REPORT**TECHNOLOGICAL EVALUATION
OF THE
DRILLING INDUSTRY
AND ITS
LONG RANGE REQUIREMENTS****March 1977****NOTICE**

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SECTION 1

STATEMENT OF GOALS AND OBJECTIVES

Purpose

The purpose of this study is to evaluate the drilling equipment industry and to determine oil field drilling equipment products that should be considered for a development program.

Goals and Objectives

The primary goals and objectives of the study are:

1. List oil field equipment products suitable for development.
2. Determine cost/time factors involved in development of selected products.
3. Define product benefit factors in terms of improved drilling rig productivity (increased drilling penetration rate).

SECTION 2

THE NEED FOR A DRILLING TECHNOLOGY PROGRAM

Higher oil and gas prices provide the drilling industry with an incentive to add new rigs and equipment and to drill additional wells.

Due to financial pressures caused by industry decline during the mid 1950's, competition for drilling contracts was strong. Drilling costs remained fairly constant and little funding was available for major research programs concerning improved drilling technology. This condition lasted until the mid-70's at which time a turn-around occurred.

During the period of peak activity prior to the mid 1950's, drilling equipment consisted of an even mix of cable rig drilling equipment and rotary drilling equipment. Since that time, the number of cable drilling rigs has declined substantially and now industry is using rotary drilling rigs almost exclusively (Table 2-1). The application of new technology noted in this report refers only to rotary drilling rigs. The cable drilling method is considered outmoded for purposes of this study.

The majority of companies involved in the drilling industry are small to medium in size with only a few large companies (Table 2-2). Large companies concentrate primarily on offshore drilling and deep land drilling. The small to medium size companies concentrate primarily on land drilling. In general, they do not have sufficient economic strength to try unproven, new technologies or advance designed equipment. If the small to medium size company tried unproven technology

TABLE 2-1

NUMBER OF ROTARY AND CABLE
DRILLING RIGS IN OPERATION
U.S.A., ONSHORE, LOWER 48 STATES
1950 - 1975

<u>Year</u>	<u>Number of Rotary Rigs</u>	<u>Number of Cable Rigs</u>	<u>Total Rigs Rotary & Cable</u>	<u>Cable Rigs as % of Total Rigs</u>
1950	2154	2363	4517	52
1955	2687	2180	4867	45
1960	1746	1797	3543	51
1965	1388	1395	2783	50
1970	1025	598	1623	37
1975	1659	175	1834	10

Source: The Drilling Contractor

TABLE 2-2

SURVEY OF DRILLING COMPANIES
PERFORMING CONTRACT DRILLING FOR
MAJOR & INDEPENDENT OIL COMPANIES
(1977 DATA)

Of 535 companies surveyed:

- 25% have only 1 rig
- 56% have 3 rigs or less
- 73% have 5 rigs or less
- 92% have 10 rigs or less

Excluded are companies with:

- a. workover rigs only
- b. foreign location of rigs

Sources: Appendix A

International Association of Drilling Contractors - 1977
Membership Directory

1977 Oil & Gas Journal. Directory - Land Drilling & Oil Well
Servicing Contractors.

or equipment that performed improperly or failed completely, serious economic problems could result. Therefore, use of new technology is limited to large companies with numerous rigs and with the economic strength to experiment.

Since this market is limited, manufacturers associated with the drilling industry hesitate to advance new technologies. Thus, new technology advances slowly. Within this limited market, however, are a number of products that should be reviewed for development. Recommendations will be based on product ability to improve rig productivity or efficiency. Increased rig productivity or efficiency would provide the necessary economic incentive to justify purchase of the product. This study relates primarily to products that can provide this type of incentive.

SECTION 3

METHODOLOGY USED TO SELECT AND STRUCTURE
A DRILLING TECHNOLOGY PROGRAM

A study of existing drilling equipment capabilities provided data to determine innovations needed by the industry and segments of the market to which they are applicable. In addition industry literature was reviewed to evaluate emerging technologies and to determine their worth. These technologies and innovations were then reviewed with industry experts to establish their anticipated value and marketability to the drilling industry. From this analysis a list of projects was compiled. These projects are listed in Table 3-1.

Each project was reviewed and analyzed to establish:

- 1--Project Definition
- 2--Project Development Time and Cost Factors
- 3--Project Potential

TABLE 3-1

PROPOSED DRILLING TECHNOLOGY PROGRAM PROJECTS

1. Technology Transfer

Project 1 - Training

2. Drilling Equipment

Project 1 - Upgrading Conventional Drilling Rigs

Project 2 - Drilling Rig Automation

Project 3 - Directional Drilling Equipment

Project 4 - Bottom-Hole Assemblies

Project 5 - Mud Automation Systems

3. Drilling Optimization

Project 1 - Rig Instrumentation/Sensing Equipment

Project 2 - Rig Floor Data Display/Analysis Equipment

Project 3 - Down-Hole Logging - Telemetry System

Project 4 - Surface Logging - Telemetry System

Project 5 - Computer Controlled Drilling

4. High Pressure Drilling

Project 1 - Jet Erosion Drilling

5. Down-Hole Motors

Project 1 - Down-Hole Motor Technology

Table 3-1, Continued

6. Drilling Bit Technology

Project 1 - Stratapax and Bit Technology

7. BOP Technology

Project 1 - Blowout Preventer Equipment

8. Advanced Drilling Technology

Project 1 - Advanced Drilling Equipment

SECTION 4

PROJECT TIME-COST ANALYSIS

The selected drilling projects (Table 3-1) were analyzed to determine individual time-cost factors and to determine the cost effectiveness of the total program. To obtain this information, each project was reviewed as follows:

1. Project Definition
 - a. Project Description
 - b. State of the Art
 - c. Project Application
2. Project Development
 - a. Project Requirements
 - b. Project Time Duration
 - c. Project Cost

Using the resulting data, the projects and time-cost factors were bar-graphed (Figure 4-1). As some projects are dependent upon the completion of segments of other projects, time phasing was analyzed and schedules set accordingly. Both yearly and total project costs were noted on the bar chart.

PROJECT NO.	PROJECT DESCRIPTION	YEAR														TOTAL PROJECT COST (\$000)
		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	
1-1	TRAINING	75	25	150	50	75	100	25								500
2-1	UPGRADE CONVENTIONAL DRILLING RIGS		125	300	300	300	1500	1000	100	100	100					3825
2-2	DRILLING RIG AUTOMATION					75	250	500	250	1000	2000	1000	50	100	100	5375
2-3	DIRECTIONAL DRILLING EQUIPMENT		75	25	100	25	250	300	50	225	300	75	75	100	100	1725
2-4	BOTTOM HOLE ASSEMBLIES	75	25	100	25	125	125	37	150	113						775
2-5	MUD AUTOMATION SYSTEMS					150	266	124	1000	1500	500	100	100	100	100	3950
3-1	RIG INSTRUMENTATION/SENSING EQUIPMENT	100	200	250	250	100	100	100								1100
3-2	RIG FLOOR DISPLAY/ANALYSIS EQUIPMENT	75	75	225	100	100	250	250	25	100	100	75				1375
3-3	DOWN HOLE LOGGING - TELEMETRY SYSTEM	600	600	100	100	100										1500
3-4	SURFACE LOGGING - TELEMETRY SYSTEM		100	83	334	83	250	250	90	350	260	25	100	100	75	2100
3-5	COMPUTER CONTROLLED DRILLING	34	66	100	300	500	500	75	150	75						1800
4-1	JET EROSION DRILLING			85	167	666	167	1290	1750	450	75	100	100	125		4885
5-1	DOWN HOLE MOTOR TECHNOLOGY	200	200	67	266	67	500	700	100	75	100	100	25			2400
6-1	STRATAPAX & BIT TECHNOLOGY	400	200	200	400	100	100	100								1500
7-1	BLOWOUT PREVENTION EQUIPMENT			75	150	150	500	1000	700	600	600	600	100	100	100	4775
8-1	ADVANCED DRILLING EQUIPMENT		100	200	100	133	267	350	350	100	100	100				1800
	TOTAL YEARLY BUDGET	1659	2741	3852	4586	5564	6354	5729	4750	2675	700	325	250	200		39385

LEGEND

PROGRAM DEVELOPMENT
LABORATORY TESTING
FIELD TESTING
TECHNOLOGY TRANSFER

Figure 4-1 Project Time-Cost Analysis (\$000-yrs.)

Project 1-1 - Training (Table 4-1)

Description: Drilling company representatives, industry institutions and organizations, and the industry in general, recognize the need for increased training of its personnel. This need has been caused by the rapid expansion of the industry, the increased technical nature of equipment, and the in-general low level education of the average field worker. Lack of trained personnel is fundamental to the slow technological advancement of the industry.

An evaluation of training needs, recommendations for necessary instruction, and a program to apply these recommendations is required.

State of the Art: IADC and API sponsor schools with appropriate training aids and equipment. Company sponsored schools are increasing. However, industry use of these schools is relatively low.

Application: Training in all phases of drilling technology for personnel from all segments of the drilling industry is essential.

TABLE 4-1
PROJECT 1-1, TRAINING

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv. Total \$
1. Survey state-of-the-art and recommend program		12			100,000	
2. Set up pilot system and test		12			200,000	
3. Commercialization		24			200,000	

Project 2-1 - Upgrading Conventional Drilling Rigs (Table 4-2)

Description: The drilling industry has approximately 1,900 drilling rigs of various types and sizes. New and advanced industry technologies will not be adaptable to all present rigs. However, when possible, new innovative products (pipe rackers, slips, elevators, tongs, etc.) should be built on a modular basis for retrofit into existing rigs. Project 2-1 is designed to evaluate conventional drilling rig obsolescence and determine what can be done to alleviate it. Methods will be determined and field tested. The drilling industry will not scrap present rig fleets to buy new rigs, but will continue drilling with existing, outdated rigs or upgrade the equipment depending on their economic ability.

State of the Art: No studies have been made in this area. Implementation of Project 1-1 and the phasing in of new techniques will affect the timing and strategy for Project 2-1.

Application: This project applies to all drilling rigs.

TABLE 4-2

PROJECT 2-1, UPGRADING CONVENTIONAL DRILLING RIGS

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv. Total \$
1. State-of-the-art		12			125,000	
2. Conceptual		12			300,000	
3. Initial Design		24			600,000	
4. Lab/Field Test		24			1,000,000	1,500,000
5. Commercialization		36			300,000	

Project 2-2 - Drilling Rig Automation (Table 4-3)

Description: After the conceptual/initial design phase of Project 2-1 is underway, Project 2-2 will use the design information to evaluate Drilling Automation and field testing of equipment to determine its feasibility. Previous work has demonstrated that the automation concept is realistic and that it should improve the drilling penetration rate, down time, rig safety, control, and reduce manpower requirements. Automation will be a vital link in the overall concept of total computerized drilling. Design should take advantage of jet erosion drilling, down-hole telemetry, and down-hole drilling.

State of the Art: Automatic Drilling Machines, Dallas, Texas, has built and field-tested two automated drilling machines. Other companies have tried experimental automation systems. The concept has never been fully proven.

Application: This concept will apply to heavier, deeper rigs and to offshore and arctic applications.

TABLE 4-3

PROJECT 2-2, DRILLING RIG AUTOMATION

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv. Total \$
1. State-of-the-art		6			75,000	
2. Conceptual and Initial Design		24			1,000,000	
3. Lab test/Field test		24			2,000,000	2,000,000
4. Commercialization		36			300,000	

Project 2-3 - Directional Drilling Equipment (Table 4-4)

Description: This project will consist of evaluation, design assistance, and field testing of several integrated drilling systems/components to advance the technology level in directional drilling.

State of the Art: Industry has worked on various components involved but little has been done to integrate these components into an overall system.

Application: This technology applies to all drilling when the rig is confined to a drilling pad or platform, such as offshore, arctic, or jungle drilling. It could be applied to advance exploration drilling concepts.

TABLE 4-4

PROJECT 2-3, DIRECTIONAL DRILLING EQUIPMENT

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv. Total \$
1. State-of-the-art		9			75,000	
2. Conceptual/Initial Design		18			150,000	
3. Lab Test		24			300,000	300,000
4. Field Test		24			600,000	
5. Commercialization		36			300,000	

Project 2-4 - Bottom-Hole Assemblies (Table 4-5)

Description: The addition of stabilizers, collars, and other down-hole drilling components, if applied properly, can assist in determining the bit drilling direction, improve bit performance and bit life, and reduce drilling costs. Previous work indicates that the proper combination of components can be attained by use of mathematical modeling. Project 2-4 will evaluate pertinent technology and assist in its advancement and field use. Project 2-4 should begin immediately and should emphasize commercialization.

State of the Art: Amoco claims to have bottom-hole assemblies fully developed with excellent results. Christenson (B. Walker) claims bottom-hole assembly service is being marketed to European companies, but is just getting started in the U.S. All work done so far has applied to hole 10,000 feet and deeper.

Application: This technology could apply to drilling in general and will definitely apply to directional drilling.

TABLE 4-5

PROJECT 2-4, BOTTOM-HOLE ASSEMBLIES

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv. Total \$
1. State-of-the-art		6			75,000	
2. Conceptual & Initial Design & Lab		18			150,000	
3. Field Test		18			250,000	
4. Commercialization		24			300,000	

Project 2-5 - Mud Automation System (Table 4-6)

Description: Proper mud control automation systems can enhance drilling safety with reference to blowouts, and improve drilling penetration rates. This project will evaluate mud control automation and assist in developing, field testing, and advancing the concept if it is economically feasible. Project 2-5 will be given low priority and should be undertaken on a go/no-go basis.

State of the Art: Several companies have done initial evaluation of automated mud control with limited success. One company, Halliburton, has an automated system but has had little success so far. A determination of the economics of the mud industry and how mud automation effects rig owners is necessary.

Application: Because of estimated costs, this concept will primarily apply to large drilling rigs.

TABLE 4-6

PROJECT 2-5, MUD AUTOMATION SYSTEMS

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv. Total \$
1. State-of-the-art		12			150,000	
2. Initial/Conceptual Design		18			400,000	
3. Lab Test		6			500,000	500,000
4. Field Test		24			1,500,000	500,000
5. Commercialization		48			400,000	

Project 3-1 - Rig Instrumentation/Sensing Equipment (Table 4-7)

Description: The application of automation-computerization techniques is dependent upon the ability of equipment to sense drilling conditions or movement of components. Unique problems encountered are not solvable by use of conventional techniques. Project 4-1 will evaluate instrumentation and sensing problems, determine solutions, and assist in developing, testing, and advancing rig instrumentation and sensing equipment techniques. Rugged, inexpensive equipment with a reasonable degree of accuracy is essential.

State of the Art: Several large companies have designed and are marketing sensing equipment. Devices now on the market are adequate for normal drilling operations, but will be inadequate for advanced applications.

Application: Industry acceptance of rig automation-computerization will require the use of instrumentation and sensing equipment. Since proper instrumentation is fundamental to optimization/computer programs and telemetry programs, Project 3-1 should begin immediately and should receive top priority.

TABLE 4-7

PROJECT 3-1, RIG INSTRUMENTATION/SENSING EQUIPMENT

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv. Total \$
1. State-of-the-art		9			100,000	
2. Conceptual & Initial Design		12			200,000	
3. Lab Test		12			150,000	100,000
4. Field Test		12			250,000	
5. Commercialization		36			300,000	

Project 3-2 - Rig Floor Data Display/Analysis Equipment
(Table 4-8)

Description: The basic drilling operation includes the monitoring and varying of a number of operating conditions. Monitoring these conditions from a central location on the rig floor with a visual readout system incorporating max-min operating limits will enhance the operation. Proper application of this type of equipment will be the first step in the computerization of the drilling operation for all segments of the drilling industry. Equipment can be combined with home office computer systems. Solution to training problems in equipment use is essential. This project will evaluate available equipment, define equipment needed, and assist in the development, testing, and application of devices.

State of the Art: Page and Tri-State may have the most advanced equipment. Large, expensive systems are being used for onshore and offshore rigs where daily operational costs are adequate to justify such equipment. Equipment available for use on small rigs is sparse. Equipment is new and has not been properly field tested to determine its full capability.

Application: Since Data Display and Analysis Equipment will be applicable to the general drilling industry, Project 3-2 should be given priority.

TABLE 4-8

PROJECT 3-2, RIG FLOOR DATA DISPLAY/ANALYSIS EQUIPMENT

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv. Total \$
1. State-of-the-art		6			75,000	
2. Conceptual and Initial Design		12			300,000	
3. Lab Test		6			100,000	100,000
4. Field Test		18			500,000	
5. Commercialization		36			300,000	

Project 3-3 - Down-Hole Logging - Telemetry System (Table 4-9)

Description: DOE participated in the field testing of the TELECO mud-pulse telemetry system, a method for transmitting down-hole information through a flowing column of drilling mud. Continued field testing is required to determine the full capability of the system.

State of the Art: Numerous companies are attempting to transmit down-hole data to the surface. TELECO appears to be one of the best systems. Information and reports available from DOE provide data to start an effective field test program. Project 3-3 is a continuation of DOE programs.

Application: This technology, due to the probable expenses involved, will apply primarily to deep hole drilling.

TABLE 4-9

PROJECT 3-3, DOWN-HOLE LOGGING - TELEMETRY SYSTEM

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv. Total \$
1. Field Test		24			1,200,000	
2. Commercialization		36			300,000	

Project 3-4 - Surface Logging - Telemetry System (Table 4-10)

Description: During the drilling operation, optimization and correction of drilling equipment control variables is dependent upon the geological strata and down-hole drilling equipment conditions. Effort is being made to monitor and transmit information from the bottom of the hole to the drilling floor. Because this process is expensive, it is limited to deep hole, platform, arctic, and offshore drilling. An inexpensive surface monitoring system that would perform preliminary tests on rock chips taken from the shale shaker will be considered. Information from these tests, combined with rig floor operating data, could predict down-hole conditions. Although the results would be less accurate than down-hole systems, the process would be less expensive and thus applicable to a larger number of rigs. Project 3-4 will evaluate existing systems, determine economic feasibility, and assist in system development.

State of the Art: The versions of this concept currently available to industry are excessively costly and therefore limited in use. Although Mobil and Conoco believe surface logging-telemetry systems have possibilities, Project 3-4 will be on a go/no-go basis.

Application: Based on the economics involved and the adequacy of the information obtained, this technology could apply to all segments of the industry.

TABLE 4-10

PROJECT 3-4, SURFACE LOGGING - TELEMETRY SYSTEMS

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv. Total \$
1. State-of-the-art		9			100,000	
2. Conceptual & Initial Design		18			500,000	
3. Lab Test		18			400,000	100,000
4. Field Test		24			500,000	200,000
5. Commercialization		36			300,000	

Project 3-5 - Computer Controlled Drilling (Table 4-11)

Description: Computer controlled drilling consists of maximizing the drilling variables to increase penetration rate of the drilling process. Considerable effort has been expended by industry to define and field test this concept.

Project 3-5 will evaluate existing computer controlled drilling systems, assist in their improvement, and foster their use by the drilling industry. System design will use high reliability, rugged hardware and be set up for use on all rig operations.

State of the Art: Amoco is the leader in computer controlled drilling technology and claims considerable success. Other corporations have also evaluated this technology, but unfortunately, use of computer controlled drilling technology is limited.

Application: Computer controlled drilling technology can be used by all segments of the industry. System design will emphasize commercialization.

TABLE 4-11

PROJECT 3-5, COMPUTER CONTROLLED DRILLING

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip./Serv. Total \$
1. State-of-the-art		9			100,000	
2. Conceptual/Initial Design		6			100,000	
3. Lab test		6			200,000	100,000
4. Field Test		12			1,000,000	
5. Commercialization		24			300,000	

Project 4-1 - Jet Erosion Drilling (Table 4-12)

Description: Jet erosion drilling uses high pressure mud jets to fracture and break the rock at the bottom of the hole. Industry has experimentally evaluated and field tested this technology and results have been mixed. However, work remains to be done.

Project 4-1 will evaluate the work done and help expand jet erosion drilling technology to facilitate building a complete system which can be made commercially available. Lab work accomplished prior to field testing will avoid field costs.

State of the Art: Exxon, Gulf, and Shell have worked on versions of this concept and have obtained encouraging results. Data will be evaluated to determine proper application.

Application: Cost will limit use of jet erosion drilling to deep land, platform, and arctic drilling.

TABLE 4-12

PROJECT 4-1, JET EROSION DRILLING

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv Total \$
1. State-of-the-art		9			85,000	
2. Lab Test		18			500,000	500,000
3. Field Test		24			500,000	3,000,000
4. Commercialization		36			300,000	

Project 5-1 - Down-Hole Motor Technology (Table 4-13)

Description: Down-hole motor technology utilizes a down-hole motor to impart rotating force to the drilling bit. DOE has sponsored projects participating in the development of down-hole motor technology. Project 5-1 will help expand this technology and make it available to the industry.

State of the Art: Project 5-1 is a continuation of DOE programs. Numerous companies and government groups are working on phases of down-hole motor technology.

Application: Cost will limit application of down-hole motor technology to deep land, platform, and arctic drilling.

TABLE 4-13

PROJECT 5-1, DOWN-HOLE MOTOR TECHNOLOGY

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv
1. Equipment Design		18			400,000	
2. Lab Test		18			300,000	100,000
3. Field Test		24			1,200,000	100,000
4. Commercialization		36			300,000	

Project 6-1 - Stratapax and Bit Technology (Table 4-14)

Description: Project 6-1, a continuation of DOE programs, will investigate, analyze, and field test bonding techniques and the technologies used to develop new and advanced drilling bits.

DOE has participated in the development of stratapax and bit technology. Continuation and expansion of project 6-1 will help advance the drilling industry.

State of the Art: Sandia Labs has developed techniques necessary for attaching man-made diamonds to drilling bit bodies.

Application: Stratapax and bit technology can be applied to all areas of the drilling industry.

TABLE 4-14

PROJECT 6-1, STRATAPAX AND BIT TECHNOLOGY

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv Total \$
1. Lab Test		18			600,000	
2. Field Test		18			600,000	
3. Commercialization		36			300,000	

Project 7-1 - Blowout Preventer Equipment (Table 4-15)

Description: Blowout Preventors (BOP) control unstable down-hole well conditions. Their use is mandatory to the safety of the drilling operation.

Project 7-1 will evaluate BOP technology, define areas requiring improvement, and assist industry in advancing BOP technology. Potential improvement may be BOP automation and down-hole BOP systems. Project 7-1 would be undertaken on a go/no go basis.

State of the Art: Industry has advanced BOP technology to meet the needs and economies of the drilling industry. However, little has been done to accelerate BOP automation technology. Analysis to determine project potential is necessary. BOP automation may be applicable only for offshore or dangerous areas.

Application: BOP technology applies to all segments of the drilling industry.

TABLE 4-15

PROJECT 7-1, BLOW OUT PREVENTER EQUIPMENT

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv Total \$
1. State-of-the-art		6			75,000	
2. Conceptual/Initial Design		12			300,000	
3. Lab Test		18			1,000,000	500,000
4. Field Test		48			2,000,000	500,000
5. Commercialization		48			400,000	

Project 8-1 - Advanced Drilling Equipment (Table 4-16)

Description: Project 8-1 will define, evaluate, and if necessary, assist in the development of advanced drilling concepts. These concepts could range from advanced offshore riser systems to advanced land mobil rig designs. Project 8-1 will provide incentive to accelerate industry advancement by defining the scope and economic value of new concepts and procedures. It will require a go/no go basis.

State of the Art: Industry will provide new technology essential to its economic need. Little effort is made to advance the industry over and above that which is absolutely essential.

Application: Project 8-1 can apply to all phases of the drilling industry and is designed to encourage advanced thinking and development.

TABLE 4-16

PROJECT 8-1, ADVANCED DRILLING EQUIPMENT

Item	Per.	Mths.	Hrs.	Labor \$ Rate/Hr.	Labor Total \$	Equip/Serv Total \$
1. State-of-the-art		12			100,000	
2. Initial Conceptual Design		18			300,000	
3. Lab Test		18			300,000	100,000
4. Field Test		24			500,000	200,000
5. Commercialization		36			300,000	

SECTION 5

PROJECT BENEFIT ANALYSIS

In the drilling equipment industry, a new product is ready to market only after extensive field testing proves it will improve productivity and/or efficiency. To measure productivity and efficiency, drilling penetration rate was selected as a standard for comparison. Since drilling penetration rate measures the ability of a drilling rig to make a hole, rig productivity increases if this ability can be improved.

Efficiency in the drilling operation includes engine maintenance, tripping operations, logistics, etc. Support operations, combined with the drilling operation, produce a hole. Therefore, if the efficiency of support operations can be improved, the overall ability of a rig to produce a hole can be improved, and the rig's productivity increases.

To determine drilling penetration rate increase of each project the following analysis was made:

1. Evaluate Project vs. Rig Depth Capability

As the projects involved are economically viable only on certain sizes (or depths) or rigs, a review was made of each project to determine its rig size applicability (Table 5-1). This determination was based on a literature survey, industry economic studies, and discussion with key industry representatives.

2. Projected Size of Rig Market and Rig Size Distribution to 1995

To determine future product sales potential, an analysis of the rig market by rig size and total rig fleet was made to the year 1995. Rig size was determined by reviewing the rig size distribution for the last eight years (Table 5-2). Although this analysis shows certain percentage variations a degree of judgment was used when extrapolating this data to the year 1995 (Table 5-3).

3. Estimated Drilling Preparation Rate Improvement

An estimate of drilling penetration rate improvement was made for each project based on the limited field or laboratory information available on similar projects (Table 5-4).

4. Project Potential

To define the meaning in terms of overall drilling penetration rate improvement to the industry in general, for each of the projects, the information attained in Steps 1, 2 and 3 above was compiled in Tables 5-5 to 5-20. In each table, total estimated rig count from Table 5-3 was listed. Estimated applicable rig count for each year was determined by multiplying the percentage of rigs (Table 5-1 as it applies to Table 5-3) by the estimated rig count of Table 5-3.

Estimated rigs using the system is a judgment factor of market drilling penetration rate multiplied by estimated number of applicable rigs.

Estimated system utilization rate is a judgment factor based on a literature survey and discussion with representatives of the industry.

Estimated maximum penetration rate is taken from Table 5-4.

Penetration rate increase was obtained by multiplying the number of estimated applicable rigs, by the number of estimated rigs using the system, by the estimated system utilization rate, and by the maximum drilling-penetration rate increase.

TABLE 5-1

PROJECT - RIG DEPTH APPLICABILITY

Project No.	Project Description	Rig Depth Applicability, K's				
		0-5	5-9	9-12	12-16	16-Up
1-1	Training	x	x	x	x	x
2-1	Upgrade Conventional Drilling Rigs	x	x	x	x	x
2-2	Drilling Rig Automation			x	x	x
2-3	Directional Drilling Equipment			x	x	x
2-4	Bottom Hole Assemblies	x	x	x	x	x
2-5	Mud Automation Systems				x	x
3-1	Rig Instrumentation/ Sensing Equipment	x	x	x	x	x
3-2	Rig Floor Display/ Analysis Equipment	x	x	x	x	x
3-3	Down-Hole Logging - Telemetry System			x	x	x
3-4	Surface Logging - Telemetry System		x	x	x	x
3-5	Computer Controlled Drilling		x	x	x	x
4-1	Jet Erosion Drilling				x	x
5-1	Down Hole Motor Technology			x	x	x
6-1	Stratapax and Bit Technology	x	x	x	x	x
7-1	Blow-out Preventer Equipment				x	x
8-1	Advanced Drilling Equipment			x	x	x

TABLE 5-2

HISTORICAL U.S. ROTARY RIG DEPTH DISTRIBUTION
(Percent of Total Rig Count)

Year	Rig Size, K's				
	0-5	5-9	9-12	12-16	16-Up
1970	23	31	17	11	18
1971	23	29	18	11	19
1972	23	29	17	9	22
1973	20	29	18	9	24
1974	20	28	18	11	23
1975	19	29	19	11	22
1976	21	29	17	11	22
1977	22	25	19	11	23

Notes:

1. Rig size denotes drilling depth capability in thousands of feet.
2. Data includes both land and offshore rigs.
3. Source: Drilling DCW, Annual Rotary Rig Census.

TABLE 5-3

PROJECTED U.S. ROTARY RIG DEPTH DISTRIBUTION
(Percent of Total Rig Count)

Year	Rig Size, K's					Total Rigs
	0-5	5-9	9-12	12-16	16-Up	
1980	21	20	23	12	24	2570
1981	20	19	24	13	24	2750
1982	19	18	24	14	25	2910
1983	18	17	25	15	25	3060
1984	18	16	25	15	26	3200
1985	17	16	26	15	26	3340
1986	17	15	26	16	26	3470
1987	16	15	27	16	26	3600
1988	16	14	27	17	26	3730
1989	15	14	28	17	26	3860
1990	15	13	28	17	27	4000
1991	14	13	29	17	27	4140
1992	14	12	29	18	27	4280
1993	14	11	30	18	27	4420
1994	13	11	31	18	27	4560
1995	13	11	31	18	27	4700

- Notes: 1. Rig size denotes drilling depth capability in thousands of feet.
2. Data includes both land and offshore rigs.

TABLE 5-4

PROJECTED PROGRAM POTENTIAL

Project No.	Project Description	Long Range Penetration Rate Improvement, %	Comments
1-1	Training	10-20	Most effective program.
2-1	Upgrade Conventional Drilling Rigs	5-10	Should be tied to Project 2-2
2-2	Drilling Rig Automation	5-10	Should be tied to Project 2-1
2-3	Directional Drilling Equipment	5-10	
2-4	Bottom Hole Assemblies	10-20	Simple project with fast return
2-5	Mud Automation Systems	0-5	Will apply primarily to deep rigs.
3-1	Rig Instrumentation/Sensing Equipment	-----	Required for 3-2,3,4,5
3-2	Rig Floor Display/Analysis Equipment	0-5	Has a large potential if hooked to computer.
3-3	Down-Hole Logging - Telemetry System	5-15	Continuation of DOE program.
3-4	Surface Logging - Telemetry System	5-10	Very little known about this technology.
3-5	Computer Controlled Drilling	20-25	Apply major effort to commercialization.
4-1	Jet Erosion Drilling	20-25	Will apply mainly to deep hole drilling
5-1	Down-Hole Motor Technology	20-25	Continuation of DOE program.
6-1	Stratapax and Bit Technology	30	Continuation of DOE program.
7-1	Blowout Preventer	-----	Basic advantage is safety.
8-1	Advanced Drilling Equipment	-----	Unknown advantage.

TABLE 5-5
PROJECT 1-1, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980	2570	100	2570	5	129	75	20	.8
1981	2750	100	2750	10	275	75	20	1.5
1982	2910	100	2910	15	436	75	20	2.3
1983	3060	100	3060	25	765	75	20	3.8
1984	3200	100	3200	35	1120	75	20	5.3
1985	3340	100	3340	45	1503	75	20	6.8
1986	3470	100	3470	55	1909	75	20	8.3
1987	3600	100	3600	65	2340	75	20	9.8
1988	3730	100	3730	70	2611	75	20	10.5
1989	3860	100	3860	75	2895	75	20	11.2
1990	4000	100	4000	75	3000	75	20	11.2
1991	4140	100	4140	75	3105	75	20	11.2
1992	4280	100	4280	75	3210	75	20	11.2
1993	4420	100	4420	75	3315	75	20	11.2
1994	4560	100	4560	75	3420	75	20	11.2
1995	4700	100	4700	75	3525	75	20	11.2

Estimated Rig Size Applicable: All Rigs
Estimated Maximum System Utilization Rate: 75%
Estimated Maximum Penetration Rate Increase: 20%

TABLE 5-6
PROJECT 2-1, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980								
1981								
1982								
1983								
1984								
1985	3340	100	3340	.1	5	75	10	.0
1986	3470	100	3470	.3	10	75	10	.0
1987	3600	100	3600	.6	20	75	10	.0
1988	3730	100	3730	1.3	50	75	10	.1
1989	3860	100	3860	2.6	100	75	10	.2
1990	4000	100	4000	5.0	200	75	10	.4
1991	4140	100	4140	9.7	400	75	10	.7
1992	4280	100	4280	18.7	800	75	10	1.4
1993	4420	100	4420	36.2	1600	75	10	2.7
1994	4560	100	4560	70.2	3200	75	10	5.3
1995	4700	100	4700	75.0	3435	75	10	5.6

Estimated Rig Size Applicable: All Rigs
Estimated Maximum System Utilization Rate: 75%
Estimated Maximum Penetration Rate Increase: 10%

TABLE 5-7
PROJECT 2-2, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980								
1981								
1982								
1983								
1984								
1985								
1986	3470	68	2360	.1	2	50	10	.0
1987	3600	69	2484	.1	5	50	10	.0
1988	3730	70	2611	.3	10	50	10	.0
1989	3860	71	2741	.5	20	50	10	.0
1990	4000	72	2880	1.2	50	50	10	.1
1991	4140	73	3022	2.4	100	50	10	.1
1992	4280	74	3167	4.7	200	50	10	.2
1993	4420	75	3315	9.0	400	50	10	.4
1994	4560	76	3466	17.5	800	50	10	0.9
1995	4700	76	3572	34.0	1600	50	10	1.7

Estimated Rig Size Applicable: 9-12^K, 12-16^K, 16^K-Up
 Estimated Maximum System Utilization Rate: 50%
 Estimated Maximum Penetration Rate Increase: 10%

TABLE 5-8
PROJECT 2-3, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980								
1981								
1982								
1983								
1984								
1985	3340	67	2238	.1	5	35	10	.0
1986	3470	68	2360	.3	10	35	10	.0
1987	3600	69	2484	.8	30	35	10	.0
1988	3730	70	2611	1.9	70	35	10	.1
1989	3860	71	2741	3.9	150	35	10	.1
1990	4000	72	2880	7.5	300	35	10	.3
1991	4140	73	3022	10.9	450	35	10	.4
1992	4280	74	3167	14.0	600	35	10	.5
1993	4420	75	3315	17.0	750	35	10	.6
1994	4560	76	3466	19.7	900	35	10	.7
1995	4700	76	3572	24.7	1160	35	10	.9

Estimated Rig Size Applicable: 9-12^K, 12-16^K, 16^K-Up
 Estimated Maximum System Utilization Rate: 35%
 Estimated Maximum Penetration Rate Increase: 10%

TABLE 5-9
PROJECT 2-4, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980								
1981								
1982	2910	100	2910	.2	5	75	20	.0
1983	3060	100	3060	.3	10	75	20	.0
1984	3200	100	3200	.9	30	75	20	.1
1985	3340	100	3340	2.1	70	75	20	.3
1986	3470	100	3470	4.3	150	75	20	.6
1987	3600	100	3600	8.3	300	75	20	1.2
1988	3730	100	3730	16.1	600	75	20	2.4
1989	3860	100	3860	31.1	1200	75	20	4.7
1990	4000	100	4000	60.0	2400	75	20	9.0
1991	4140	100	4140	75.0	3105	75	20	11.2
1992	4280	100	4280	75.0	3210	75	20	11.2
1993	4420	100	4420	75.0	3315	75	20	11.2
1994	4560	100	4560	75.0	3420	75	20	11.2
1995	4700	100	4700	75.0	3525	75	20	11.2

Estimated Rig Size Applicable: All Rigs
Estimated Maximum System Utilization Rate: 75%
Estimated Maximum Penetration Rate Increase: 20%

TABLE 5-10
PROJECT 2-5, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987	3600	42	1512	.1	3	25	5	.0
1988	3730	43	1604	.3	10	25	5	.0
1989	3860	43	1660	.5	20	25	5	.0
1990	4000	44	1760	1.2	50	25	5	.0
1991	4140	44	1822	1.9	80	25	5	.0
1992	4280	45	1926	2.8	120	25	5	.0
1993	4420	45	1989	5.7	250	25	5	.1
1994	4560	45	2052	8.8	400	25	5	.1
1995	4700	45	2115	11.3	530	25	5	.1

Estimated Rig Size Applicable: 12-16^K, 16^K-Up
 Estimated Maximum System Utilization Rate: 25%
 Estimated Maximum Penetration Rate Increase: 5%

TABLE 5-11
PROJECT 3-1, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980	2570							
1981	2750							
1982	2910							
1983	3060							
1984	3200							
1985	3340							
1986	3470							
1987	3600							
1988	3730							
1989	3860							
1990	4000							
1991	4140							
1992	4280							
1993	4420							
1994	4560							
1995	4700							

Estimated Rig Size Applicable: All Rigs
Estimated Maximum System Utilization Rate: --
Estimated Maximum Penetration Rate Increase: --

TABLE 5-12
PROJECT 3-2, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980	2570	100	2570	.1	2	75	5	.0
1981	2750	100	2750	.4	10	75	5	.0
1982	2910	100	2910	.9	25	75	5	.0
1983	3060	100	3060	2.5	75	75	5	.1
1984	3200	100	3200	4.7	150	75	5	.2
1985	3340	100	3340	9.0	300	75	5	.3
1986	3470	100	3470	17.3	600	75	5	.6
1987	3600	100	3600	33.3	1200	75	5	1.2
1988	3730	100	3730	53.6	2000	75	5	2.0
1989	3860	100	3860	74.5	2875	75	5	2.7
1990	4000	100	4000	75.0	3000	75	5	2.8
1991	4140	100	4140	75.0	3105	75	5	2.8
1992	4280	100	4280	75.0	3210	75	5	2.8
1993	4420	100	4420	75.0	3315	75	5	2.8
1994	4560	100	4560	75.0	3420	75	5	2.8
1995	4700	100	4700	75.0	3525	75	5	2.8

Estimated Rig Size Applicable: All Rigs
Estimated Maximum System Utilization Rate: 75%
Estimated Maximum Penetration Rate Increase: 5%

TABLE 5-13
PROJECT 3-3, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980	2570	59	1516	.1	2	50	15	.0
1981	2750	61	1678	.2	5	50	15	.0
1982	2910	63	1833	.3	10	50	15	.0
1983	3060	65	1989	.5	15	50	15	.0
1984	3200	66	2112	0.9	30	50	15	.1
1985	3340	67	2238	1.8	60	50	15	.1
1986	3470	68	2360	3.5	120	50	15	.3
1987	3600	69	2484	6.9	250	50	15	.5
1988	3730	70	2611	10.7	400	50	15	.8
1989	3860	71	2741	15.5	600	50	15	1.2
1990	4000	72	2880	20.0	800	50	15	1.5
1991	4140	73	3022	22.9	950	50	15	1.7
1992	4280	74	3167	25.5	1090	50	15	1.9
1993	4420	75	3315	26.2	1160	50	15	2.0
1994	4560	76	3466	26.5	1210	50	15	2.0
1995	4700	76	3572	26.6	1250	50	15	2.0

Estimated Rig Size Applicable: 9-12^K, 12-16^K, 16^K-Up

Estimated Maximum System Utilization Rate: 50%

Estimated Maximum Penetration Rate Increase: 15%

TABLE 5-14
PROJECT 3-4, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980								
1981								
1982								
1983								
1984	3200	82	2624	.1	2	50	10	.0
1985	3340	83	2772	.1	5	50	10	.0
1986	3470	83	2880	.3	10	50	10	.0
1987	3600	84	3024	.4	15	50	10	.0
1988	3730	84	3133	.9	35	50	10	.0
1989	3860	85	3281	1.8	70	50	10	.1
1990	4000	85	3400	3.7	150	50	10	.2
1991	4140	86	3560	7.2	300	50	10	.4
1992	4280	86	3687	12.9	550	50	10	.6
1993	4420	86	3801	18.1	800	50	10	.9
1994	4560	87	3967	25.2	1150	50	10	1.3
1995	4700	87	4089	30.4	1430	50	10	1.5

Estimated Rig Size Applicable: 5-9^K, 9-12^K, 16^K-Up

Estimated Maximum System Utilization Rate: 50%

Estimated Maximum Penetration Rate Increase: 10%

TABLE 5-15
PROJECT 3-5, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980								
1981	2750	80	2200	.2	5	50	25	.0
1982	2910	81	2357	.3	10	50	25	.0
1983	3060	82	2509	.8	25	50	25	.1
1984	3200	82	2624	1.6	50	50	25	.2
1985	3340	83	2772	3.0	100	50	25	.4
1986	3470	83	2880	7.2	250	50	25	.9
1987	3600	84	3024	13.9	500	50	25	1.7
1988	3730	84	3133	21.4	800	50	25	2.7
1989	3860	85	3281	29.8	1150	50	25	3.7
1990	4000	85	3400	37.5	1500	50	25	4.7
1991	4140	86	3560	45.9	1900	50	25	5.7
1992	4280	86	3681	53.7	2300	50	25	6.7
1993	4420	86	3801	64.5	2850	50	25	8.1
1994	4560	87	3967	65.1	2970	50	25	8.1
1995	4700	87	4089	65.3	3070	50	25	8.2

Estimated Rig Size Applicable: 5-9^K, 9-12^K, 12-16^K, 16^K-Up

Estimated Maximum System Utilization Rate: 50%

Estimated Maximum Penetration Rate Increase: 25%

TABLE 5-16
PROJECT 4-1, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980								
1981								
1982								
1983								
1984	3200	41	1312	----	2	50	25	.0
1985	3340	41	1369	.1	5	50	25	.0
1986	3470	42	1457	.3	10	50	25	.0
1987	3600	42	1512	0.7	25	50	25	.1
1988	3730	43	1604	1.3	50	50	25	.2
1989	3860	43	1660	2.6	100	50	25	.3
1990	4000	44	1760	5.0	200	50	25	.6
1991	4140	44	1822	10.9	450	50	25	1.4
1992	4280	45	1926	15.7	674	50	25	2.0
1993	4420	45	1989	15.7	696	50	25	2.0
1994	4560	45	2052	15.7	718	50	25	2.0
1995	4700	45	2115	15.7	740	50	25	2.0

Estimated Rig Size Applicable: 12-16^K, 16^K-Up
 Estimated Maximum System Utilization Rate: 50%
 Estimated Maximum Penetration Rate Increase: 25%

TABLE 5-17
PROJECT 5-1, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980								
1981								
1982								
1983	3060	82	2509	.1	2	50	25	.0
1984	3200	82	2624	.2	5	50	25	.0
1985	3340	83	2772	.3	10	50	25	.0
1986	3470	83	2880	.7	25	50	25	.1
1987	3600	84	3024	1.4	50	50	25	.2
1988	3730	84	3133	2.7	100	50	25	.3
1989	3860	85	3281	5.2	200	50	25	.6
1990	4000	85	3400	11.2	450	50	25	1.4
1991	4140	86	3560	16.9	700	50	25	2.1
1992	4280	86	3681	21.0	900	50	25	2.6
1993	4420	86	3801	24.9	1100	50	25	3.1
1994	4560	87	3967	30.4	1388	50	25	3.8
1995	4700	87	4089	30.4	1431	50	25	3.8

Estimated Rig Size Applicable: 9-12^K, 12-16^K, 16^K-Up

Estimated Maximum System Utilization Rate: 50%

Estimated Maximum Penetration Rate Increase: 25%

TABLE 5-18
PROJECT 6-1, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980								
1981	2750	100	2750	.4	10	50	30	.1
1982	2910	100	2910	1.0	30	50	30	.2
1983	3060	100	3060	2.5	75	50	30	.4
1984	3200	100	3200	4.7	150	50	30	.7
1985	3340	100	3340	11.9	400	50	30	1.8
1986	3470	100	3470	20.2	700	50	30	3.0
1987	3600	100	3600	27.8	1000	50	30	4.2
1988	3730	100	3730	34.9	1300	50	30	5.2
1989	3860	100	3860	41.5	1600	50	30	6.2
1990	4000	100	4000	46.3	1850	50	30	6.9
1991	4140	100	4140	50	2070	50	30	7.5
1992	4280	100	4280	50	2140	50	30	7.5
1993	4420	100	4420	50	2210	50	30	7.5
1994	4560	100	4560	50	2280	50	30	7.5
1995	4700	100	4700	50	2350	50	30	7.5

Estimated Rig Size Applicable: All Rigs
Estimated Maximum System Utilization Rate: 50%
Estimated Maximum Penetration Rate Increase: 30%

TABLE 5-19
PROJECT 7-1, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980	2570							
1981	2750							
1982	2910							
1983	3060							
1984	3200							
1985	3340							
1986	3470							
1987	3600							
1988	3730							
1989	3860							
1990	4000							
1991	4140							
1992	4280							
1993	4420							
1994	4560							
1995	4700							

Estimated Rig Size Applicable: 12-16^K, 16^K-Up
 Estimated Maximum System Utilization Rate: Unknown
 Estimated Maximum Penetration Rate Increase: --

TABLE 5-20
PROJECT 8-1, POTENTIAL

YEARLY PENETRATION RATE INCREASE (PERCENT)

Year	Estimated Rig Count Total	Estimated Applicable Rigs		Estimated Rigs Using System		Estimated System Utilization Rate %	Estimated Maximum Penetration Rate Increase %	Penetration Rate Increase of Total Rig Count %
		Total Rig Count %	No.	Total Rig Count %	No.			
1980	2570							
1981	2750							
1982	2910							
1983	3060							
1984	3200							
1985	3340							
1986	3470							
1987	3600							
1988	3730							
1989	3860							
1990	4000							
1991	4140							
1992	4280							
1993	4420							
1994	4560							
1995	4700							

Estimated Rig Size Applicable: 9-12^K, 12-16^K, 16^K-Up

Estimated Maximum System Utilization Rate: --

Estimated Maximum Penetration Rate Increase: --

APPENDIX A

DRILLING COMPANY ANALYSIS

The following tabulation of drilling companies shows the number of drilling rigs by type. Offshore rigs are shown as platform, mobile, or barge mounted.

The following abbreviations are included:

- F - Foreign location of rig
- C - Cable tool rig
- W - Workover rig

Because rigs can be moved to and from foreign locations and workover rigs can be adapted for new hole production, this analysis should not be regarded as definitive. It does indicate make-up and size distribution of the drilling companies.

Sources: 1977 Oil & Gas Journal "Land Drilling & Oil Well Servicing Contractors"

1977 Membership Directory of the International Association of Drilling Contractors

DRILLING COMPANY ANALYSIS

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
A & A Drilling Co., Inc., Lafayette, LA 70501	3			
ABC Drilling Co., Inc., Loveland, CO 80537	1			
Abercrombie Drilling, Inc., Wichita, KS 67202	5			
ADCO Producing Co., Inc., Natchez, MS 39120	1			
A&F Drilling Co., Inc., Victoria, Texas 77901				
A & P Drilling Company, Inc., Oklahoma City, OK 73112	2			
ABB Drilling Co., Wichita Falls, TX 76301				
AWI, Inc., Harvey, LA 70059	3			3
ACCU Drill, Inc., Lafayette, LA 70501				
Aikins Drilling Co., Shelby, MT. 59474				
Alladin Drilling Activities A/S, Dreggen, Norway (F)			2	
Aladdin-Middle East, Ltd., Wichita, KS 67202 (F)	1			
Alanco Drilling Co., Alice, TX 78332	1			
Allen, W.C., & Sons, Shreveport, LA				
Allison Drilling Co., Inc., Denver, CO 80203	4			
Alpha Drilling, Inc., Edmond, OK 73034	1			
American Drilling, Inc., Lafayette, LA 70505	2			
American Natural Service Company, Detroit, MI 48226	2+1C			
AMCC Energy Corp., Dallas, TX 75234	2			
American Well Service & Salvage, Inc., Lafayette, LA 70505				
American Well Services, Inc., Altus, OK 75321	4			
Amini Drilling Co. (See: KKA Drilling Co.)				
Amoy Minerals Corp., San Antonio, TX 78217	3+3W			
Amy Drilling Company, Opelousas, LA 70570				
Anders, Odell, Drilling Company, Midland, TX 79701				
Anderson, K.W., Drilling, Delta, CO 81416	2			
Anderson Drilling Company, Denver, CO 80202	10			
The Anschutz Corporation, Denver CO 80202				
An-Son Corp., Anson Drilling Corp., Oklahoma City, OK 73118	8	1		
Apache Drilling Co., Inc., Lubbock, TX 79143	1			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Apollo Drilling & Exploration, Inc., Dallas, TX 75206	6			
Arapahoe Drilling Co., Albuquerque, NM 87125	5			
Ard Drilling Co., Midland, TX 79701	8			
Arden Drilling Co., Edmond, OK 73034	3			
Ardmore Drilling Co., Ardmore, OK 73401	4			
Armstrong Drilling Inc., Wooster, OH 44691	9			
Astro Drilling Co., Oklahoma City, OK 73139	1			
Atlantic Oil Co., Los Angeles, CA 90014	12			
Atlantic Pacific Marine Corp., Houston, TX 77057			3+3W	6
Atwood Oceanics, Inc., Houston, TX 77024			10	
Austin Drilling Company, Seminole, OK 74868	1			
AVA Drilling Co., Senecaville, OH 43780	1			
B & B Drilling, Inc., Wichita, KS 67202	1			
B C Well Service, Inc., Rangely, CO 81648				
B.D.K. Drilling, Co., Victoria, TX 77901	4			
BMG, Inc., Denver, CO 80228				
B & N Drilling Company, Independence, KS 67301	7			
Baggett Drilling, Eagle Pass, TX 78852	1			
Bailey, Pernie Drilling Co., Houston, TX 77027	6			
Baird & Tucker Drilling Co., Ardmore, OK 73401	3			
Baker & Taylor Drilling Co., Amarillo, TX 79105	11			
Bandera Drilling Co., Wichita, KS 67202	1			
Banner Drilling Co., Scottsbluff, NB 69361	1			
Bar J Drilling Co., Inc., Waskom, TX 75692	1			
Barger Engineering, Inc., Evansville, IN 47714				
Barnes Core Drilling Co., Bakersfield, CA 93308	1			
Barnhart Drilling Co., Inc., Casper WY 82601	3			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Barr Drilling Corp., Salem, IL 62881	1			
Barrett Drilling Company, Shawnee, OK 74801	5			
Basin Drilling Corp., Oklahoma City, OK 73112	9			
Basin Petroleum Corp. (See: Reserve Oil Inc.)				
Baski Drilling, Inc., Pueblo, CO 81006	1+2C			
Bawden Drilling Inc., Houston, TX 77027 (F)	18		6	
Bawden, Peter, Drilling, Inc., Orange, CA 92667	2W			3
Bay Drilling Corp., Thibodaux, LA 70301	3			
M. F. Bear, Wichita, KS 67202	1			
Beard Drilling Company, Carmel, IL 62863				
Bearden, Jack E., Drilling Company, Wichita Falls, TX 76302	4			
Berentz Drilling Company, Eureka, KS 67045	1			
Bergman Drilling, Inc., Wichita, KS 67202	1			
Big A Well Service, Bloomfield, NM 87413				
Big Chief Drilling Co., Oklahoma City, OK 73114	17			
Big Lake Drilling Co., Dallas, TX 75201				
Big Red Drilling Co., Rangely, CO 81648	2			
Big "6" Drilling Company, Houston, TX 77002	4			
Big Seven Drilling Co., Evansville, IN 47708	2			
Big West Drilling Co., Fort Worth, TX 76102	2			
Bigard, James, Drilling, Co., Mt. Pleasant, MI 48858	3			
Bilbo Drilling Co., Victoria, TX 77901	2			
Billings Oil Service, Inc., Corpus Christi, TX 78410	2			
Bill's Well Service, Codell, KS 67630	2			
Blackstone Drilling Inc., McPherson, KS 67460	2			
Bluco, Inc., Tyler, TX 75711	1			
Blue, Theo H., Drilling, Inc., Crane, TX 79731				
Bodard Drilling Co., Shawnee, OK 74801	6			
Bode, E. L., Drilling Company, Houston, TX			1	
Bokenkamp Drilling, Co., Inc., Houston, Texas 77002				

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Bolin Oil Company, Wichita Falls, TX 76301 Bomac Drilling, Lakewood, CO 80215 Bonray Oil Company, Oklahoma City, OK 73120 Booker Drilling Co., Inc., Metairie, LA 70002 Boone, Wm. S., Drilling Contractor, Shreveport, LA 71109	3 12 7	16W		
Boyd, Durst & Kuenstler, Inc., Victoria, TX 77901 Braden-Deem, Inc., Wichita, KS 67202 Brady Brothers Well Servicing Co., Cushing, OK 74023 Raymond K. Brake Well Service, Fisher, IL 61843 Brandt Drilling Co., Wichita, KS 67202	4 3 2W 1W 1			
Brazzel Well Service, Inc., Lafayette, LA 70501 C. E. Brehm Drilling & Producing, Mt. Vernon, IL 62864 "C" Brewer, Inc., Roundup, MT 59072 Bridgeport Drilling Co., Inc., Olney, IL 62450 Brinkerhoff Drilling Co., Inc., Denver CO 80202	1W 17			
Brothers Drilling Co., Corpus Christi, TX 78410 Brown & Lawhorn Drilling Co. (See: Sundance Drilling Corp.) Curt Brown Drilling Company, Tulsa, OK 74103 Brown, Tom, Inc., Midland, TX 79702 Brownie Drilling Co., Lake Charles, LA 70602	3 3 20 1+4W			
Bulford Drilling Company, Houston, TX 77027 Bullock, A. O., Drilling Co., Casper, WY 82601 Burger Drilling Co.; Ltd., Abilene, TX 79601 Burton Drilling Co., Houston, TX 77002 Burton/Hawks Drlg. Co., Casper, WY 82602	 1 2 1			
Butler County Drilling Co., Winfield, KS 67156 Butler Drilling Co., Houston, TX 77021 Butler-Johnson, Inc., Bossier City, LA 71111 Buzzini Drilling Co., San Antonio, TX 78209 Byrd Drilling Co., Midland, TX 79701	2+1C 7 8 3 7			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
CBM Drilling Co., Houston, TX 77006	2+1W			
C-G Drilling Co., Withita, KS 67202	1			
D & L Drilling Company, Dallas, TX 75202	1			
C & R Drilling Co., Perry, OK 73077	2			
Cactus Drilling Co., Richardson, TX 75080	18			
Cactus Drilling Corporation of Texas, Richardson, TX 75080	31			
California Prod. Service, Inc., Compton, California 90224	2+10W	1W		
Calvert Western Exploration Co., Fort Worth, TX 76102	6			
Cam Drilling Co., Abilene, Tx 79604	1			
Camay Drilling Co., Los Angeles, CA 90010	10			
Camden Drilling Company, Corpus Christi, TX 78401				4
Camrich Drilling Co., Tyler, TX 75701	5			
Cape Drilling Company, Tyler, TX 75701	4			
Caprock Drilling Service, Amarillo, TX 79108				
Captain Drilling Company, Inc., Odessa, TX 79762	7			
Caraway, Frank, Drilling Co., San Angelo, TX 76901	2			
Cardinal Drilling Company, Billings, MT 59103	11			
Carmack Drilling Co., Grand Junction, CO 81501	3			
Carnet, Inc., Shreveport, LA 71165				
Cedco Drilling Company, Olney, IL 62450	7			
Centreville Petroleum, Inc., Harvey, LA 70058				2
Century Drilling Company, Shelby, MT 59474	3			
Challenger Drilling Inc., Calgary, Alta, Canada	2			
Chandler & Associates, Inc., Denver, CO 80202	2			
Cherokee Drilling & Development Corp., Northfield, IL 60093	2			
Chief Drilling Company, Inc., Wichita, KS 67202	1			
Chico Drilling Company, Inc., Fort Worth, TX 76102	4			
Chiles Drilling Company, Houston, TX 77056			1	
Chital Drilling Company, Wichita Falls, TX 76307	1			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Choya Drilling Company, Alice, TX 78332	10			
Cinco Drilling Company, Corpus Christi, TX 78401	4			
Circle "A" Drilling Co., Denver, CO 80202	7			
Circle Bar Drilling Company, New Orleans, LA 70112				1
Circle G Drilling Company, Bridgeport, TX 76026	1			
E. B. Clark, Sr., Wichita Falls, TX 76301	1			
Clawson, Don, Drilling Contractor, Ada, OK 74820	1			
Claybrook Drilling Co., Inc., Wewoka, OK 74884	3			
Clem Corporation, The, Houston, TX 77002	1			
George B. Cole & Sons, Benton Harbor, MI 49022	4			
Coleman Drilling Co., Farmington, NM 87401	6			
Columbia Drilling Co., Houston, TX 77098	2			1+1W
Comet Drilling Co., Lafayette, LA 70505	3			
Commianche Drilling Co., Cut Bank, MT 59427	4			
Copenhaver Drilling Co., Victoria, TX 77901	2			
Craneco, Farmington, NM 87401	4			
Crescent Drilling Company, Owensbory, KY 42301	2W			
Drescent Well Service, Inc., Harvey, LA 70058				
Croatian Drilling Co., Inc., Harvey, LA 70058				
Croom, Bob, Inc.,				
Crow-Quaid Enterprises, Seal Beach, CA 90740	1			
Cyclone Drilling Inc., Gillette, WY 82716	2			
Cyclops Drilling Co., New Orleans, LA 70112		2		1
DB Drilling Corporation, Abilene, TX 79601	11			
D & D Drilling Company, Ferriday, LA 71334	3			
D & N Drilling Co., Thermopolis, WY 82443				
DNB Drilling, Inc., Wichita, KS 67202	4			
Damac Drilling, Inc., Great Bend, KS 67530	4			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Damson Drilling Corp., Houston, TX 77060 Darling & Kelley, Inc., Opelousas, LA 70570 Davidson, H.W., Midland, TX 79701 Decatur Drilling Co., Mt. Carmel, IL 82863 Dee Drilling Co., Mt. Carmel, IL 62863	1			1
Delaney Drilling Co., Inc., Dallas, TX 75201 Delaune Drilling Service, Alice, TX 78334 Delta Drilling Co., Tyler, TX 75710 Delta Marine Drilling Co., Tyler, TX 75701 Derrick Drilling, Inc., Shreveport, LA 71109	8 2C 33 1	1		
Diamond M Drilling Co., Houston, TX 77027 Dilley Drilling Co., Inc., San Antonio, TX 78216 Discovery Drilling Inc., Dallas, TX 75201 Dixon Drilling Co., Abilene, TX 79604 Dixilyn International, Inc., Houston, TX 77021	1 1 3 1	7 1	5 4	11
Dolphin International, Inc., Houston, TX 77002 Doss, Inc., Edna, TX 77957 Double Eagle Drilling, Dallas, TX 75204 Doye Well Service, Inc., Lafayette, LA 70502 Dreiling Drilling, Inc., Denver, CO 80202	1 2 2 3	2		
Dreiling Oil Inc., Victoria, KS 67671 Drillers, Inc., Houston, TX 77027 Dual Drilling Co., Wichita Falls, TX 76301 Duke Drilling Co., Great Bend, KS 67530 Dunn-Smith, Inc., Houston, TX 77042	2 9 14 3 1			
Dunne-Gardner Petroleum, Inc., Wichita, KS 67202	1			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
E & H Drilling Co., Graham, TX 76046	5			
ESI Drilling, Inc., Moab, UT 84532				
Eagle Drilling Co., Natchez, MS 39120	2			
Eason Oil Company, Oklahoma City, OK 73118	1			
Edico Drillers, Inc., Liberal, KS 67901	6			
Eggleston, A.W., Inc., Crowley, LA 70526	1			
Eklund Drilling Co., Carlin, NV 89822	4			
El Dorado Drilling, Inc., Oklahoma City, OK 73112	2			
Elenburg Exploration, Inc., Havre, MT 59501				
El Gato Drilling Company, Dallas, TX 75201	2W			
Empire Drilling Co., Denver, CO 80207	2			
Energy Drillers, Inc., Ft. Worth, TX 76102	1			
Roy Ensminger, Chanute, KS 88720	7			
Euphoria Oil Corporation, Alexandria, VA 22302	2			
Evertson Well Service, Inc., Kimball, NB 69145	23			
Evitt Drilling & Service Co., Ft. Lupton, CO 80621	4			
Exeter Drilling Northern, Inc., Denver, CO 80264				
Exeter Drilling Southern, Inc., New Orleans, LA 70112	3			
F-W Drilling Co., Abilene, TX 79605	25			
FWA Drilling Company, Inc. Wichita Falls, Texas 76301	7			
Fairman Drilling Co., Du Bois, PA 15801	2			
Faith Drilling Co., Houston, TX 77001	1			
Farmer, John O., Inc., Russell, KS 67665	5			
Farnsworth & Kaiser Drilling Co., Newcastle, WY 82701				
Felderhoff Bros. Drilling Co., Muenster, TX 76240	1C			
Ferguson Drilling Co., Oklahoma City, OK 73120	15		5	i
Field Drilling Co., San Antonio, TX 78205	2			
Field Rocky Mountain Drilling Co., Riverton, WY 82501				

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Sherman H. Finke Company, Metropolis, IL 62960	2			
Finley Oilwell Service, Inc., Long Beach, CA 90807	1+1W			
Fitzpatrick Drilling Co., Corpus Christi, TX 78401	1			
Five P's Drilling Co., Ft. Worth, TX 78102	8			
Flournoy Drilling Co., Alice, TX 78332	1		7	
Fluor Drilling Services, Inc., Santa Ana, CA 92705 (F)	4		4	
Fluor Drilling Services, Inc., Coral Drilling Div., New Orleans, LA. 70112	5			
Forster Drilling Co., Inc., Midland, TX 79703	3			
Fortenbery Drilling Co., Inc., Natchez, MS 39120	5			
Fortune Drilling Corp., San Angelo, TX 76901	5			
Four Corners Drilling Co., Farmington, NM 87401	10			
Frederickson's, Inc., Hutchinson, MN 55350	1			
French Oil Co., Gridley, KS 66852	4			
Frio Drilling & Prod. Co., Corpus Christi, TX 78401	4			
Froman Drilling, Inc., Cut Bank, MT 59427	3			
Frontier Drilling Corp., Oklahoma City, OK 73102	6			
Frontier Oil Co., Wichita, KS 67202	6			
GCO Drilling Co. (Subsidiary General Crude Oil Co.), Abilene, TX 79604	3			
G-E Drilling, Inc., Victoria, TX 77901	6			
Gabbert-Jones, Inc., Wichita, KS 67202	2			
Garnett Drilling Ltd., Williston, ND 58801	2			
Gary Drilling Co., Bakersfield, CA 93308	1			
El Gato Drilling Co., Dallas, TX 75201	2			
Gay Drilling Contractor, Duncan, OK 73533	1			
Gear Drilling Co., Denver, CO 80202	2			
Gearhart Drilling Co., Wichita, KS 67202	1			

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A Resource Services Company

WILLIAMS BROTHERS ENGINEERING COMPANY

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DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
General Well Service, Inc., Cut Bank, MT 59427	2W			
Gibson Drilling Co., Kilgore, TX 75662	8+1W			
Gladson, Willard, Oil Field Contracting Co., Snyder, TX 79549	1C+2W			
Glasscock, Drilling, Inc., Lafayette, LA 70501	9			
Global Marine Inc., Los Angeles, CA 90054 (F)			13	
Globe Drilling Co., Inc., Tyler, TX 75701	5			
F.E. Gober Drilling Co., Long Beach, CA 90806	1			
Golden Lane Drilling Co., Galveston, TX 77553	3		1	2
Goldrus Drilling Co., Houston, TX 77002	13			
Gotco International Inc., Houston, TX 77090	1			
Grace, Luke Drilling Co., Wichita Falls, TX 76367	2			
Grafton Drilling & Workover, Inc., New Iberia, LA 70560				
Graham, Jack H. Oilwell Service Co., Inc., Stockton, CA 95209	1W			
Graham, Paul, Drilling & Service Co., Rio Vista, CA 94571	1W			
Graves Drilling Co., Inc., Wichita, KS 67202	1			
Great Plains Drilling Co., Wichita, KS 67202	2			
Green Drilling Company, Gillette, Wyoming 82716	1			
Grey Wolf Drilling Co., Houston, TX 77056	1			
Griffin Drilling Corp., Denver, CO 80202	6			
Guffey-Schlensker Drilling Corp., Dallas, TX 75206	2			
Gwaltney Drilling, Inc., Washington, IN 47501	1+1C			
H-30 Drilling, Inc., Wichita, KS 67202	4			
H & J Drilling Co., San Antonio, TX 78212	2			
H & S Drilling Company, Tulsa, OK 74103	2			
Hack Drilling Company, Abilene, TX 79605	4			
Hackathorn Drilling Co., Denver, CO 80204	1C			
Harkins & Company, Alice, TX 78332	14			
Junior Haney Drilling Co., Bowie, TX 76230	5			
Harpel Petroleum Corporation, Casper, WY 82601	2			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Harper-Turner Drilling, Div., Harper Oil Company, Okla. City, OK 73102	4			
Harris Drilling Company, Grayville, IL 62844	1			
Hatcher, H.F., & Son, Smackover, AR	2			
Hauge Brothers, Conrad, MT 59425				
Headwaters Oil Company, Dallas, TX 75235				
Helmerich & Payne, Inc., Tulsa, OK 74114	22			
Herb Exploration Company, Abilene, TX 79604	1			
Herring, Maxwell Drilling Corporation, Tyler, TX 75710	6			
Hickman Drilling Co., Woodward, OK 73801	2			
Hill, Jim B. Drilling Co., Ventura, CA 92003	1			
Hillin Drilling Co., Odessa, TX 79760	7			
Hinton, W.B., Drilling Co., Inc., Mt. Pleasant, TX 75455	6			
Hogan Drilling Co., Baton Rouge, LA 70806	1			
Holliday Drilling Co., Midland, TX 79702	2			
Holmes Drilling Co., Houston, TX 77002				
Holston Well Services, Inc., Jennings, LA 70546	4			
Hondo Drilling Co., Midland, TX 79702	7			
Honeymon Drilling Co. Ltd., Oklahoma City, OK 73107	3			
Hoover Drilling Co., Bakersfield, CA 93308	1			
Houston, Jack Exploration Co., Dallas, TX 75230	1			
Houston Offshore International, Inc., Houston, TX 77027			1	
Howell Drilling, Inc., San Antonio, TX 78205	2			
Hudson, Leonard Drilling Company, Inc., Pampa, TX 79065	6			
Hughes Drilling Company, Enid, OK 73701	4			
Hunnicuttt & Camp Drilling Company, Rio Vista, CA 94571	5			
Huthnance Drilling Company, Houston, TX 77002		1		
Hylton Drilling Company, Bakersfield, CA 93304	5			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Inland Well Service, Abbeville, LA 70510 Intairdril Ltd., Houston, TX 77063 (F)	4 25			5W
J-V Drilling Company, Inc., Evansville, IN 47710 J & C Drilling Company, Inc., Refugio, TX 78377 Jackson, L.B., Co., Tulsa, OK 74135 Jernigan Drilling Company, Oklahoma City, OK 73112 Jet Drilling Co., Inc., Shreveport, LA 71101	5 1 1+1C 1 7			
Johnn Drilling Company, Odessa, TX 79762 Johnson-Bates Drilling Company, Konawa, OK 74849 Johnston Drilling Company, Houston, TX 77043 Jones Bros. Drilling Co., Inc., Shreveport, LA 71101 Jones Drilling & Producing Co., Fairfield, IL 62837	4 6 9C 2+1C			
Jones Drilling Corporation, Duncan, OK 73533 Justiss-Mears Oil Company, Inc., Jena, LA 71342 KKA Drilling Company, Midland, TX 79701 Kay Drilling Co., Ponca City, OK 74601 Kellogg, K.L. & Sons, Long Beach, CA 90807	9 21 5 1 1			
Kenai Drilling Limited, New York, NY 10022 Kendall Drilling Company, Inc. Kern Drilling Co., Inc. Magnolia, AR 71753 Key International Drilling Company Limited, Houston, TX 77002 Keydril Company, Houston, TX 77002	18 3 5			3 3
Kingery Drilling Company, Inc., Ardmore, OK 73401 Kirby Oil Industries, Inc., Omaha, NB 68102 Kirk Drilling Co., Carmi, IL 62821 Kissinger Petroleum Corporation, Englewood, CO 80110 Kissner, B.F., Drilling Company, Dedarodge, CO 81413	2 1C 1			

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DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Klaeger Drilling Corp., Palestine, IL 62451 Krueger Drilling & Service Co., Denver, CO 80231 Kuykendall Drilling Co., St. Elmo, IL 62458	8			
L & F Drilling Co., Corpus Christi, TX 78401 L.L.L. Drilling Co. Inc., Bloomfield, NM 87413 L & N Drilling Company, Shreveport, LA 71108 L & R Drilling Co., Pierre, SD 75701 Lagersen Drilling Company, Inc., Shreveport, LA 71101	1 2 2 1			
Lance Drilling Co., Inc., Casper, WY 82601 Landford Drilling Co. Inc., Shreveport, LA 71106 Langston Drilling Co., Longview, TX 75601 Larco Drilling Company, Inc., Jackson, MS 39201 Lartex Drilling & Service Co., Inc., Shreveport, LA 71101	4 3			
La-Tex Gulf Drilling Company, Inc., Houma, LA 70360 Lauck, D.R. Oil Company, Wichita, Kansas 67202 Lenhart & Bennett, Inc., Sapulpa, OK 74066 Lester, Dan, Drilling Co., Inc., Jefferson, TX 75657 Lewis C. Long Drilling Co., Hamilton, KS 66853	2 6 2 6			
Lewmont Drilling Associates, Inc., Denver, CO 80202 Lindsey, W.W., Pikeville, KY 41501 Lin-Mour Drilling Co., Wichita Falls, TX 76301 Lloyd Drilling Company, Taft, CA 93268 Loeffler Oil Corp., Allendale, IL 62410	6 1C 4 1			
Loffland Brothers Company, Tulsa, OK 74101 Lohmann-Johnson Drilling Co., Inc., Evansville, IN 47708 Longhorn Drilling Co., Inc., Sequin, TX 78155 Louise Drilling Company, Inc., Louise, TX 77455 Lowe Drilling Co., Albany, TX 76430	125 12 1 1 4			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
M & C Drilling Co., Casey, IL 62420				
Mc Drilling Company, Inc., El Campo, TX 77437	1			
M & E Drilling Co., Casey, IL 62420				
MGF Drilling Co., Inc., Midland, TX 79701	8			
M N D Drilling Corporation, Houston, TX 77002	10			
Mac Drilling Inc., Livonia, LA 70755	2			
Mack Oil Co., Duncan, OK 73533	1			
L. C. Madison Drilling Co., Bowling Green, KY 42101	4			
Mallard Drilling Corporation, Shreveport, LA 71165				
Mallard Well Service, Inc., Lafayette, Louisiana 70505		5W		11W
Manning, R.L., Company, Denver, Colorado 80202	15			
Marcum Drilling Company, Midland, TX	4			
Marias River Drilling Co., Inc., Shelby, MT 59474	1			
Marine Drilling Company, Corpus Christi, TX 78401	1		5	3
Marion Drilling Company, Inc., Mobile, AL 36616	4			
Marlin Drilling Co., Inc., Houston, TX 77027	1	3	4	
Marshall Drilling Co., Marshall, TX 75670	2			
Marwood Oil Co., Inc., Houston, TX 77015				
Materi Exploration, Inc., Upton, WY 82730	1			
Maxwell Herring Drilling Corp., Tyler, TX 75710				
Maynard Oil Co., Dallas, TX 75230	4			
Mayronne Company, The, Harvey, Louisiana 70058		2		4W
McAllen, Inc., Vidalia, LA 71373	1			
McAllister Engineering, Inc., Liberal, KS 67901	4			
McConnell Drilling Company, Lockhart, TX 78644	3			
McCutchen, J.W., Drilling Company, Wichita Falls, TX 76301	2			
McDowell Well Service, Shreveport, LA 71107				
McDrilling Company, Inc., El Campo, TX 77437	1			
McElroy Drilling Company, Bastrop, LA 71220	2			
McGoldrick & Watson Drilling Co., Shreveport, LA 71101				

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
McLennan Drilling Co., Nowata, OK 74048	2			
McVay Drilling Company, Tulsa, OK 74103	5			
Megargel Drilling Co., Inc., Megargel, TX 76370	6			
Melland Drilling Co., Inc., McPherson, KS 67460	1			
Melton Drilling Company, Bakersfield, CA 93308	2			
Melton, Joe, Drilling Co., Inc., Midland, TX 79701	1			
Mercury Drilling Co., Tulsa, OK 74114				
Mesa Drillers, Dolores, CO 81323	1			
Mid-Continent Oil & Gas Corporation, Downey, CA 90241	3			
Midstates Drilling Company, Rising Star, TX 76471	2			
Milam Drilling Co., San Antonio, TX 78205				
Miller Brothers Drilling Corp., Allegan, MI 49010	2			
Miller Drilling Company, Ft. Smith, AR 72906	9			
Marion F. Miller Drilling Co., St. Peter, IL 62880				
Minor, F. M. Drilling Company, Olney, IL 62450	2			
Mission Drilling & Exploration Corporation, New Orleans, LA 70139			1	
Mitchell, George N. Drlg. Co., Carmi, IL 62821	4			
Molen Drilling Co., Inc., Billings, MT 59103	3			
Montgomery, R.B., Drilling, Inc., Bakersfield, CA 93303	8			
Moran Bros., Inc., Wichita Falls, TX 76301 (F-3 Plat)	16			
Moran, E.W., Drilling Company, Inc., Wichita Falls, TX 76301	15			
Moran, F.E. Oil Co., Owensboro, KY 42301				
Moranco, Hobbs, N.M. 82240	7			
Morco Drilling, Inc., Corpus Christi, TX 78408	1			
Morgan Drilling Co., Shreveport, LA 71106				
Morrow Drilling Co., Odessa, TX 79760	1			
Mt. Carmel Drilling Co., Mt. Carmel, IL 62863				
Mountain Air Drilling & Service Co., Grand Junction, CO 81501	1			
Murco Drilling Corporation, Shreveport, LA 71101	9			
Murfin Drilling Company, Wichita, KS 67202	6+16			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Murlynson Drilling Company, Alice, TX 78332	1			
Murph Drilling Co., Inc., Mils, WY 82644				
Pete Murphey Drilling Co., Alice, TX 78332	1			
Murphey Well Service, Inc., Alice, TX 78332	2W			
Mustang Drilling Corporation, Tyler, TX 75701	2			
N.E.C.K. Drilling Company, Taft, CA 93268	2			
NRG Drilling Co., Owensboro, KY 43201	1			
National Energy Corp., Brentwood, TN 37027	2+1W			
Neaves Petroleum Developments, Beverly Hills, CA 90212	1			
Nelson Drilling & Well Service, Inc., Shreveport, LA 71101	1			
Newman Brothers Drilling Co., San Antonio, TX 78205				
New & Hughes Drilling Co., Inc., Natchez, MS 39120	8			
Nicklos Drilling Company, Houston, TX 77002	6	2		2
Noble Drilling Corporation, Tulsa, OK 74104	29	5	1	5
Norris, W.D.I., Graham, TX 76046	1			
North American Drilling Company, Mt. Pleasant, MI 48858	3			
Northwest Drilling Co., Inc., Parker, CO 80134	2			
Norton Drilling Company, Lubbock, TX 79401	4			
Norwood, A.N., Inc., Midland, TX 79702	3			
Nossaman Drilling Co., Alva, OK 73717	1			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Odeco, Inc., New Orleans, LA 70161 Offshore Company, Houston, TX 77001 O'Neal Drilling Company, Oklahoma City, OK 73120 Owen Drilling Company, Inc., Magnolia, Arkansas 71753	(F) 7 4 1 4	1	36 22	
Padre Drilling Company, Inc., Corpus Christi, TX 78410 Paramount Drilling Co., Inc., Shreveport, LA 71166 Par-Co Drilling, Inc., Natchez, MS 39120 Parker Drilling Company, Tulsa, OK 74103 Paul's Drilling Company, Inc., Kermit, TX 79745	(F-38 Land) 3 7 3 39 2	2		
Pearl, Bill, Drilling Co., Inc., Alice, TX 78332 Pearson Drilling Company, Enid, OK 73701 Penrod Drilling Company, Dallas, TX 75202 Pep Drilling Company, Mt. Vernon, IL 62864 Permian Rathole Drilling, Inc., Odessa, TX 79760	1 2 10 5 40	27	10	
Peterson Brothers Drilling Co., Salt Lake City, UT 84116 Petro Drilling Company, Mt. Vernon, IL 62864 Petro Drilling & Producing Co., Inc., Archer City, TX 76351 Phillips, Richard, Drilling Company, Corpus Christi, TX 78403 W. B. Phillips Company, Bowling Green, KY 42101	3 1 3 3			
Pinkrell Drilling Co., Wichita, KS 67202 Plateau Drilling Co., Houston, TX 77002 Platte Valley Drilling Company, Ralston, NB 68127 Pool Company, San Angelo, TX 76902 Porter, Gene, Drilling Company, Inc., Cushing, OK 74023	2 1 2+8W 1	6	9	
Post & Mastin Well Service, Inc., Garden City, KS 67846 Power Rig Drilling Company, Inc., Lafayette, LA 70501 Prairie Drilling Company, Casper, WY 82601 Prentice Oil and Gas Co., Houma, LA 70360 Price Drilling Co., Norwalk, OH 44857	4W 12 5 3			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Prince Brothers Drilling Company, Electra, TX 76360	2			
Progress Drilling & Marine, Inc., Houston, TX 77027	28	6+8W	1	3
Pronghorn Drilling, Glenrock, WY 82637				
Prudential Drilling Co., Houston, TX 77027				
Pruett, Chesley, Drilling Co., El Dorado, Arkansas 71730	4			
Pyburn Drilling Co., Shreveport, LA 71104	2			
PHD Drilling Co., Houston, TX	2			
Pease Drilling, Grand Junction, CO	5			
Pennsylvania Drilling Co., Pittsburgh, PA	10			
Quad Drilling Corporation, Bossier City, LA 71010				
Quasar, Incorporated, Evansville, IN 47715	2			
Ray Resources, Charleston, W. VA.	8			
R K Petroleum Corp., Mt. Carmel, IL 62863	1+1C			
Rains & Williamson Oil Co., Inc., Wichita, KS 67202	7			
Ratliff Drilling Company, Duncan, OK 73533	10			
Reading & Bates Drilling Co., Houston, TX 77002 (F-9 Land, 15 Mobile)		2	2	
Rebstock Drilling Company, Kenner, LA 70062				1+2W
Red Tiger Drilling Company, Wichita, KS 67202	6			
Reid Drilling Company, Casper, WY 82601				
Remco Drilling Corp., Haughton, LA 71037	1			
Republic Geothermal, Inc., Santa Fe Springs, CA 90670	1+3W			
Reserve Oil, Inc., Oklahoma City, OK 73112	9			
Reynolds, R & J Drilling Co., Inc., Telferner, TX 77988	1			
Rhodes & Hicks Drilling Company, Alice, TX 78332	2			
Richards Drilling Co., Bay City, TX 77414	5			
Riley Drilling Co., Big Spring, TX 79720	3			
Rine Drilling Co., Wichita, KS 67202	7			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Roberts Drilling, Inc., Casper, WY 82601				
Robinson Brothers Drilling Co., Midland, TX 79701	5			
Robinson Drilling of Texas, Inc., Big Spring, TX 79720	4			
Rockhold Engineering, Inc., Great Bend, KS 67530	2C			
Rod Ric Corporation, Midland, TX 79701	5			
Roden Drilling Co., Casper, WY 82601				
Rosamond, Phillip Drilling Co., Inc., West Monroe, LA 71291	4			
Rotary Drilling, Inc., Tyler, TX 75701	2			
Rowan Companies, Inc., Houston, TX 77056	12	4	1	
Rwit Drilling, Holdenville, OK	3			
R.O. Roy, Shreveport, LA	1			
Sandex Drilling, Kaysville, UT	2			
S & H Drilling Company, Inc., Victoria, TX 77901	2			
S H & J Drilling Corporation, Magnolia, AR 71753	3			
S & W Drilling Company, Inc., Lawrenceville, IL 62439	5			
Sabre Drilling, Cushing, OK 74023	3			
Sabre Drilling Co., Inc., Billings, Montana 59102	1			
Safari Drilling Corporation, Abilene, TX 79601	6			
Sage Drilling Co., Inc., Wichita, KS 67202	5			
Salen Offshore Drilling Co., Houston, TX 77027			2	
San Jacinto Drilling Co., Houston, TX 77002	2			
Sanders Workover & Drilling Company, Inc., New Iberia, LA 70560				1+1W
Santa Fe Drilling Company, Orange, CA 92668 (F)	34+6	3	11	5
Sawyer Drilling & Service, Inc., Shreveport, LA 71165	9			
Scandinavian Montgomery Drilling, Bakersfield, CA 93303	4			
Schlaikjer, A. L., Inc., Upton, WY 82730	1			
Schlensker Drilling Corp., Richardson, TX 75080	8			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Scott, Don, Drilling Co., Inc., Jonesville, MI 49250	1			
Scott, Jerry Drilling Company, Inc., Seminole, OK 74868	4			
Sea Drilling Corporation, New Orleans, LA 70112		2		
Seaboard Well Service, Inc., Lafayette, LA 70505	5W			
Search Drilling Company, Wichita, KS 67218	1			
Sedco, Inc., Dallas, TX 75201 (F-46 Land, 2W, 19 Mobile)			2	
Service Drilling Company, Tulsa, OK 74119	10			
Services, Equipment & Engineering, Inc., Houma, LA 70360		4W		
Shaft Drillers, Inc., Spokane, WA 99202				
Sharp Drilling Company, Inc., Midland, TX 79702	18			
Shields Drilling Co., Inc., Russell, KS 67665	1			
Shirer Well Servicing Co., Inc., Hoisington, KS 67544	4			
Shuler Drilling Co., El Dorado, AR 71730	3			
Signal Drilling Company, Denver, CO 80202	12			
Sioux Drlg. Corp., Odessa, TX 79760				
Sitton Drilling Company, Lubbock, TX 79401	3			
Sitton, C.W., Drilling Co., Inc., Evansville, IN 47708	5			
Slawson Drilling Co., Inc., Wichita, KS 67202	3			
Sledge, Gene, Drilling Corp., Midland, TX 79701	4			
Snyder Drilling-Well Servicing Co., Grayville, IL 62844	1			
Soape Drilling Company, Billings, MT 59103	1			
Sojourner Drilling Corp., Abilene, TX 79604	5			
Southland Drilling Co., Inc., Houston, TX 77024	9			
South Texas Drilling Company, San Antonio, TX 78205	3			
Standard Drilling Co., Inc., Oklahoma City, OK 73101	3+2C			
Sterling Drilling Company, Sterling, KS 67579	3+1W			
Stoeppelwerth Drilling, Inc., McCook, NE 69001	1			
Strata Drilling Company, Great Bend, KS 67530	1			
Sumpter & Barker Drilling Co., Inc., Stillwater, OK 74074	1			
Sun Marine Drilling Co., Los Angeles, CA 90005				

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Smackover Drilling, Eldorado, AR	3			
Spade Drilling, Shreveport, LA	3			
Sparton Drilling, Corpus Christi, TX	8W			
Spalding Drilling Co., Burger, TX	1			
Sutherland Drilling Co., Terre Haute, IN	3			
Sunde Company, Long Beach, CA 90806	1			
Sweetman Drilling, Inc., Wichita, KS 67202	1			
Sweetwater Drilling Co., Inc., Sweetwater, TX 79556	2			
Springer Drilling, Abilene, TX	1			
Standard American, Boise, IN	1			
Sundance Drilling Co.	3			
Staska Drilling, Albion, NB	4			
Stevens Prod. Co., Ft. Smith, AR	3			
Superior Drilling, Denver, CO	4			
T & B Well Service, Mansfield, LA 71052				
T & H Well Service, Inc., Eunice, LA 70535	19W			
T.J. Service Co., Corpus Christi, TX 78410	16W			
T & L Well Service Company, Inc., Kilgore, TX 75662				
T-I. Drilling Company, Inc., Houston, TX 77048	1			
TR Drilling Co., Monroe, LA 71203	3			
T & R Drilling Company, Pawhuska, OK 74056	1			
TRG Drilling Corporation, Oklahoma City, OK 73118	6			
T.W.T. Exploration, Inc., Park City, UT 84060	2			
Tannehill Well Service, Goree, TX 76363				
Target Directional Drilling, Inc., Corpus Christi, TX 78403				
Teledyne Movable Offshore, Lafayette, LA 70501		3+5W	4	
Tesoro Drilling Company, San Antonio, TX 78286	3			
Teion Exploration Drilling Co., Inc., Casper, WY 82602	21			
Texas Drilling Co., Abilene, TX 79603	9			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Thomas Drilling Company, Duncan, OK 73533	5			
Thompson, A.W., Inc., Midland, TX 79702	12			
Thompson Drilling Company, Newport Beach, CA 92663	1			
Thomson Drilling, Inc., Houston, TX				
Thomson Industries Ltd., Houston, TX	8			
Thunderbird Drilling, Inc., Wichita, KS 67218	141C			
Todd, C.H., Inc., Wichita, KS 67202				
Toles, John R., Drilling Contractor, Bloomfield, NM 87413				
Toltek Drilling Company, Denver, CO 80202	3			
Top Drilling Company, Inc., Oklahoma City, OK 73118	4			
Torreon Drilling Co., Inc., Corpus Christi, TX 78401	2			
Trace Drilling, Inc., Natchez, MS 39120	1			
Transamerica Oil Corporation, South Hutchinson, KS 67505	1			
Trans Continental Drilling Co., Houma, LA 70360				1
Transworld Drilling Co., Oklahoma City, OK 73125		2	9	
Triad Drilling Corporation, Wichita, KS 67202	4			
Triangle Drilling Company, El Dorado, KS 67042	2			
Trigg Drilling Company, Oklahoma City, OK 73118	7			
Triple J Explorations Development Company, Inc., Las Vegas, NV 89109	1			
Tri-Service Drilling Co., Midland TX 79701				
Tropic Drilling & Exploration Co., Bellaire, TX 77401 (F)			1	
True Drilling Co., Casper, WY 82602	11			
Tucker Drilling Company, Inc., San Angelo, TX 76901	8			
2-M Drilling Company, Inc., Woodward, OK 73801	2			
Two "R" Drilling Co., Inc., Metairie, LA 70005				8
Twin Arrow Drilling Co., Rangely, CO 81648	1			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Union Drilling, Inc., Buckhannon, WVA 26201	7			
Unit Drilling Company, Tulsa, OK 74119	10			
United Drilling Company, Tulsa, OK 74119	4			
United Drilling Company of Tyler, Tyler, TX 75703	6			
United Petroleum & Drilling Co., Inc., Houston, TX 77024	2			
Universal Drilling Co., Denver, CO 80265	1			
Uranium Exploration, Inc., Tulsa, OK 74105	14			
V-T Drilling Co., Evansville, IN 47708	1C			
Venekamp Drilling, Rapid City, SD 57701	2			
Venture Drilling Co., Cushing, OK 74023	1			
Verna Corporation, Houston, TX 77002				
Verna Drilling Company, Levelland, TX 79336	9			
Viersen & Cochran Drilling Company, Okmulgee, OK 74447	14			
W. E. K. Drilling Co., Inc., Roswell, NM 88201	2			
Wakefield, Earl F., Inc., Wichita, KS 67203	2			
War Bonnet Drilling Co., Houston, TX 77002	1			
Warren Drilling Co., Inc., Owensboro, KY 42301				
Warren, O. F., Drilling Company, Tulsa, OK 74103	6			
Warrior Drilling & Engineering Company, Tuscaloosa, AL 35401	2			
Warton Drilling Company, Odessa, TX 79760	6			
Weal Drilling Company, Inc., Carmi, IL 62821	4			
Weber Drilling Co., Hooker, OK 73945	1			

DRILLING COMPANY ANALYSIS, CONTINUED

COMPANY	NUMBER OF RIGS			
	Land	Platform	Mobile	Barge
Wek Drilling Co., Inc., Roswell, NM 88201	2			
Welltech, Inc., Houston, TX 77056	96 W			
Wes-Mor Drilling Inc., Graham, TX 76046	11			
Westburne Drilling Inc., Denver, CO 80202	12			
Wes-Tex Drilling Company, Abilene, TX 79604	11			
Western Gulf Drilling Co., New Orleans, LA 70112				
Western Oceanic, Inc., Houston, TX 77027			2	
Western Oil Well Service Co., Glendive, MT 59330	14 W			
Whatley Drilling Co., Inc., Tucson, AZ 85704				
Wheeler, F.C., Drilling Co., Stanton, TX 79782				
Wheless Drilling Co., Shreveport, LA 71101	3			8
White & Ellis Drilling, Inc., El Dorado, KS 67042	7			
Whitehead, E.E., Drilling Contractor, Drumright, OK 74030	1			
Whitley, Frank J., Houston, TX 77027				
Wilcox Drillers, Inc., Natchez, MS 39120				
Williams Drilling Co., Gillette, WY 82716				
Williams Drilling Co., Lafayette, LA 70505	8			8 W
Williams, R.E. Drilling Co., Memphis, TN 38103				
Willis Drilling Company, Inc., Edinburg, TX 78539	5			
Wilson Brothers Corporation, Shreveport, LA 71161	2			
Wilson, Fred, Drilling Co., Inc., Shreveport, LA 71161	6			
Wolfe Drilling Contractors, Inc., Lander, WY 92420	6			
Woolf & Magee Inc., Tyler, TX 75711	6			
Xplor Drilling Co., Wichita, KS 62707	1			
Young Drilling Company, Farmington, NM 87401				
Zapata Off-Shore Company, Houston, TX 77210	2			
Zenith Drilling Corporation, Inc., Wichita, KS 67202	6	1	8	

(F-9 mobile)

APPENDIX B

RELATIONSHIP OF FOOTAGE TO PRODUCTION

Domestic petroleum production in the United States has declined since 1970. Combined with a steady increase in demand, this decline has created an ever widening gap between supply and demand that must be filled by imported oil (Figure B-1).

In recent years, the only significant input to United States supplies has been production from the North Slope of Alaska. However, North Slope production has not lessened the gap between domestic supply and demand. This gap makes the nation vulnerable to imposition of oil embargoes between 1978 and 1995. The Drilling Technology Program proposed in this document covers this time period. It offers a way to reduce the nation's vulnerability to oil embargoes that are critical to our current economy.

Virtually all the oil and gas produced in the United States is produced from holes that must be drilled into the ground. Historical analysis shows that increased drilling results in increased reserves of oil and gas being found, which leads to increased oil and gas production (Table B-1). The proposed Drilling Technology Program, using the rigs already in operation, can improve oil supply by increasing the productivity of the drilling industry.

It is important to note that increasing the drilling rate does not provide oil and gas reserves or production additional to ultimate reserves. Additional drilling only provides the opportunity to increase production in the near future. In

Figure B-1 U.S. Supply and Demand Liquid Products 1960-1985

B-2

TABLE B-1

U.S. OIL RESERVES VERSUS FOOTAGE DRILLED

Period	New Reserves Found (Millions of Barrels)	Number of Wells Drilled (Thousands)	Reserves Per Well (Barrels)	Total Footage Drilled (Millions)	Reserves Per Foot Drilled (Barrels)
1946-1950	14668	185.0	79286	649	22.6
1951-1955	16202	250.0	64808	1004	16.1
1956-1960	14039	258.0	54414	1054	13.3
1961-1965	12724	219.0	58100	945	13.5
1966-1970	13590*	158.5	85741	756	18.0
1971-1975	9333	152.0	61401	748	12.5
			(avg. 67300)		

* excludes Prudhoe Bay reserves

Sources: World Oil
U.S. Bureau of Mines
American Petroleum Institute

this respect, additional drilling differs from an enhanced oil recovery program. An enhanced oil recovery program provides an increase in the ultimate reserves of oil by allowing the production of a greater percentage of the known oil in-place within reservoirs. For instance, increasing production from 30 percent of the oil in-place to 36 percent of the oil in-place in a reservoir by an enhanced recovery technique provides 20 percent more oil from that reservoir than could be recovered without the enhanced technique.

A review was made to determine the number of projects applicable simultaneously to individual rigs and the resulting effect of project application to productivity.

Table B-2 indicates mutually exclusive projects and groups from which only one project can be used at a time.

In addition to the exclusivity factor, a factor to reduce the overall effectiveness of simultaneous operating projects must be applied. This factor, the Multiple Program Factor (MPF), provides the reduction to compensate for inherent dependencies which would reduce overall effectiveness. Table B-3 shows compatible projects with the projected number of rigs to which they can be applied. The MPF is determined from this data and is applied in Table B-4.

Yearly tables, excluding training, are multiplied by the respective yearly MPF and the product determined is shown in Table B-4. Percent of improvement from Training Project 1-1 is added to obtain the expected improvement.

TABLE B-2

MUTUALLY EXCLUSIVE TECHNOLOGIES

1-1	Training	Applies to all projects.
2-1	Upgrade Conventional Drilling Rigs	} Mutually exclusive.
2-2	Drilling Rig Automation	
2-3	Directional Drilling Equipment	} Mutually exclusive.
2-4	Bottom-Hole Assemblies	
2-5	Mud Automation Systems	Applies to all projects.
3-1	Rig Instrumentation/Sensing Equipment	} Not Applicable.
3-2	Rig Floor Display/Analysis Equipment	
3-3	Down-Hole Logging - Telemetry System	} Mutually exclusive.
3-4	Surface Logging - Telemetry System	
3-5	Computer Controlled Drilling	Applies to all projects.
4-1	Jet Erosion Drilling	} Mutually exclusive.
5-1	Down-Hole Motor Technology	
6-1	Stratapax and Bit Technology	Applies to all projects.
7-1	Blowout Preventer	Not applicable.
8-1	Advanced Drilling Equipment	Not applicable.

TABLE B-3

MULTIPLE PROJECT ADJUSTMENT FACTOR
Rigs to which Technology Applies, Percent

Project No.	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
2-1								1.3	2.6	5.0	9.7	18.7	36.2	70.2	75
2-4				0.9	2.1	4.3	8.3	16.1	31.1	60	75	75	75	75	75
2-5													5.7	8.8	11.3
3-2			2.5	4.7	9.0	17.3	33.3	53.6	74.5	75	75	75	75	75	75
3-5			0.8	1.6	3.0	7.2	13.9	21.4	29.8	37.5	45.9	53.7	64.5	65.1	65.3
5-1						0.7	1.4	2.7	5.2	11.2	16.9	21	24.9	30.4	30.4
6-1	0.4	1.0	2.5	4.7	11.9	20.2	27.8	34.9	41.5	46.3	50	50	50	50	50
TOTAL	0.4	1.0	5.8	11.9	26	49.7	84.7	130	184.7	235	272.5	293.4	331	374.5	382
MULTIPLE PROGRAM FACTOR	1.0	1.0	.994	.988	.974	.950	.915	.870	.815	.765	.727	.707	.669	.625	.618

Note: The multiple program factor (MPF) is based on a 10% reduction in effective use per conflicting program.

$$\text{Thus MPF} = 1 - \frac{\text{Total}}{1000}$$

TABLE B-4
PERCENT ANNUAL IMPROVEMENT IN DRILLING RATE
BY PROJECT

Project No. & Description	1980	1981	1982	1983	1984	1985	Y 1986	E 1987	A 1988	R 1989	1990	1991	1992	1993	1994	1995
1-1 Training	0.8	1.5	2.3	3.8	5.3	6.8	8.3	9.8	10.5	11.2	11.2	11.2	11.2	11.2	11.2	11.2
2-1 Upgrade Drilling Rigs									0.1	0.2	0.4	0.7	1.4	2.7	5.3	5.6
2-4 Bottom Hole Assemblies					0.1	0.3	0.6	1.2	2.4	4.7	9.0	11.2	11.2	11.2	11.2	11.2
2-5 Mud Automation																
3-2 Rig Display Systems														0.1	0.1	0.1
3-5 Computer Con- trolled Drilling				0.1	0.2	0.3	0.6	1.2	2.0	2.7	2.8	2.8	2.8	2.8	2.8	2.8
5-1 Down Hole Motors				0.1	0.2	0.4	0.9	1.7	2.7	3.7	4.7	5.7	6.7	8.1	8.1	8.2
6-1 Stratapax Bits							0.1	0.2	0.3	0.6	1.4	2.1	2.6	3.1	3.8	3.8
TOTAL Excluding Training	0.1	0.2	0.4	0.7	1.8	3.0	4.2	5.2	6.2	6.9	7.5	7.5	7.5	7.5	7.5	7.5
TOTAL Adjusted for Multiple Projects Excluding Training	0.1	0.2	0.6	1.2	2.8	5.2	8.5	12.7	18.1	25.2	30.0	32.2	35.5	38.8	39.2	
FINAL PERCENT IMPROVEMENT EXPECTED	0.8	1.6	2.5	4.4	6.5	9.5	13.2	17.6	21.5	26.0	30.5	33.0	34.0	34.9	35.4	35.4