma, through the Panhandles of Texas and Oklahoma, and eventually grades into the Hugoton Embayment.

The GASIS Project included reservoir characterization studies conducted within 5 of the 8 plays defined by the Atlas of Major Texas Gas Reservoirs. These plays are as follows, with the plays subject to this study marked with an asterisk (*):

Permian [PM] Plays:

PM-7 Wolfcampian Platform Dolostone - Texas Panhandle

PP-1 Permian/Pennsylvanian Shallow-Marine Carbonate and Siliciclastics - Texas Panhandle

Pennsylvanian [PN] Plays:

PN-9 Panhandle Morrow Sandstone

*PN-10 Pennsylvanian Shallow-Marine Carbonate - Texas Panhandle

*PN-11 Des Moinesian/Missourian Deltaic and Basinal Sandstone - Anadarko Basin

*PN-12 Virgilian Basinal and Deltaic Sandstone - Anadarko Basin

*PN-13 Pennsylvanian Fan-Delta Sandstone - Anadarko Basin

Lower Paleozoic [SD] Plays:

*SD-5 Pre-Pennsylvanian Shallow-Marine Carbonate

Within the 5 plays studied, a total of 50 fields involving 67 reservoirs were characterized.

Play Selection

Determination of which plays and fields to characterize were subject to several selection criteria:

1) Significance of play production.

2) Discovery date of the field. Old fields are notorious for poor and inconsistent data.

3) Number of wells drilled within a field since 1970. This increases the probability that a porosity tool was run in the borehole.

4) Availability of both resistivity and porosity surveys for a significant number of wells within a specific field. Both surveys are required to properly characterize the reservoir.

5) Play representation: A significant number of the fields must be available so that a statistically sound representation of the play can be characterized.

6) Reservoirs classified as tight gas reservoirs were given priority over reservoirs not classified as tight gas.

Play selection was designed to include a statistically significant, representative sample throughout the study area, both geographically and stratigraphically. In the Texas Panhandle region, the plays that were not characterized were PM-7, PP-1, and PN-9.

Plays PP-1 and PM-7 make up the Texas Hugoton and/or Texas Panhandle field. These plays are so large and extensive that, combined with the Oklahoma and Kansas portions of the Hugoton Embayment, they combine to create the largest gas field in the Continental United States. The prolific nature, areal extent, and potential stratigraphic complexity would require separate funding to adequately characterize the PP-1 and PM-7 Plays.

PN-9 is the Panhandle Morrow Sandstone play. This is the second largest producing play in the Panhandle region, after Play PP-1. This is potentially the most stratigraphically complex play in the Panhandle region. In the Texas Panhandle, the Morrow and Springer Groups do not appear to be correctly identified and the work previously conducted in the Oklahoma portion of the Anadarko Basin suggests that the Morrow and Springer producing horizons will prove to be a problem within the Texas Panhandle study area. The prolific nature, areal extent, potential stratigraphic complexity, and economic importance of the Panhandle Morrow Sandstone (PN-9) Play would require a separate study to adequately characterize.

Data Availability

The staff of Dwight's Energydata thoroughly researched the data availability, both quantity and quality, for the Texas Panhandle area. The Oklahoma City Geological Society Library, located in Oklahoma City, had the best and most complete log coverage for the study area. Virtually every log, except the ones not yet released, was available to the Dwight's staff. Scout tickets indicating completion, as well as re-completion information, were also available for all logs used in the study. Data for the Texas Panhandle is easily accessed and is in excellent condition.

Allocation Problems

Allocation problems are present in the Texas Panhandle. However, they are not as significant as compared to other areas studied. The producing formation is defined and reported by the operator of the well. There is no standard to which operators are held to correctly define the producing formation. Due to this lack of a standard, the formation names can end up as vague, elusive, or incorrect altogether. Also, because of the Texas Railroad Commission's reservoir naming conventions, Dwight's' geologists were limited in their freedom to correctly re-allocate production. Consequently, in the GASIS database the corrected producing reservoir is often different than the Texas Railroad Commission's defined reservoir.

The first process that the Dwight's geological staff had to perform on each field studied, was to create a grid work of stratigraphic correlations that could be applied to each producing horizon to ensure consistent and precise reservoir allocations throughout the field. This process was then gradually spread throughout the entire study area to ensure that reservoirs of a given age and/or formation in one field are the same age and/or formation in the next field. In this way a consistent, concise, and correct data base has been established for the GASIS characterization studies. Because a GASIS type log was defined for each reservoir study, the actual producing interval can be reviewed. (See the GASIS Type Log Book)

Play Assignments

Because of the Texas Railroad Commission's conventions for naming fields and reservoirs, and because the PN-9 Play was excluded from the Texas Panhandle study, there were relatively small amounts of re-allocations within the plays studied. The only re-allocations that were of any significance occurred in the SD-5 Play. In this play two new reservoirs were identified from geologic correlations and were re-allocated to a formation other than Hunton. However, these re-allocations remained within the SD-5 Play.

Future

Future work in the Texas Panhandle area must include extensive work on the PN-9, Panhandle Morrow Sandstone play. This stratigraphically complex reservoir is the second largest producing play in the Texas Panhandle and will continue to be an exploration/exploitation target for operators.

Future work in this study area would also require considerable work to be done on the largest producing play, Play PP-1, the Texas Panhandle/Hugoton Trend. The early discovery date, enormous number of wells, and large areal extent will require the PP-1 Play to be done as a separate study.

Recommendations

Drilling activities in the Texas Panhandle region are consistently higher than drilling activities for entire states. Only Oklahoma and Louisiana can generate enough drilling activity to record a higher rig count. A large portion of the drilling activity in the Texas Panhandle is focused on Morrow exploration. The Morrow Play [PN-9], is ranked as the eleventh largest play for the entire state of Texas by the Gas Atlas. To date, the Morrow has not been studied or characterized.

The largest gas play in the state of Texas is Play PP-1. This play is larger than the next three Texas plays combined. Play PP-1 is the Permian/Pennsylvanian Shallow-Marine Carbonate and Siliciclastics and it makes up the Texas Panhandle/Hugoton Trend. This play combines with the Guymon Hugoton and Hugoton Embayment to create the largest gas field in the Continental United States. The GASIS Project has not had the opportunity to evaluate and characterize any of these extremely prolific gas fields. The PP-1 Play needs to be studied.

EAST TEXAS, District 5 & 6

The East Texas Study Area (comprising Texas Railroad Commission Districts 5 & 6) is located in the Northeastern corner of Texas, bounded on the north by Oklahoma and on the east by Arkansas and Louisiana, and incorporating approximately 48,000 square miles. Progressing from the east to the west of the study area, the major structural elements include the Sabine Uplift along the east-central boundary dipping into the East Texas Basin with the Talco Fault Zone (in the north) and the Mexia Fault Zone (in the south) separating this basin from the Fort Worth Basin along the eastern Boundary.

The GASIS Project included reservoir characterization studies conducted within 8 of the 11 plays defined by the Atlas of Major Texas Reservoirs. These plays are as follow with the plays subject to this study marked with an asterisk (*):

Jurassic Carbonate (J) Plays:

*J-1 Smackover Shallow-Marine Carbonate

*J-2 Gilder-Haynesville (Cotton Valley Lime) Shallow-Marine Carbonate

Lower Cretaceous-Jurassic Sandstone (K) Plays:

*K-1 Travis Peak Formation-Cotton Valley Group Sabine Uplift Area

*K-2 Travis Peak Formation-Cotton Valley Group Salt Structures-Eastern Margin-East Texas Basin

K-3 Travis Peak Formation-Cotton Valley Group Salt Structures-Western Margin-East Texas Basin

Lower Cretaceous Trinity Group Carbonate Plays:

*KC-1 Sabine Uplift Area

*KC-2 Salt Structures-Eastern Margin-East Texas Basin

*KC-3 Salt Structures-Western Margin-East Texas Basin

Upper Cretaceous Sandstone Plays:

KS-1 Sabine Uplift Area

*KS-2 Salt Related Structures

KS-3 Downdip Shelf Margin

Within the 8 plays studied, a total of 73 fields involving 90 reservoirs were completed. These reservoirs contained more than 3,300 producing wells for an average well count/reservoir of

37 wells and a range of 1 to 600 wells/reservoir. The reservoirs studied ranged in discovery year from 1936 to 1989 with most discoveries having taken place in the 1960s and 1970s.

Play Selection

Selection of the reservoirs to study was designed to include a representative sample (both geographic and stratigraphic distribution) and a statistically significant number of the plays, fields and reservoirs. The three plays not included were considered either an extension of a very similar play that was studied or involved relatively minor amounts of production as compared to the plays that were evaluated. Additional selection parameters included:

1) Significance of play production.

2) Discovery date of the field; very old fields generally are lacking in the quality and quantity of data needed to do a valid reservoir characterization study.

3) Number of wells drilled in the field since 1970; newer wells have a greater likelihood of having a porosity tool available.

4) Availability of both a resistivity and porosity tool; both are required in a given borehole to do a valid reservoir characterization.

5) Play representation. A significant number of the fields must be available so that a statistically sound representation of the play can be characterized.

6) Reservoirs classified as tight gas reservoirs were given priority over those that were not tight gas.

Data Availability

The first step to any study is to research data availability and quality and the method of acquisition of such data. The staff of Dwight's Energydata thoroughly researched various data sources for both quantity and quality. For the East Texas Study Area, the Shreveport Petroleum Data Association (SPDA) located in Shreveport, Louisiana was the source which had the best coverage across the area of interest and could ship data to Oklahoma City, Oklahoma for use by the Dwight's staff.

Although there was wide variation, for most of the reservoirs studied, log and completion cards were available on less than half the wells. Additionally, on some of the available logs, the reservoir of interest was perforated as a recompletion and completion card data for such recompletion was often missing. Further, porosity logs (which are critical for complete reservoir characterization) were available on only a small portion (averaging approximately 25%) of the wells for which resistivity log and completion card data was available. As a result of data limitations, Dwight's staff used all the wells available which had the full suite of logs

(resistivity and porosity) and completion card data for reservoir characterization studies.

Further complicating the process, the logs received were in various scales with the porosity log usually on a detail scale of 20' to the inch while the resistivity log was usually on a small scale of 100' to the inch. This made the log analysis tedious but more importantly, when dealing with the type of reservoirs subject to this study, a resistivity log on a small scale is very difficult to accurately read and analyze.

However, the reservoir characterization studies which were completed did have enough data available and of high enough quality to insure their validity.

Allocation Problems

The East Texas Study Area had relatively minor allocation problems. The major stratigraphic divisions, in descending order, Paluxy, Glen Rose, Rodessa, James, Pettet, Travis Peak, Cotton Valley and Smackover were relatively well identified and recognized. Mis-allocations were the possible result of typographical errors, failure of recompletions to be properly entered into the data or stratigraphic juxtapositioning due to faulting in some of the fields, this leads to incorrect correlations.

Nomenclature problems were generally the result of "local" usage conventions where recognized stratigraphic divisions were subdivided (i.e., Travis Peak into 6,100' Unit, Upper Unit, Lower Unit, 9,000' Unit or Cotton Valley into Upper [Sandstone] Unit, Jurassic [Haynesville Lime] Unit). These subdivisions were generally useful in the areas applied but were not regionally applicable and may be somewhat confusing. Because a GASIS type log was defined for each reservoir study, the actual producing interval can be reviewed. (See the GASIS Type Log Book)

Future

Future work could include additional reservoir characterization studies within the plays already studied but with emphasis on District 5. The Smackover (JC-1) in District 5 was worked to attain additional characterization data which had been lacking to some degree on the Smackover characterizations in District 6. Due to time constraints, no other plays were worked or characterizations accomplished in District 5. The fields within the "unworked" plays in District 5 should be evaluated to complete District 5.

Due to time constraints, plays K-3, KS-1 and KS-3 of both Districts 5 and 6 were not worked and warrant investigation.

Recommendations

Three plays in District 6 should be evaluated and all the plays in District 5 (except JC-1) warrant investigation to complete the "East Texas" Region.

North Louisiana

The North Louisiana Study Area is bounded to the north, east, and west by the state boundaries of Louisiana. The southern boundary is approximately located where the La Salle Arch grades into the Comanchea Shelf Edge. Major structural elements of the study area are the State Line Fault Zone or Graben trend to the north between Arkansas and Louisiana, the Sabine Uplift, North Louisiana Salt Basin, and Monroe Uplift from west to east, and the La Salle Arch to the south.

The GASIS Project included reservoir characterization studies conducted within 7 of the 12 plays as defined by the Atlas of Major Central and Eastern Gulf Coast Gas Reservoirs. The plays that were studied for the GASIS Project are marked with an asterisk (*):

Paleocene-Eocene Plays:

- WX-5 Wilcox Fluvial, deltaic, and Shallow-Marine Sandstone - Louisiana and Mississippi

Cretaceous Plays:

- *KS-1 Trinity Group Sandstone - Sabine Uplift
- KS-4 Austin-Taylor-Navarro Groups Shallow-Marine Sandstone - ARKLA Region
- KS-6 Lower Tuscaloosa Fluvial to Shallow-Marine Sandstone - Mississippi and Louisiana
- KG-5 Upper Cretaceous Gas Rock - Louisiana and Mississippi
- *KS-10 Hosston Sandstone - North Louisiana and South Arkansas Salt Basins
- *KC-1 Trinity Group Carbonate - Sabine Uplift
- KC-4 Trinity Group Carbonate - Salt Structures - North Louisiana Salt Basin
- *KJ-1 Hosston Formation and Cotton Valley Group Sandstones - Sabine Uplift

Jurassic Plays:

- *JC-1 Upper Jurassic Shallow-Marine Carbonate - ARKLATEX Region
- *JS-1 Cotton Valley Shallow-Marine Sandstone - ARKLA Region
- *JS-3 Upper Jurassic Submarine-Fan Sandstone - North Louisiana

Within the 7 plays studied, a total of 28 fields involving 39 reservoirs were completed. The fields contained about 2500 wells for an average of 89 wells per field studied. Well counts within each field ranged from 12 to 313 wells per field.

Play Selection

Determination of which plays and fields to characterize were subject to several selection criteria:

1) Significance of play production.

2) Discovery date of the field. Old fields are notorious for poor and inconsistent data.

3) Number of wells drilled within a field since 1970. This increases the probability that a porosity tool was run in the borehole.

4) Availability of both resistivity and porosity surveys for a significant number of wells within a specific field. Both surveys are required to properly characterize the reservoir.

5) Play representation. A significant number of the fields must be available so that a statistically sound representation of the play can be characterized.

6) Reservoirs classified as tight gas reservoirs were given priority over reservoirs not classified as tight gas.

Play selection was designed to include a statistically significant, representative sample throughout the study area, both geographically and stratigraphically. Of the five plays that were omitted from the North Louisiana study, four of them, Plays WX-5, KS-4, KG-5, and KC-4, were discovered and developed prior to the 1940's. Within these plays log data and scout tickets for individual wells, required for a reservoir evaluation, were unavailable or poorly represented. Therefore the plays had to be omitted from the reservoir evaluation effort. Unfortunately, Play KG-5 and Play KC-4 are two of the top Cretaceous producing plays in North Louisiana. The fifth play, KS-6, was omitted due to time constraints.

Allocation Problems

The North Louisiana study area is a difficult area to work because of the condition of the available data. Production data is collected on a field level, it is not allocated by reservoir. Therefore, until a log is correlated and the perforations checked against the log, the correct producing horizon is unknown. For this reason it is difficult to know which reservoirs within a field are actually GASIS size.

The availability of logs and completion cards created problems in the study area. After calling upon and visiting several data resources, it was determined by the staff at Dwight's Energydata that the best source for North Louisiana logs and completion cards was the Shreveport Petroleum Data Association (SPDA). Using the Dwight's monthly oil and gas production data, the geological staff was able to pull up properties based upon API number and compare to the SPDA data base to determine if a particular log suite was available for each well within a field.

Inconsistent and irregular well data was the standard. Log and completion card availability ranged from 50% to 75% of the wells in a field. Of that percentage, often only a small portion would have both resistivity and porosity surveys available. Generally only the resistivity survey was available. A quantitative reservoir characterization study requires that

both types of surveys be present. Additionally, based upon completion dates and perforation depths, workover and/or re-completion information was completely absent. Despite the above problems, reservoir characterization studies completed in North Louisiana did have enough quality data available to insure validity.

Prior to the GASIS Project, records on a reservoir level in North Louisiana were non-existent. Reservoir names are not reported by the state, and gas production is reported on a "well completion" basis, or by individual well. To determine the producing formation, Dwight's staff would generate a list of all producing wells within a field, correlate available logs to identify producing horizons, and then use perforation depths and the prefix found in the "Lease/Well Name" provided by the state of Louisiana to give a reservoir designation for a producing property that had no log available. Due to the lack of data, all wells could not be correctly allocated and as a result, accurate production could not be assigned to GASIS records. Because a GASIS type log was defined for each reservoir study, the actual producing interval can be reviewed. (See the GASIS Type Log Book)

Future

Further studies in North Louisiana would need to include several fields in the KS-6 Play. This play is the second most productive of the Cretaceous Plays and was omitted due to time constraints. The most productive North Louisiana Play, KG-5, would probably be the most difficult play to work because of its age and the terrible condition of the producing properties. Dwight's would not recommend a KG-5 study. With the advent of better seismic technology, especially 3-D seismic, further reservoir characterization studies in the plays that are associated with the North Louisiana Salt Basin would be the best plays to target for further evaluation.

Based upon the overall data condition, and GASIS budget considerations, further studies in Louisiana would be of little value. The complete lack of reservoir records would mean that any model for Louisiana reservoirs would not tie to any available production data. The model is only good for the field from which the data was gathered. Further DOE funding would be most beneficial if applied towards reservoir level allocations for the entire state of Louisiana. Until this is done, reservoir models are of little use.

EASTERN GULF COAST - Alabama & Mississippi

The Eastern Gulf Coast study area includes Mississippi Alabama. The major structural elements in Mississippi are the Interior Salt Basin (from which most of the state's gas production is derived) which is bounded to the northwest by the Sharkey Platform and Jackson Dome, to the north central by the Pickens Fault System and to the northeast by the Gilbertown Fault System. In Alabama the majority of the gas production comes from fault traps. The Gilbertown Fault System progresses into southwest Alabama from the northwest and Mississippi. It bifurcates into the Mobile Graben and the West Bend Fault System with the West Bend Fault System then bifurcates again into the Pollard and Foshee Fault System.

The GASIS Project included reservoir characterization studies conducted within 10 of the 14 plays which occurred in Mississippi and Alabama as defined by the Atlas of Major Central and Eastern Gulf Coast Gas Reservoirs. These plays are as follow with the plays subject to this study marked with an asterisk (*).

Miocene Plays:

MC-7 Upper Middle Miocene Sandstone
Louisiana Gulf Coast and Alabama

Paleocene - Eocene Plays:

WX-5 Wilcox Fluvial, Deltaic and Shallow-Marine Sandstone
Louisiana and Mississippi

Cretaceous Plays:

*KS-5 Eutaw-Upper Tuscaloosa Shallow-Marine Sandstone
Mississippi Interior Salt Basin

*KS-6 Lower Tuscaloosa Fluvial to Shallow-Marine Sandstone
Mississippi and Louisiana

KG-5 Upper Cretaceous Gas Rock
Mississippi and Louisiana

*KS-7 Washita-Fredericksburg Sandstone
Mississippi Interior Salt Basin

*KS-8 Trinity Group Sandstone
Mississippi Interior Salt Basin

*KS-9 Hosston-Sligo Sandstone
Mississippi Interior Salt Basin

*KC-3 Trinity Group Carbonate
Mississippi Interior Salt Basin

Jurassic Plays:

*JC-3 Upper Jurassic Shallow-Marine Carbonate and Sandstone
Mississippi, Alabama and Florida region

*JS-2 Cotton Valley Sandstone
Mississippi Interior Salt Basin

*JS-4 Norphlet Fluvial and Eolian Sandstone
Alabama and Mississippi

Pennsylvanian - Mississippian Plays:

*PN-MS-1 Pennsylvanian-Mississippian Deltaic and Marine-Shelf Sandstone
Alabama and Mississippi

PN-14 Pennsylvanian Coalbed Methane
Alabama

Play Selection

Within these 10 plays a total of 75 fields involving 100 reservoirs were completed. These reservoirs contained more than 1240 producing wells for an average well count of 12 wells/reservoir and a range of 1 to 40 wells/reservoir.

Selection of the reservoirs to study was designed to include a representative sample (both geographic and stratigraphic distribution) and a statistically significant number of plays, fields and reservoirs. The 4 plays which were not studied were either aerially and/or volumetrically small within the states studied, and were judged to have inadequate data available with which to do a valid reservoir characterization study (some involved coal gas which was not subject to this study).

Specifically, selection parameters included:

1) Significance of play production.

2) Discovery date of the field; very old fields generally are lacking in the quality and quantity of data needed to do a valid reservoir characterization study.

3) Number of wells drilled in the field since 1970; newer wells have a greater likelihood of having a porosity tool available

4) Availability of both a resistivity and porosity tool; both are required in a given borehole to do a valid reservoir characterization.

5) Play representation; enough fields within a play meet the above requirements so that a statistically significant number of the fields and reservoirs can be characterized within a play for modeling purposes.

6) Reservoirs classified as tight gas reservoirs were given priority over those that were not tight gas.

Data Availability

The first step to any study is to research data availability and quality and the method of acquisition of such data. The Dwight's Energydata staff thoroughly researched various data sources for both quantity and quality of data. For the Eastern Gulf Coast Study Area of Mississippi and Alabama, the Jackson Log Library located in Jackson, Mississippi had the best coverage and could ship data to Oklahoma City, Oklahoma for use by the Dwight's staff.

Even though Dwight's staff used the best available data source, data availability was a notable problem. The states involved did a poor job of requiring, acquiring and maintaining well data. As an example, they saved only the resistivity logs but discarded the porosity logs for lack of storage space. This is an incomprehensible logic and value system to a geologist requiring such data. Therefore, private collections such as the Jackson Log Library became the best sources but still lacked a tremendous amount of data. Generally, completion card data was very good, resistivity log coverage was fair, porosity log coverage was poor and recompletion data was very poor. Additionally, problems were encountered due to the fact that many wells were multiple zone completions (commingled) and many of the perforations listed on the completion cards were only the large, gross intervals requiring Dwight's staff to interpret the most likely zones of production and allocate and characterize accordingly.

Lastly, in instances where no porosity logs were available, porosity was inferred from the Spontaneous Potential (SP) Curve and resistivity responses based on prior studies and knowledge. However, the Jackson Log Library did have core data available and it was used whenever possible. The reservoir characterization studies that were completed used all available data. There was enough data, both quantitatively and qualitatively, to insure the validity of the studies.

Allocation Process

Mis-allocation problems varied by play and reservoir and were usually due to one of two reasons. First, problems originated from the fact that some of the boundaries within the stratigraphy as outlined above were vague and led to a great deal of interpretation being used in assigning nomenclature. Second, the major subdivisions as outlined above were subject to substantial amounts of subdivision, which was generally useful in the areas applied but were

not regionally applicable. These allocation problems were easily overcome by developing a consistent framework of stratigraphy over the study area. Because a GASIS type log was defined for each reservoir study, the actual producing interval can be reviewed. (See the GASIS Type Log Book)

Future Work

Future work should include evaluating the larger and/or older fields and reservoirs that were not included in this study but were within defined plays. Also, the four plays that were not studied, which were generally oil productive, should be included in any future studies.

Recommendations

Most of the fields for which reservoir characterization studies could be evaluated in a GASIS economically viable method were completed. Additional field studies would be proportionally more expensive because of size and cost of data searches. Thus, this area should be of low priority for future evaluations.

Greater Green River Basin of Wyoming

The Greater Green River Basin is essentially the southwestern quarter of Wyoming, a small portion of northwestern Colorado, and a small sliver of Utah adjacent to Colorado and Wyoming. The Greater Green River Basin is made up of several structural elements. It is divided into east and west halves by the Rock Springs Uplift. The east half is made up of the Great Divide, or Red Desert Basin, the Wamsutter Arch, Washakie Basin, Cherokee Ridge, and the Sand Wash Basin. The west half is comprised of the Farson Deep, Sandy Bend Arch, Green River or Bridger Basin, the La Barge Platform, and the Moxa Arch. For the purpose of the GASIS Project, all these structural elements will be called the Green River Basin (GRB).

The GASIS Project included reservoir characterization studies conducted within 6 of the 12 plays as defined by the Atlas of Major Rocky Mountain Gas Reservoirs. The plays that were studied for the GASIS Project are marked with an asterisk (*).

Tertiary [T] Plays:

T-1	Wind River and Wasatch Formations
T-2	Fort Union Formation
T-3	Almy Formation

Upper Cretaceous [KU] Plays:

KU-1	Lance Formation
*KU-2	Lewis Shale (and Fox Hills Sandstone)
*KU-3	Mesaverde Group
*KU-5	Frontier Formation

Lower Cretaceous [KL] Plays:

*KL-1	Muddy Sandstone
KL-2	Bear River Formation
*KL-3	Dakota/Fall River Sandstone

Rocky Mountain Foreland Structure [FS] Play:

*FS-4	Greater Green River Basin

Thrust Belt [TB] Structure Plays:

*TB-7	Ordovician Bighorn Dolomite

Within the 6 plays, a total of 16 fields involving 33 reservoirs were characterized. These reservoirs contained 933 productive wells for an average well count per reservoir of 28 wells and a range of 2 to 98 wells per reservoir.

Play Selection

Determination of which plays and fields to characterize were subject to several selection criteria:

1) Significance of play production.

2) Discovery date of the field. Old fields are notorious for poor and inconsistent data.

3) Number of wells drilled within a field since 1970. This increases the probability that a porosity tool was run in the borehole.

4) Availability of both resistivity and porosity surveys for a significant number of wells within a specific field. Both surveys are required to properly characterize the reservoir.

5) Play representation: A significant number of the fields must be available so that a statistically sound representation of the play can be characterized.

6) Reservoirs classified as tight gas reservoirs were given priority over reservoirs not classified as tight gas.

Play selection was designed to include a statistically significant, representative sample throughout the study area, both geographically and stratigraphically. Within the GRB (due to budget constraints) it was decided to study reservoirs that had made 10 BCF of gas or greater, even though the Atlas lists reservoirs that made 5 BCF or greater. This way the GASIS data base will be consistent. Play selection was designed to include a statistically significant, representative sample throughout the study area, both geographically and stratigraphically. Initially, as fields and reservoirs were being selected, there was an emphasis on the Tight Sands of the Mesaverde Group (Play KU-3). As the project progressed, other plays of significant gas production were given emphasis. The five plays that weren't studied, Plays T-1, T-2, T-3, KU-1, and KL-2, make up less than 7% of the gas production in the GRB.

Data Availability

The staff of Dwight's Energydata thoroughly researched the data availability, both quantity and quality, for the GRB. The Herold Geological Research Center (HGRC), located in Denver Colorado, had the best and most complete log coverage for the study area. Virtually every log, except the ones not yet released, was available to the Dwight's staff. Scout tickets indicating completion, as well as re-completion information, were also available for all logs used in the study. Data for the GRB is easily accessed and is in excellent condition.

Allocation Problems

Allocation problems within the GRB were confined to 2 separate plays; the Mesaverde Group [KU-3], and the Frontier Formation [KU-5]. Both plays can be subdivided into more definitive nomenclature to define the producing reservoir. The Mesaverde was divided into the Almond, Ericson, Rock Springs, and Blair Members. The Frontier was divided into the First, Second, Third, and Fourth Frontier Members. A GASIS type log was defined for each reservoir studied, and the actual producing interval can be reviewed. (See the GASIS Type Log Book)

Many times production was reported as Mesaverde, but the predominant producing member of the field was Almond with minor contributions from the Ericson. After allocation of the field it can be demonstrated that the major producing horizon is the Almond. Reservoirs characterized as Almond are all the Uppermost Mesaverde Member and are stratigraphically correlative. This provides better resolution for users of the data base.

The Frontier Formation was plagued with a similar problem. It is of greater benefit to know if the production is from one of the Frontier Members, such as Second Frontier, or from commingled Frontier Members, such as First and Second Frontier. Although the various Frontier Members are not in pressure communication throughout the GRB, it can be demonstrated that they are correlative stratigraphic units.

Future

Further work in the Greater Green River Basin should include more reservoir characterization studies on the following plays: KU-3, KU-5, KL-1, KL-3, and FS-4. These 5 Plays account for 70% of the production to date in the study area.