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MONITORING TO DETECT GROUNDWATER PROBLEMS RESULTING FROM ENHANCED OIL RECOVERY

by

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FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimonies to the deterioration of our natural environment. The complexity of that environment and the interplay of its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution; it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems to prevent, treat, and manage wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, to preserve and treat public drinking water supplies, and to minimize the adverse economic, social, health and aesthetic effects of pollution. This publication is one of the products of that research and provides a most vital communications link between the researcher and the user community.

This report develops a groundwater monitoring program for the early detection of any environmental problem that may result from enhanced oil and gas recovery operations. The program is readily adaptable for use at specific sites. The report will be of interest to all those interested in the potential environmental impacts that may be associated with tertiary oil and gas production. Further information may be obtained through the Oil and Hazardous Materials Spills Branch, Edison, New Jersey 08837.

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ABSTRACT

This report develops a four-stage monitoring program to detect groundwater contamination events that may potentially result from enhanced oil recovery (EOR) projects. The monitoring system design is based on a statistical analysis evolving from a series of equations that model subsurface transport of EOR spills. Results of the design include both spatial and frequency monitoring intervals that depend on properties of the local geology and dispersion characteristics of the potential contaminants. Sample results are provided for typical reservoir characteristics.

Selection of measures to be sampled is based on a review of the identity of likely contaminants, on the available sample and analysis procedures, and on the cost and time constraints on analysis. Nonspecific indicator measures are identified that can be used to flag those intervals requiring more intensive and specific monitoring.

The number of independent variables in the analysis dictate that EOR monitoring systems be designed on a site-specific basis. Sampling designs can be easily formulated to conform to the peculiarities of chosen EOR sites based on data already available from federal and state geological surveys and from oil company statistics.

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ABBREVIATIONS AND ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BOD	Biochemical Oxygen Demand
DOE	Department of Energy
EGR	Enhanced Gas Recovery
EOR	Enhanced Oil Recovery
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
EV	Environmental Office, Department of Energy
GC/FID	Gas Chromatograph with Flame Ionization Detector
GC/MS	Gas Chromatograph/Mass Spectroscope
ICAP	Inductively Coupled Argon Plasma Detector
IOCC	Interstate Oil Compact Commission
MBA	Methylene Blue Active Substances Test
MERL	Municipal Environmental Research Laboratory, EPA
NAS	National Academy of Science
NASQAN	National Stream Quality Accounting Network
NIH	National Institutes of Health
NWDE	National Water Data Exchange
NWQSS	National Water Quality Surveillance System
OSHA	Occupational Safety and Health Act
RCRA	Resource Conservation and Recovery Act
TOC	Total Organic Carbon
TDS	Total Dissolved Solids
TSCA	Toxic Substances Control Act
USGS	United States Geological Survey

SECTION 1

INTRODUCTION

THE NEED FOR MONITORING PROGRAMS[1]

Various recent studies of the environmental aspects of enhanced oil recovery (Donaldson, 1978; United States Department of Energy, 1978; and Beck et al., 1980, for example) have identified contamination of freshwater in aquifers as a potential consequence of extensive enhanced oil recovery (EOR) activities. The DOE has ranked micellar polymer flooding as having the potential for significant environmental constraints (United States Department of Energy, Office of the Assistant Secretary for Environmental Protection, Safety and Emergency Preparedness, 1980). Many potential routes exist for groundwater pollution. No firm evidence is available that such pollution does or will occur, nor is there a complete understanding of the pollutant mechanism.

Relatively few data have been collected from the aquifers that may be contaminated from currently active enhanced recovery programs. Many of the enhanced recovery projects are experimental in nature, and all available resources were devoted to assembly of engineering performance data. Many of the early EOR projects took place in sparsely populated areas where no convenient water wells useful for the sampling of aquifer quality existed. Uncertainties as to whether groundwater contamination does in fact take place will persist until adequate data sets become available for study, or until a major pollutant event occurs that is readily detected by the public. For assembled data to be useful for pollutant detection and analysis, data must be collected consistently and according to statistically valid sampling procedures.

The various organizations responsible for environmental data collection (oilfield operators, U.S. EPA, USGS, U.S. DOE, state resource agencies and local resource agencies) have different monitoring objectives. Thus, each group's

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[1]For meaning of abbreviations and acronyms in this and subsequent sections, refer to listing on p. ix.

monitoring program design will be different although some elements will be in common.

A monitoring system is needed for use by research and policy groups such as the U.S. EPA, U.S. DOE and API. They will require nationwide data sets that can be used to detect long-term trends, to identify regional problems, and to determine how much attention should be paid to potential hazards to groundwaters from EOR activities. Any analysis that is to be applied to large data sets will require consistent data. If each station selects an entirely new set of variables to sample, intervals of sampling, and sampling procedures, then the statistical problems involved with using the entire national data set will be large.

The lack of sets of data collected over a long period of time to serve as a baseline is probably the most significant constraint as regards groundwater sampling, since chemicals can be expected to move only a few feet per year in most subsurface environments.

Additionally, the groundwater problem is so broad in scope that a generalized sampling plan at an affordable level of effort will be unlikely to yield useful results.

With these problems and provisos in mind, there is needed a set of procedures that will accomplish routine monitoring in an efficient fashion.

BACKGROUND

Information is available from various environmental monitoring programs developed over the last 15 years. For example, the USGS has developed the NASQAN water-quality monitoring network and the EPA has developed the NWQSS network. The USGS has maintained a computer file of groundwater quality data for over more than 10 years.[1] The states of California, Texas, Kansas, Oklahoma, and Illinois (among others) maintain records of oilfield connate waters, brines,

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[1]Contact the USGS National Water Data Exchange, Reston, Virginia, for further information.

[2]All unpublished data available from the state agencies (California Division of Oil and Gas, California Department of Water Resources, Texas Railroad Commission, Kansas, Oklahoma, and Illinois Geological Surveys) and some data available on tape from the U.S. DOE, Bartlesville Energy Research Center.

and adjoining aquifers.[2] EPA is developing monitoring programs regarding Underground Injection Control regulations.

Each of these existing monitoring or data repository systems is an important element in the design of a monitoring program for enhanced recovery operations. In addition, hierarchical chemical analysis schemes have been developed to deal with the requirements of RCRA, the Safe Drinking Water Act, and TSCA. Finally, the EPA Las Vegas Laboratory has developed a series of comprehensive documents regarding monitoring to detect groundwater pollution from oil-shale projects (Todd et al., 1976; Slawson, 1979; Slawson and McMillian, 1979; Pimental et al., 1979).

The statistical and sampling theory bases for developing groundwater monitoring program all exist for other applications. Modeling work includes Bender et al. (1977), Gray and Pinder (1976), Peaceman (1977), and Aris (1978). A variety of monitoring program designs for other applications were developed by Gunnerson (1966), Matalas (1967), Lettenmaier (1975), Montgomery (1974), and Beck and Pierrehumbert (1976).

OBJECTIVES OF THIS STUDY

This study aims at meeting the data needs for the identification of the nature and extent of groundwater contamination due to enhanced oil recovery activities.

The primary objective of this study is to design an efficient EOR project groundwater monitoring program and to develop the necessary procedures to accomplish this. This study is to provide the groundwork for development of standard principles to be used in monitoring EOR projects.

Monitoring guidelines are to be developed through analysis of: (a) review of chemical use data and of toxicity and carcinogenicity studies that establish the pollutants of concern, (b) statistical analysis of patterns of variability to establish suitable sampling frequency and sample well spacing and patterns, and (c) review of analytical protocols available that will yield valid results.

SECTION 2

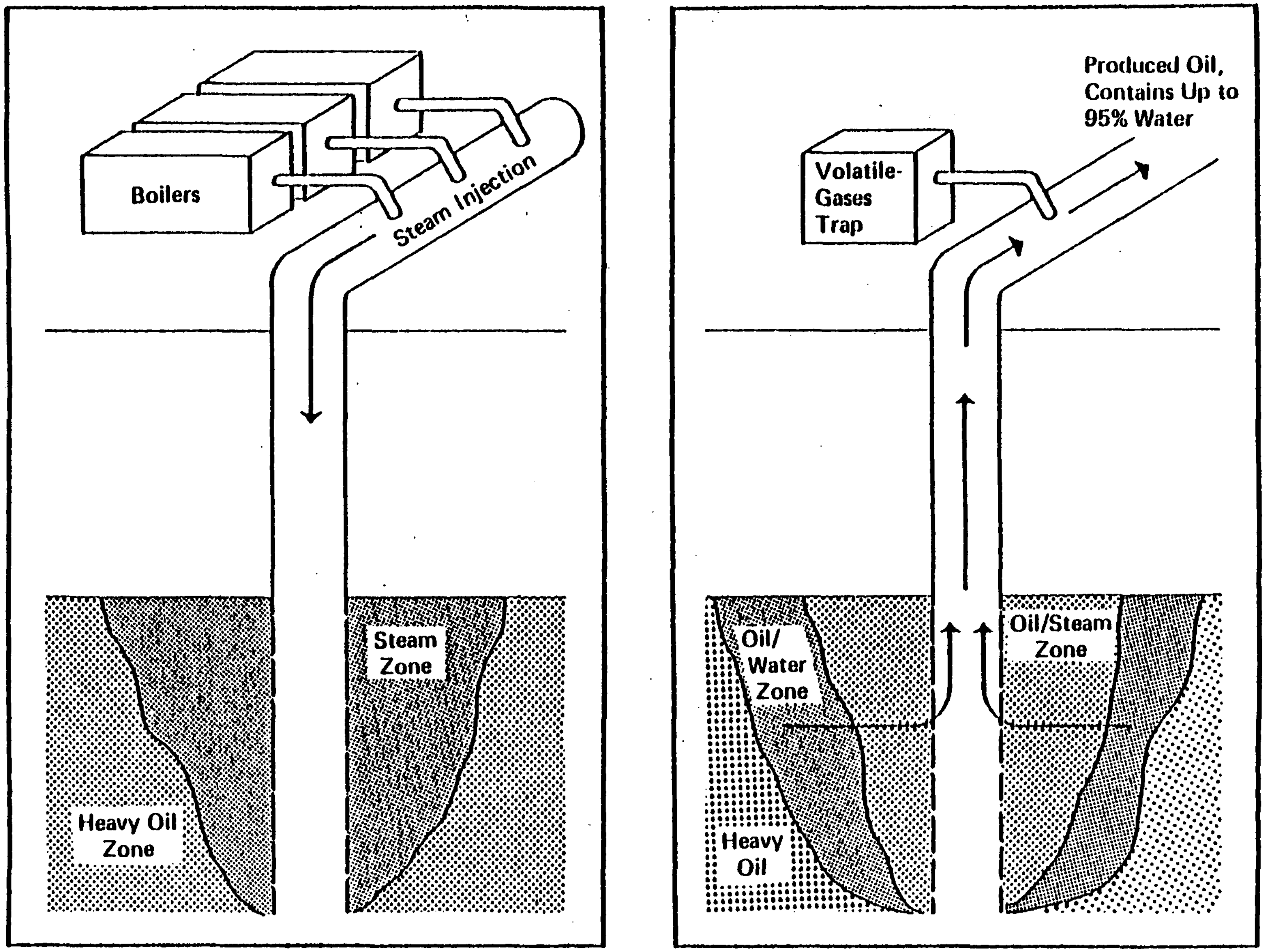
OVERVIEW OF EOR PROCESSES

After World War II, as a result of the increasing demand for crude oil, attention was given to improved management of the known oil in place, as well as to an expansion in exploration. Scientists and engineers had recognized that simple techniques of improved oil recovery were potentially useful and realized that new methods could play a very important role in adding to oil reserves and reservoir productivity (American Petroleum Institute, 1961). Since the end of the war various new fluid-injection methods have been researched that provide the potential to recover large volumes of oil left in reservoirs after conventional recovery. Little effort, however, has been applied to identification of environmental problems.

STEAM INJECTION

Documented cases of steam injection were reported in the 1920's and 1930's, and apparently the technique had been discovered long before that. In at least one case -- in the tight sands of the Bradford, Pennsylvania, field -- the steam or hot water injection was initiated to improve injectivity of the water rather than to increase production (American Petroleum Institute, 1961). In other situations the steam had been intended for paraffin removal from the well bore. Steam injection did not significantly progress until the 1960's, when the Shell Oil Company succeeded with a cyclic steam soak in California (American Petroleum Institute, 1961). Since then, steam flooding has been applied successfully to heavy oils in a variety of California fields (Figures 1 and 2). At the present time, steam soak is a technically proven and economically acceptable enhanced-recovery process, and in some cases steam flooding looks promising. Large-scale expansion of steam soak in California is currently being held up by air-pollution concerns. Various options are under consideration, including use of scrubbers, low-NO_x burners, fluidized-bed coal generators and solar generated steam. Possible revision of air-pollution regulations would simplify the problem.

There has been little concern about environmental protection until the present. Conflicts with air regulations have



I. INJECTION PHASE

II. PRODUCTION PHASE

Figure 1. Steam-soak process.

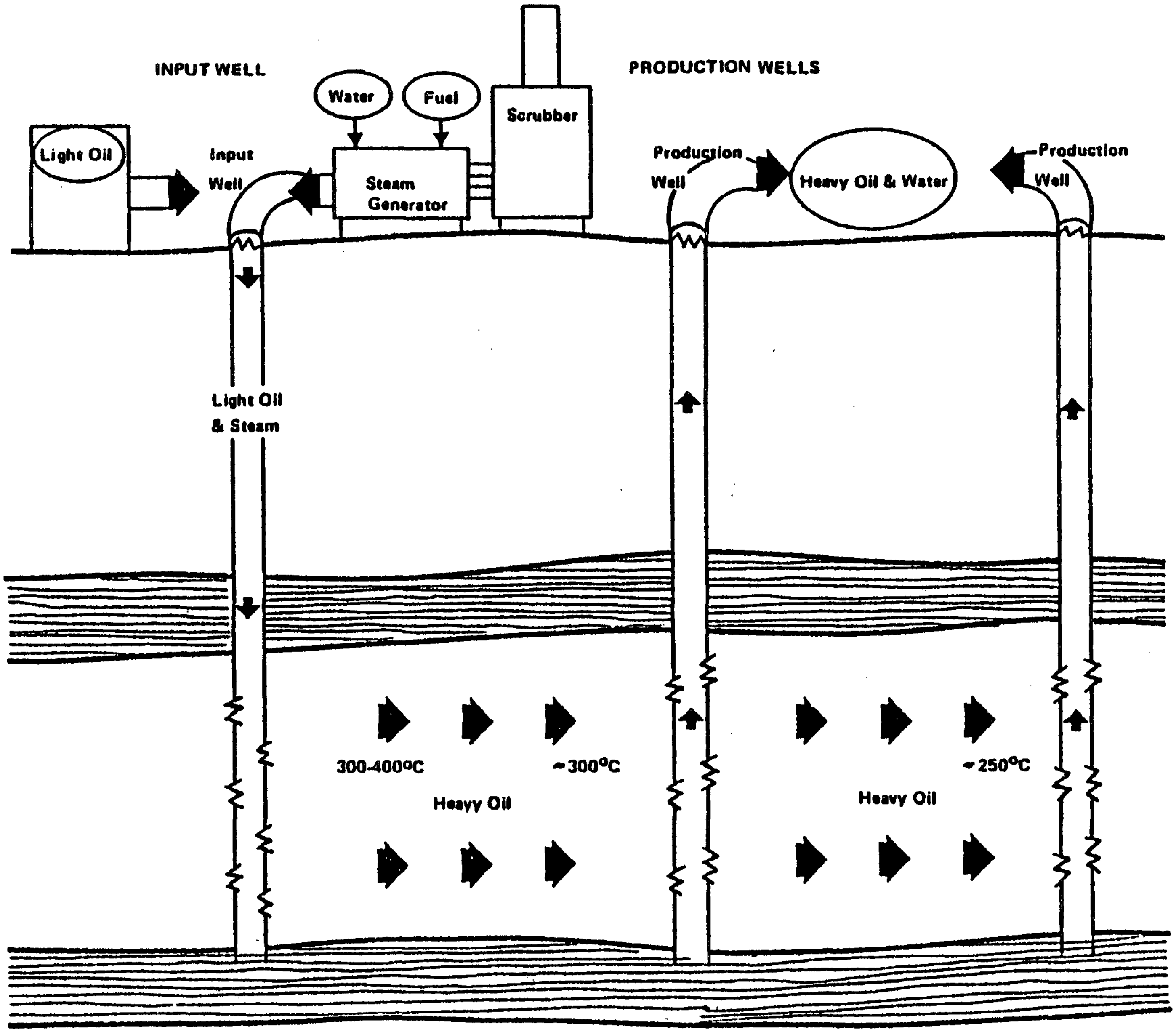


Figure 2. Steam-drive process.

led to air sampling, stack sampling, air-dispersion modeling, and developmental scrubber engineering. Re-use of produced water for steam injection is also under study.

IN SITU COMBUSTION

Air and water injection were common in the earlier part of the 1900's. The purpose of air injection at that time was to "push" the oil toward the producing well. Yet the O_2 content of the resulting air samples indicated that subterranean combustion had been at least partially responsible for the "air-injection" that increased production.

In situ combustion was probably unknowingly conducted in the early 1900's before it was recognized as such. Some of the earliest work in in situ-combustion EOR occurred in Russia in 1935, in shallow, high-permeability, high-porosity sands. The oil-laden sand was ignited by glowing charcoal (American Petroleum Institute, 1961). This work was performed in a pressure-depleted reservoir with 36 API gravity crude. The recovery was small, but significant. The most significant present work in the United States is in California, by Getty and Citgo (Beck et al., 1980). Figures 3 and 4 depict the process. Environmental studies have not been performed.

IMPROVED WATERFLOOD[1]

Simple waterflooding had its beginning over a century ago, in the Bradford field of western Pennsylvania, when an insufficient packer[2] allowed leakage of shallow groundwater into a well's oil column. While the production of the immediate well was curtailed, there was a marked increase in oil production at the surrounding wells.

Early operators built on this experience and developed "circle floods" whereby they would waterflood their field incrementally by turning central producing wells into water injectors and, as oil production continued, they would, in an expanding circle, convert the closest watered-out producers to water injectors.

For many years waterflooding was practiced illegally in Pennsylvania; not until 1921 was the practice legalized there. Other early waterflooding projects took place at

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[1]Summarized from Schumacher, 1978.

[2]Packer - the outer supporting structure of a well.

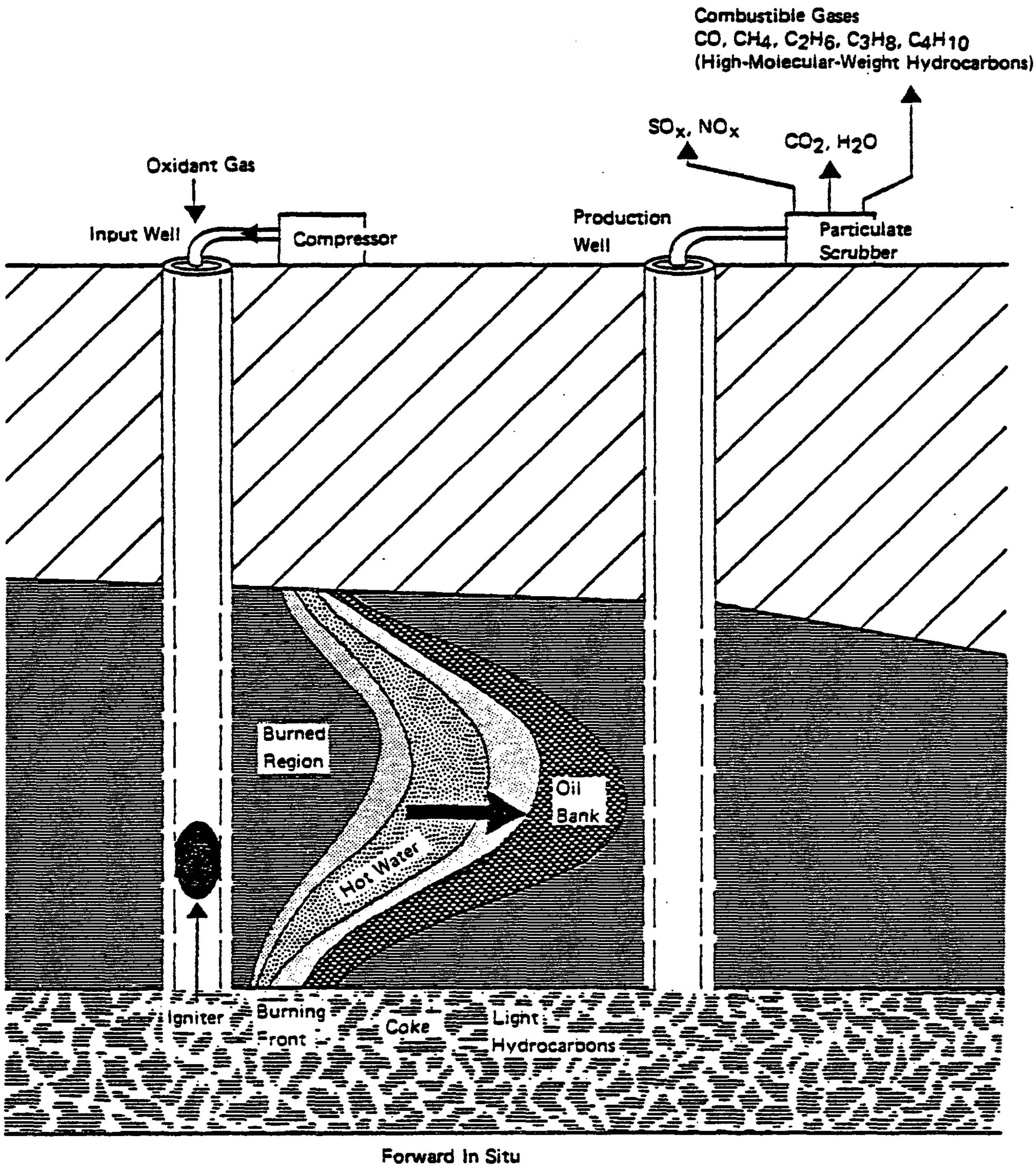
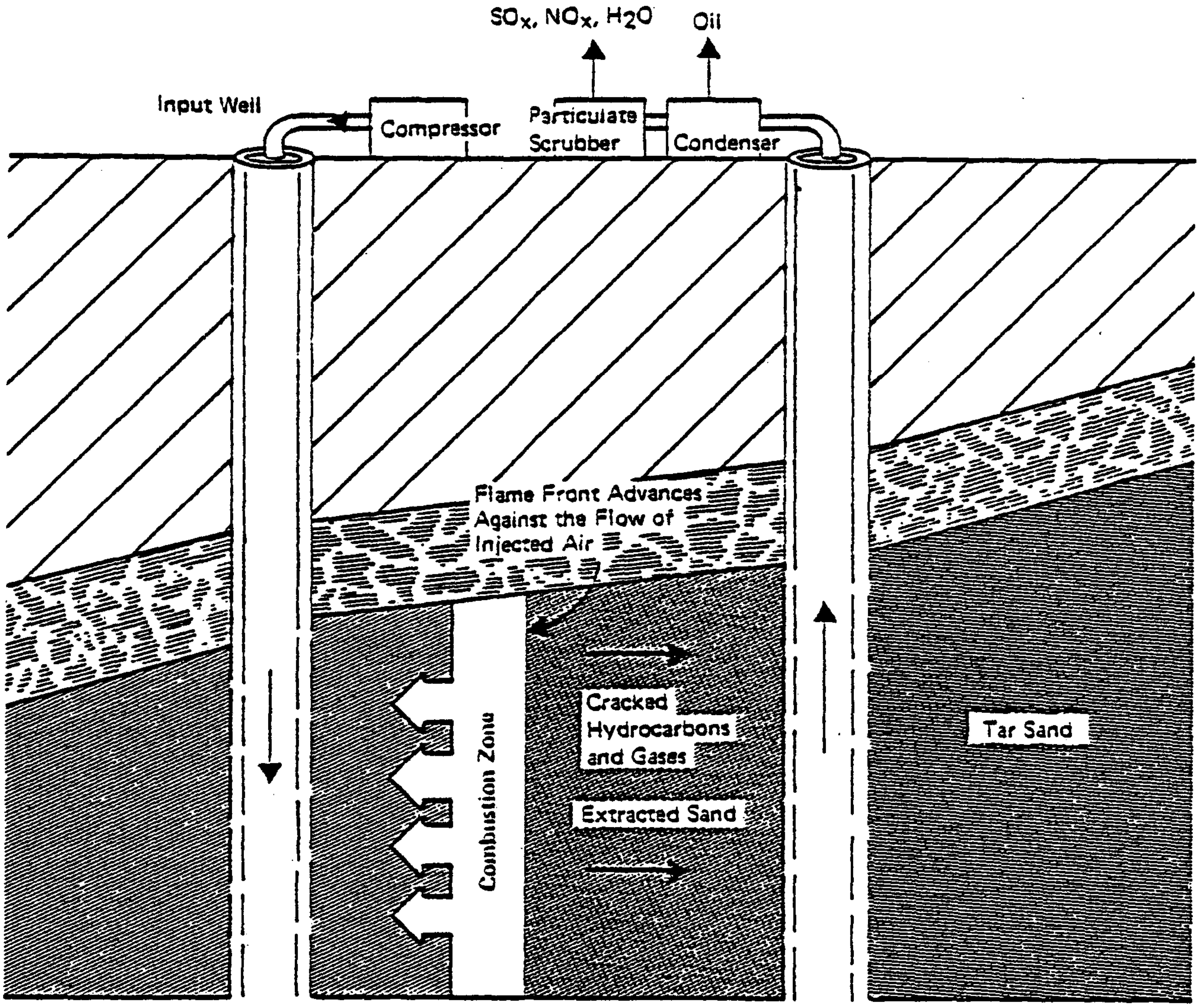


Figure 3. Forward in situ-combustion process.



Reverse In Situ

Figure 4. Reverse in situ-combustion process.

California's Kern River field and in Ontario (Interstate Oil Compact Commission, 1974), but many believed the water would contaminate or dilute the oil. Legislative constraints diminished in the 1940's, however, and the practice spread to fields across the country.

Improved waterfloods or polymer-augmented waterfloods were developed in order to increase recovery efficiency of the flood. The improvement in oil-displacement efficiency over and above straight waterflooding is minimal, but the polymer thickens the injected water and greatly improves the sweep conformance,[3] causing the waterflood to affect a larger fluid mobilities, and particularly to the fluid mobility ratio of oil to water on injection and production in flood patterns. The results suggested increasing waterflood's sweep efficiencies by increasing the viscosity of the injected water (Chang, 1978). Then in 1964 water-soluble polymers were suggested as the preinjection thickening to reduce water mobility. Numerous laboratory and field studies have been done since that time to further refine the process. Improved waterfloods were field-tested in the 1960's.

The injected chemicals are of potential enviromental concern. Historical data on polymers used in this process exist from their use as flocculating agents in water-treatment processes. Flocculating agents have been screened for health hazards on a regular basis by the chemical manufacturers that supply them; there is no formal EPA review process, however, nor have any detailed EPA studies been performed to evaluate use of flocculants.

MICELLAR/POLYMER FLOODING[4]

Micellar/polymer flooding involves the use of a surfactant/water injection followed by polymer/water injection.

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[3]In summary, sweep conformance means flooding the entire volume of the oil-bearing zone. See petroleum engineering texts, for example, the Society of Petroleum Engineers monograph series, for a detailed explanation of this.

[4]Gogarty (1975) reviews the development of surfactant or micellar/polymer flooding in his paper on the "Status of Surfactant or Micellar Methods."

[5]Sweep Efficiency is the percentage of recoverable oil that is produced at time of water breakthrough in the production well.

These "slugs" of fluid act to improve the displacement efficiency and sweep efficiency over a conventional waterflood. Polymer injection adds conformity to and enhances sweep efficiency[5] of the surfactant slug, which acts to minimize fluid-oil interfacial tension[6] (see Figure 5). Surfactant flooding was initiated in the late 1920's and the 1930's, using polycyclic sulfonic substances and wood sulfite liquor. As the technique progressed, a variety of chemical substances were considered for use as long as they achieved the desired results of reduced interfacial tension between oil and flooding fluid and prevention of excessive adsorption of the surfactants in the reservoir. A range of surfactant-solvent compounds are still used in micellar/polymer flooding today, and as a result it is difficult to analyze the pollution effects from the surfactant slug.

Additional laboratory studies and refinement of the chemical-flooding theories gave rise to the so-called low-tension flooding process, whereby large volume (30 percent of the pore volume), low-surfactant-concentration (<2 percent) floods are used. In 1959 and 1961 this process was further refined by patents teaching injection of surfactant in low-viscosity hydrocarbon solvent (Holm and Bernard) and other hydrocarbon solutions for specific reservoir conditions. The processes using petroleum-based sulfonate slugs became known as soluble-oil flooding processes.

Microemulsions[7] for use in oil recovery were first patented as part of a well-stimulation process to remove obstructing waxy solids. Twenty years later, what would become the well-known "Maraflood" enhanced-recovery process, licensed by Marathon Oil Company, was introduced by Gogarty and Olsen. This process differed from the low-tension floods because a small fraction of the pore volume and a relatively high surfactant concentration (>5 percent) were used.

Several types of surfactant flooding have been developed, but generally they are of two types. In the first, large volumes (15 to 60+ percent pore volume) and low concentrations of surfactant dissolved in oil or water are injected. The second type involves a relatively small volume (3 to 20 percent pore volume) of highly concentrated surfactant.

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[6]Interfacial tension is an instability between two liquids along their interface caused by dissimilarities in molecular compositions.

[7]Microemulsions: surfactant-stabilized dispersion of water and hydrocarbons. The aggregates of surfactants and hydrocarbons (micelles) are in the general size range of 10^{-6} to 10^{-4} mm.

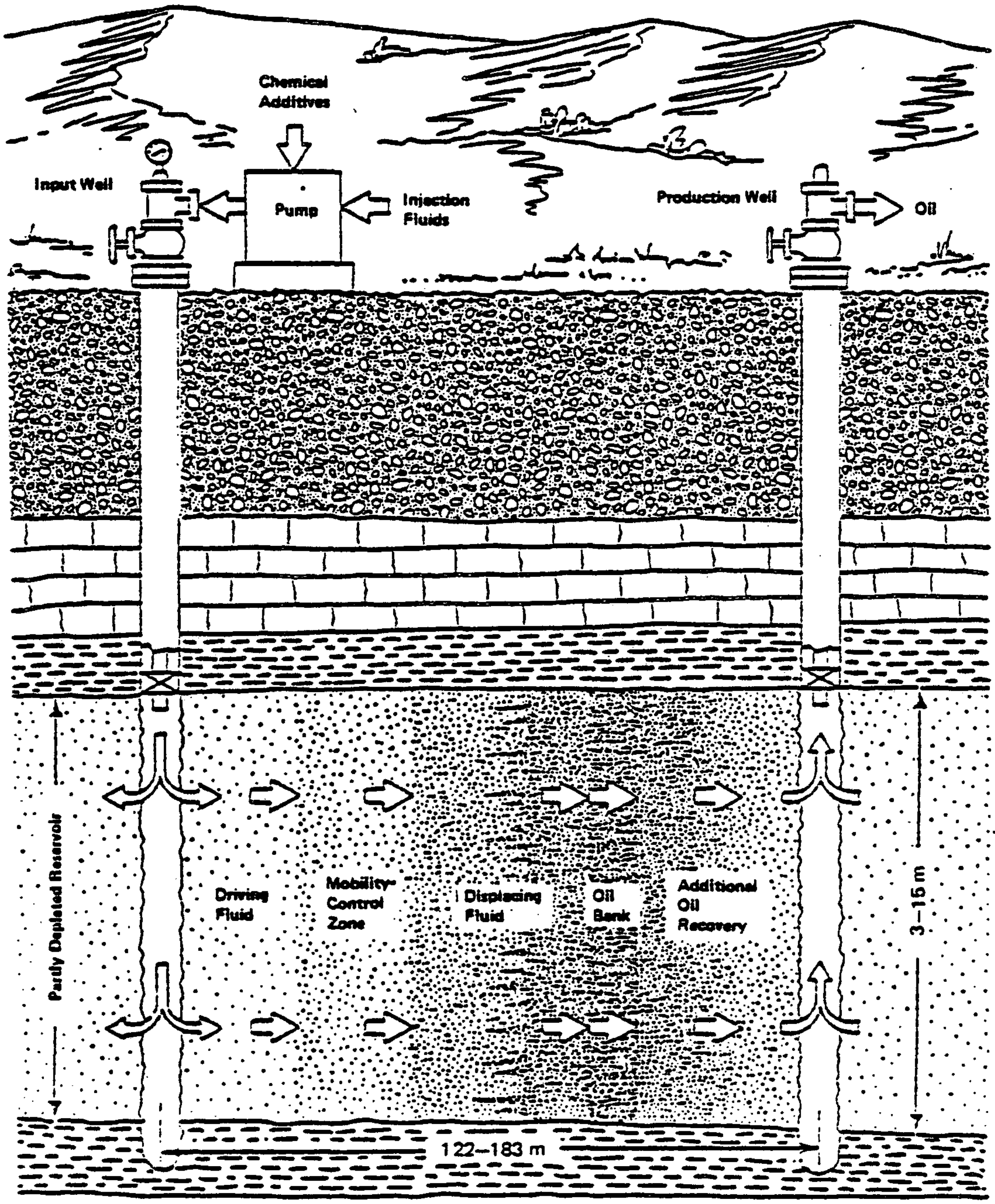

Figure 5. The micellar-polymer flooding process (ERDA, 1975).

The slug that is used in micellar/polymer floodings can have a variety of components that make assessment of its environmental hazards difficult at best. Often the exact composition of additives used is not known, since crude extracts of a roughly determined nature may be added. The basic composition of a micellar slug is hydrocarbon, surfactant, and/or water, and often added to these are a cosurfactant (usually alcohol) and electrolytes (inorganic salts).

ALKALINE FLOODING

The history of alkaline flooding is most likely directly aligned with that of waterflooding. After waterflooding was recognized as an effective recovery mechanism, the addition of various alkaline chemicals was considered as an option for recovery of further fractions of the remaining oil in suitable reservoirs. The alkaline chemicals, such as sodium hydroxide and potassium hydrate, were added to the drive water to enhance recovery by improving formation wettability and oil emulsification and by reducing interfacial tension (U.S. Deparatment of Energy, 1978).

Regarding environmental protection, the only relevant work has been a recent environmental assessment (O'Banion, 1978b).

CO_2-MISCIBLE FLOODING

Out of the search for the development of more efficient recovery technologies, the concept of miscible-fluid flooding developed, and many petroleum scientists were intrigued by the idea of miscible-fluid displacement (Interstate Oil Compact Commission, 1974). Although the concept of miscible-fluid displacement was proposed in 1972, the idea was not tested in field applications until the late 1950's (Schumacher, 1978).

The use of CO_2 as a miscible-flooding agent evolved because it was known to be one of the few low-cost fluids that could be miscible with both oil and water if the right physical conditions were maintained (Schumacher, 1978). A carbonated waterflood using this concept was initiated in the Bartlesville sand formation, Oklahoma, in 1961. From 8 to 10 pounds of CO_2 were added to each barrel of injected water. However, this application had very disappointing recovery effects, apparently due to formation fractures and peripheral stratifications that diverted the mainstream of the fluid (Interstate Oil Compact Commission, 1974). Though laboratory tests showed the CO_2 process to be promising and very efficient, in field applications the miscible slug of solvent apparently becomes enriched with oil as it passes through the reservoir, and loses a large part of its scavenging ability (Interstate Oil Compact Commission, 1974).

SECTION 3

GROUNDWATER CONTAMINATION PATHWAYS

Enhanced recovery can result in contamination of aquifers by a variety of pathways that fall into three general categories: 1) downward leaching from surface disposal, 2) communication to aquifers via improperly sealed or cased wells, and 3) communication to aquifers through fractures or cracks in previously impermeable formations. Such fractures may be opened up by changed reservoir pressures accompanying enhanced oil-recovery techniques and subsequent reinjection or by gas fracturing. Figure 6 depicts the major routes of contamination.

Evaluation of existing information can provide only tentative conclusions regarding groundwater degradation. Significant risks to groundwater quality are apparent. Some of the chemicals employed in enhanced recovery may be toxic or carcinogenic. Little is known about the degradation products of these chemicals, which may be more or less toxic than the parent chemicals. Brines, which are produced in a ratio with oil as high as 20:1 in current enhanced-recovery operations, have the potential to contaminate freshwater aquifers by reinjection or disposal. Brines also contain heavy metals that may migrate from the disposal site. Some of the pathways depicted in Figure 6 are known to exist as a result of pollutant events that have already occurred. Others only represent possible pathways. The volumes and concentrations of chemicals used are significant enough to warrant further investigation of the toxicities of the chemicals and of the pollutant pathways.

All enhanced-recovery technologies involve potential groundwater concerns. Those technologies that require injection of chemicals into the reservoir or fracturing of formations hold the most potential for contamination. In situ combustion is also of particular concern, because of the range of chemicals that are formed during the subsurface combustion process. Table 1 summarizes the types of pollutant problems that may occur.

In addition to the generic concerns, there are various environmental/institutional situations that may enhance pollutant risks. These must be looked at in a site-specific

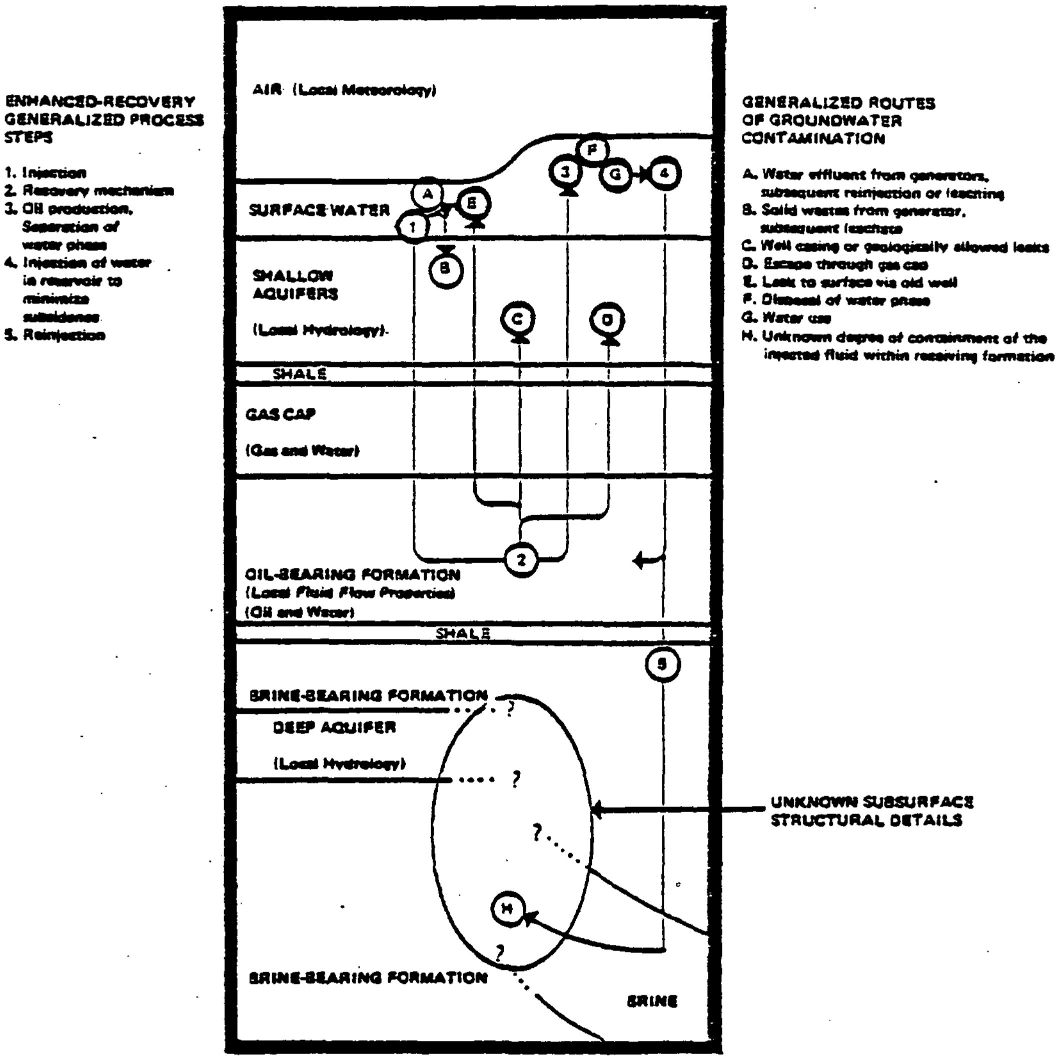

Figure 6. Major routes of groundwater contamination associated with enhanced recovery.

or a technologywide assessment, and should be considered in terms of their probability of occurrence. Insufficient information is available to make reliable determinations of such probabilities at this time. The types of situations of concern include:

1. EOR programs taking place in old fields in which unmapped abandoned wells exist. These old wells are in some cases imperfectly sealed and may lead to communication with freshwater aquifers.

2. EOR programs making use of old fields in which old wells are not all reworked or recapped. Cracks in cement or casings, as a result of corrosion, age, or both, may allow communication with freshwater aquifers. Proposed underground injection regulations would require reworking of all wells within .4 km of all EOR activities.

3. Freshwater aquifers located just above or below the producing formation. This would greatly increase the opportunity for contamination over the more common situation, in which aquifers are far removed from producing layers.

4. EOR programs taking place in areas that have undergone significant subsidence. In such areas the subsidence events may have resulted in fracturing or other structural alterations allowing transport of pollutants.

5. High seismic activity in the region of the project. The producing reservoir will become a repository for brines containing a variety of injected chemicals. These hazardous wastes may escape the oil formation following seismic events.

6. Freshwater aquifers located below disposal ponds for drilling muds and hydraulic fracturing fluids. In these situations, leachate contamination may occur.

TABLE 1. SUMMARY OF LEVELS OF RISK ANTICIPATED FROM VARIOUS ACTIVITIES CARRIED OUT DURING ENHANCED-RECOVERY PROGRAMS. THESE ARE ERCO ESTIMATES BASED UPON AVAILABLE EVIDENCE.

		Activities Causing Groundwater Contamination				
		Injection of Chemicals	In Situ Formation of Pollutants	Cause Subsurface Structural Changes (new pollutant routes)	Disposal of Solid Wastes with Hazardous Leachate	Summary of Potential for Groundwater Problems
Enhanced Recovery Processes	Steam	–	+	–	+	Low
	In Situ Combustion	–	*	–	–	Medium
	Polymer	*	–	+	–	High
	Polymer/ Miçellar	*	–	+	–	High
	Alkaline	*	*	+	–	High
	CO_2	+	–	+	–	Low
	Hydraulic Fracturing	+	–	++	+	Medium
	Explosive Fracturing	–	–	++	–	Medium
	Directional Drilling	–	–	–	–	Low

LEGEND:
–*Negligible Risk*
+Potential for Occasional Pollutant Events
*Significant Potential for Regular Occurrence of Pollutant Events If No Measures Are Taken

SECTION 4

A SIMPLE PROGRAM TO MONITOR EOR PROJECTS

This chapter presents a simple monitoring scheme that can be implemented as part of an enhanced oil-recovery project. The purpose of such a so-called detection monitoring program will be to check for indications that groundwater degradation may be occurring as a result of the EOR project. A more sophisticated monitoring procedure may be appropriate in cases where the project is very large or where the regional geology has been identified as making the project particularly susceptible to pollutant events. In such situations, the procedures discussed in Sections 5 through 8 will be pertinent.

OVERVIEW

Particular monitoring activities and intensities of sampling will be associated with different EOR technologies and with each stage of an EOR project. Table 2 depicts a general scheme for monitoring. The scheme involves assembly of background and baseline information during the early stages of a project, with routine monitoring during the course of the project and, in some cases, follow-up monitoring for 5 years after the project is completed. For relatively low-risk technologies such as thermal-oil recovery, less monitoring is required.

CONCEPTUAL DESIGN OF THE MONITORING PROGRAM

Figures 7 and 8 summarize the overall concept of EOR/EGR (Enhanced Gas Recovery) monitoring. Figure 7 gives a step-by-step outline of the tasks to be carried out in an environmental-monitoring program. The approach is a hierarchical one, in which the simplest, broadest monitoring activities are first performed and then only those analytical tests relevant to specific environmental problems are incorporated in the detailed and comprehensive phases of a monitoring program. Figure 8 characterizes each of four hierarchical stages in a monitoring program.

TABLE 2. GENERAL SCHEME FOR MONITORING OF EOR IMPACTS ON GROUNDWATER.

Type of Project / Stage of Project	Conception	Field Management (Rework or seal old wells, drill new wells)	Preflush	Injection of Chemical Slugs	Production by Water or Steam Injection	Post Production
Steam Soak, Steam Drive	Assemble Baseline Data; Formulate Pollution-Response Plan	Prepare a Map of All Old Wells; Monitor Reworking Activities	N.A.*	N.A.	Perform Diagnostic Monitoring Only If Unusual Reservoir Conditions Are Noted	None Required
In Situ Combustion			N.A.	N.A.		
Steam Drive with Additives			N.A.	Monitor for Presence of Chemicals in Produced Oil & Water		
CO_2, Other Miscible Gas			Carry Out Tracer Studies	Carry Out Tracer Studies	Conduct Routine Monitoring of Nearby Groundwater	
Advanced Waterflood, Polymer Flood						Conduct Routine Monitoring of Nearby Groundwaters
Alkaline Flood Micellar/Polymer Flood						

*N.A. = Not Applicable.

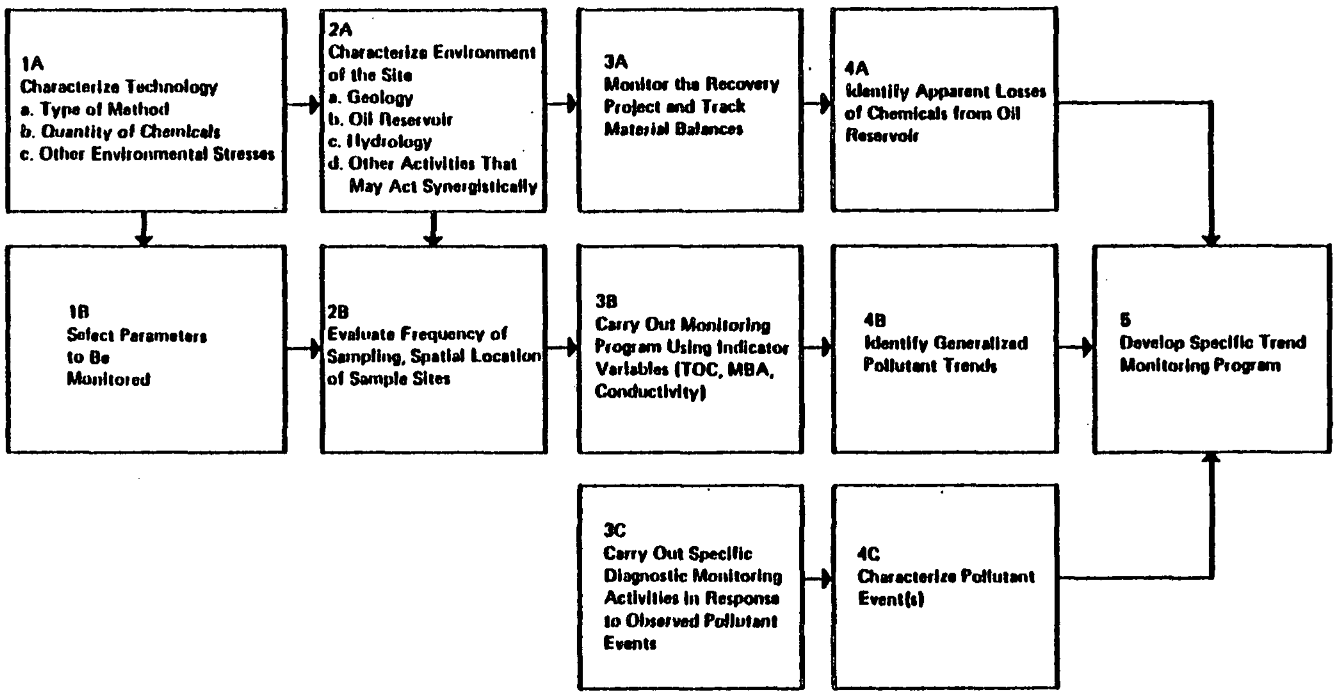

Figure 7. Monitoring Program: Water-Quality Degradation from EOR/EGR.

	STAGES OF MONITORING			
	I DEVELOP BASELINE	II MONITOR TRENDS	III SPECIFICIALLY EVALUATE FLAGGED PROBLEMS	IV ASSESS EFFECTIVENESS OF CONTROLS
Parameters to be Measured	Indicators	Indicators	Specify Chemicals	Specify Chemicals
Purpose of Monitoring	Determine Existing Conditions	Identify Changes In Levels	Identify Problem Contaminants, Identify Violations of Standards	Compare Levels with Regulatory Criteria; Check for Reduction in Levels to Below Criteria Values
General Strategy	a. Measure Baseline Levels b. Identify Spatial and Temporal Patterns	a. Select Key Stations b. Take Periodic Measures c. Look for Changes in Identification Patterns	a. Perform Specific Tests to Determine Contaminants That Have Caused Trends b. Determine If Criteria Have Been Violated c. Determine Spatial Extent of Contamination	a. Evaluate Contaminant Trends in Response to Controls
Major Dimension(s) of Analysis	Spatial and Temporal	Temporal for Representative Sites	Profile of Classes of Contaminants	Temporal for Specific Problem Zones

Figure 8. EOR/EGR Environmental Monitoring Overview Matrix. This display summarizes the major characteristics of the four types of monitoring needed to evaluate environmental quality.

REPRESENTATIVE MONITORING PROGRAMS

To show how the general scheme in Table 2 should be applied to a particular project, two typical monitoring programs are outlined, for a polymer flood in Table 3, and for a steam flood in Table 4. Each element of the monitoring program for the polymer-flood example is described below.

Design of Project

During the initial design stages of a polymer-flood project, available data on local groundwaters are collected. At a minimum, a cross-sectional mapping of the location of all freshwater aquifers in relationship to the producing formation is prepared. In particular, aquifers that are traversed by injection, production, or abandoned wells are noted. Additionally, all available monitoring data on the quality of these local aquifers are assembled. Geostatistical procedures such as "kriging" are employed to develop averages weighted by the spatial distribution of the sample points.

Reworking of Oilfield Wells

During the preparation stage of the polymer flood, a map is drawn that locates all the wells that penetrate the formation to be flooded. All wells are keyed by age, and all plugged and otherwise abandoned wells are noted. During the drilling of new EOR wells and reworking of old wells for use during the project, well-log data and well pressures are monitored to detect any communication of fluids with freshwater aquifers that are traversed. This monitoring procedure is a standard part of oilfield operations.

Preflush

During the preflush stage of the polymer flood, the initial pressurization of the reservoir takes place (even though sometimes the field has been subjected to secondary waterflooding for several years prior to the polymer project). A tracer is injected during the preflush to track the movement of the injected fluids under the new pressure conditions. The tracer is tracked in existing oil wells and also in water wells penetrating adjacent aquifers, to verify that no communication is occurring with freshwater bodies. Samples of the preflush fluids are drawn to determine their chemistry, in case any pollutant event (such as leakage via a sealed well) should occur.

TABLE 3. MONITORING PROGRAM FOR A POLYMER FLOOD TO BE CONDUCTED OVER A 20-YEAR PERIOD

Stage of Project	Monitoring Events
Design of Project	1. Identify all freshwater aquifers. 2. Collect monitoring data on aquifer water quality; utilize "kriging"[a] statistics to develop average values. Look for seasonal trends.
Rework Oilfield Wells	1. Develop maps of all old and all sealed wells, and inventory the condition of all old wells. 2. Monitor reworking procedure to detect any communication with aquifers.
Preflush	1. Conduct tracer studies to determine dynamics of injected fluids. 2. Monitor quality of preflush fluids.
Injection of Chemical Slugs	1. Conduct tracer studies to determine dynamics of chemical slug. 2. Inventory known degradation tendencies, toxicity, carcinogenicity of chemicals used; identify persistent potentially harmful components.
Production	Monitor for unusual levels of indicators (Total Organic Carbon, Methylene Blue, Active Substances, Conductivity, Reservoir/Welltest Pressure, Resistivity and the Geophysical Logs) on a weekly to monthly basis, depending on the proximity

[a]See Section 8, "Selection of a Statistic" for definition of "Kriging."

TABLE 3 (cont.)

Stage of Project	Monitoring Events
	of the aquifer to the producing zone. Sampling sites to be spaced at not more than 4 times well spacing if possible.
Post-production	1. Monitor for unusual levels of indicators on a yearly basis. 2. Monitor pressure for a statistically selected sample of oil wells.

TABLE 4. MONITORING PROGRAM FOR A STEAM FLOOD TO BE CONDUCTED OVER A 20-YEAR PERIOD

Stage of Project	Monitoring Events
Design of Project	1. Identify all freshwater aquifers 2. Collect monitoring data on aquifer water quality; utilize "kriging" statistics to develop average values. Look for seasonal trends.
Rework Oilfield Wells	1. Develop maps of all old and all sealed wells, and inventory the condition of all old wells. 2. Monitor reworking procedure to detect any communication with aquifers.
Steam-soak Selected Wells	Monitor produced oil and water phases to detect heat-induced synthesis of hazardous organics.
Fieldwide Steam Soak	Monitor produced oil and water phases to detect heat-induced synthesis of hazardous organics.
Post-production	None

Injection of Chemical Slugs

During the polymer stage of a project a succession of concentrated chemicals is injected into the formation. Many of these, such as biocides and polymers, are subject to fairly rapid degradation within the formation. Background information is assembled on the known chemical and toxicological properties of the chemicals being used, and inferences regarding synergistic effects are developed. A tracer is injected with the chemical slug to track its progress through the formation.

Production

The production stage of the project involves injection of water to force out additional oil, utilizing the polymer as a mobility control zone, and a piston. During this time surrounding freshwater zones need to be monitored regularly. Sampling wells should be spaced as closely as possible to increase the chances of early flagging of any contamination events. Since each sampling well will cost $1,000 to $10,000 (1980 dollars) or more to drill, a comprehensive sampling network will not be economically justifiable until a significant contamination event is suspected. Wells already completed to the freshwater formations will have to be used for sampling. If possible, freshwater sampling stations should be spaced no farther apart than four times the spacing of the oilfield's producing wells.

Samples of produced fluids will be monitored to determine the composition of the oil and brine phases, with particular attention paid to degradation products of the injected chemicals and other potentially hazardous substances.

Post-production

After the polymer project is completed, regular monitoring of groundwater sampling stations is continued, to check for fluids moving out of the former producing zone (and the disposal zone if the produced water has not been returned to the producing zone). Well pressures at a random sample of wells are monitored for unusual reservoir conditions or well failures.

If Pollutant Events Are Detected

If pollutant events are detected, then additional sampling, as outlined in Sections 5 through 8 of this report, will be required.

SECTION 5

IDENTIFICATION OF CHEMICALS USED IN ENHANCED RECOVERY PROGRAMS

This section discusses the selection of parameters for further consideration in the analytical stages of the design of a monitoring program. The major problem at hand is to reduce the list of chemicals to a manageable size. In eliminating a chemical from the list, the cost of monitoring must be weighed against the potential of the substance to pose an environmental threat. Monitoring costs are usually well known. The environmental hazards, on the other hand, are difficult to establish. The information herein and in Section 6 provides a variety of ways of partitioning the lists to make the selection tasks easier. There are three major sources of working lists: 1) lists of known chemicals used in the technologies assembled by the EPA (Braxton et al., 1976; Beck et al., 1980); 2) lists of chemicals covered under current regulations assembled by the DOE (Booz, Allen, and Hamilton 1978); and 3) lists of parameters that can serve as indicators of categories of contaminants. For purposes of monitoring activities, lists of parameters to be measured are most useful if arranged according to analytical methods. This task report, then, provides a discussion of the various lists of chemicals and the development of an integrated list organized by analytical techniques and discussion of the utility of the lists.

CHEMICALS USED IN EOR AND ENHANCED GAS RECOVERY PROCESSES

A wide variety of chemicals are used during the course of enhanced-recovery projects. These range from the drilling muds, added during the preliminary drilling of injection and production wells for a project, to toxic biocides and anticorrosion additives, which are used to counteract chemical reactions that have been found to reduce the effectiveness of enhanced recovery. Despite the apparent vastness of these lists, many of the chemicals are very similar; and, in fact, groups of chemicals can each be measured through one analytical procedure.

The list developed by Braxton et al. (1976) for the EPA was a preliminary one, based on a review of current practices and patent literature. This list thus includes some chemicals that although theoretically interesting are not now being considered for use in field applications. The list included as Tables 5 through 12 is a revised version of Braxton's list, which takes these changes into account.[1] To further qualify the information considered in Tables 5 through 12, a separate list has been developed, which includes only those chemicals known to be commercially available for use in EOR projects. This list of trade products, Table 13, represents those chemicals which are likely to be used in projects taking place today and in the near future. The appendix presents a list of chemicals generally in use in oil and gas development that are also used in conjunction with enhanced recovery.

CHEMICALS COVERED UNDER CURRENT REGULATORY STRUCTURE

Regulations are not usually specific with respect to chemicals used in oil and gas applications. In fact, this lack of specificity has been at the center of the controversy regarding the regulation of drilling-mud wastes and brines. The EPA is currently beginning a detailed monitoring investigation of drilling mud wastes.

In an attempt to deal with these uncertainties, the DOE developed an analysis of the currently regulated chemicals. Other relevant lists include the NIH list of carcinogens, drinking water criteria, water quality criteria, and California air quality standards.

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[1]The revised surfactant list (1976) is now outdated; developments since its revision are likely to have caused additions and/or changes.

TABLE 5. ENHANCED OIL RECOVERY: EXAMPLES OF CHEMICALS PROPOSED FOR USE AS SURFACTANTS[a]

SULFONATES	
	Alfo olefin sulfonate
	Alky alryl sulfonate
	Alky aryl napthenic sulfonate with monovalent cation
	Hexadecylnaphthenic sulfonate
	Sodium laryl sulfonate
LAURATES	
	p-Chloroaniline sulfate laurate[b]
	p-Toluidene sulfate laurate
	Polyglycerol monolaurate
	Triethanolamine laurate
	Sodium glyceryl monolaurate sulfate
AMMONIUM CHLORIDES	
	Ditetradecyl dimethyl ammonium chloride
	Dodecyl trimethyl ammonium chloride
	Hexadecyl trimethyl ammonium chloride
MYRISTATES	
	Glycerol disulfoacetate monomyristate
	Triethanolamine myristate
SULFATES	
	n-Dodecyl-diethyleneglycol sulfate
	Monobutylphenyl phenol sodium sulfate
	Diethyleneglycol sulfate
OTHERS	
	n-Methyltaurine oleamide
	Morpholine stearate
	Pentaerythritol monostearate
	Dihexyl sodium succinate
	Sodium sulfate oleylethylanilide
	Triethanolamine oleate
	Alkyl phenoxypolyethoxy ethanol
	Polyoxyethylene alkyl phenol

[a]Braxton et al. (1976).

[b]Halogenated compounds, though proposed in the literature, are unlikely to be used in field operations, because their possible presence in produced oil streams would poison the catalysts at the refinery.

TABLE 6. ENHANCED OIL RECOVERY: CHEMICALS PROPOSED FOR USE AS COSURFACTANTS[a]

Alcoholic liquors
Fusel oil
Alcohols
Alkaryl alcohols
Phenol
p-Nonyl phenol
Cresol
Alkyl alcohols
Isopentanol[b]
2-Pentanol[b]
Decyl alcohols
Ethanol
Isobutanol
n-Butanol
Cyclohexanol
1-Hexanol[b]
2-Hexanol[b]
1-Octanol
2-Octanol
Isopropanol[b]
Aldehydes
Formaldehyde
Gluteraldehyde
Paraformaldehyde
Amides
Amino compounds
Esters
Sorbitan fatty ester
Ketones

[a]Braxton et al. (1976).
[b]Most commonly used.

TABLE 7. ENHANCED OIL RECOVERY: HYDROCARBONS USED AS A FRACTION OF MICELLAR SLUG (OR IN MISCIBLE-DISPLACEMENT PROCESSES)[a]

Alkylated aryl compounds
Anthenic compounds
Aryl compounds with mono cyclic compounds
Alkyl phenols
Benzene
Toluene
Acryl compounds with polycyclic compounds
Crude oil[b]
Partially refined fractions of crude oil
Overheads from crude columns
Side cuts from crude columns
Gas oils
Straight run gasoline
Kerosene
Liquefied petroleum gas
Naphthas
Heavy naphthas
Refined fraction of crude oil
Paraffinic compounds
Decane
Dodecane
Heptane
Octane
Pentane
Propane
Cycloparaffinic compounds
Cyclohexane
Naphthenic compounds

[a]Braxton et al. (1976).
[b]Most commonly used.

TABLE 8. TERTIARY OIL RECOVERY: CHEMICALS PROPOSED FOR USE AS MOBILITY BUFFERS[a]

Aldoses	B series
	L series
Amines	
Carboxymethylcellulose	
Carboxyvinyl polymer	
Dextrans	
Desoxyribonucleic acid	
Glycerin	
Ketoses	B series
	L series
Polyacrylamide[b]	
Polyethylene oxide[b]	
Polyisobutylene in benzene	
Rubber in benzene	
Saccharides	
Conjugated saccharides	
Disaccharides	
Monosaccharides	
Polysaccharides[b]	
Hydroxyethylcellulose	

[a]Braxton et al. (1976).

[b]Most commonly used.

TABLE 9. TERTIARY OIL RECOVERY: CHEMICALS PROPOSED FOR USE AS BACTERICIDES AND BIOCIDES[a]

Aldehydes
Formaldehyde
Gluteraldehyde
Paraformaldehyde
Alkyl phosphates
Acetate salts of coco amines
Alkyl amines
Quaternary amines
Alkyl dimethyl ammonium chloride
Coco dimethyl benzyl ammonium chloride
Diamine salts
Acetate salts of coco diamines
Acetate salts of tallow diamines
Calcium sulfate
Sodium hydroxide
Heavy metal salts
Chlorinated phenols
Alkyl dichlorophenol
Pentachlorophenol
Substituted phenols
Sodium salts of phenols

[a]T. J. Robichaux, "Bactericides Used in Drilling and Completion Operations," U.S. EPA Symposium on Environmental Aspects of Chemical Use in Well Drilling Operations, Houston, May 1965, p. 4.

TABLE 10. TERTIARY OIL RECOVERY: CHEMICALS PROPOSED FOR USE TO BLOCK EXCHANGE SITES IN THE FORMATION[a] (PREFLUSHING)

Quaternary ammonium salts
Fluoride solutions
Potassium permanganate
Sodium hydroxide

[a]Braxton et al. (1976).

TABLE 11. TERTIARY OIL RECOVERY: CHEMICALS PROPOSED AS ELECTROLYTES[a]

Acids
Hydrochloric acid
Inorganic acids
Organic acids
Sulfuric acid
Bases
Inorganic bases
Organic bases
Sodium hydroxide
Salts
Inorganic salts
Organic salts
Sodium hydroxide
Sodium nitrate
Sodium sulfate
Sodium silicate

[a]Braxton et al. (1976).

TABLE 12. TERTIARY OIL RECOVERY: CHEMICALS PROPOSED FOR USE TO INCREASE EFFICIENCY OF THERMAL METHODS[a]

Quinoline
Sodium hydroxide
Toluene

[a]Braxton et al. (1976).

TABLE 13. EOR CHEMICAL PRODUCING COMPANIES AND THEIR PRODUCTS - SUMMARY FOR UNITED STATES[a]

	Description	Use	Physical Properties
A. Amoco Chemical Company			
Surfactants:			
Amoco Sulfonate 155	a highly consistent ammonium salt of a sulfonated petroleum fraction	for use in formulating micellar fluids for enhanced oil recovery	Sulfonate activity wt % 48-52 Oil wt % 7-12 Inorganic salts wt % 15 max Water wt % 27-33
Amoco Sulfonate 151	a medium equivalent weight (420) sodium salt of a polybutene sulfonate	for use in formulating micellar fluids for enhanced oil recovery	Sulfonate activity wt % 47-52 Oil wt % 8-18 Inorganics salts wt% 15 max Water wt % 23-29
Amoco Sulfonate 152	an ammonium salt of a sulfonated petroleum fraction	for use in formulating micellar fluids for enhanced oil recovery	Sulfonate activity wt % 48-52 Oil wt % 7-12 Inorganic salts wt % 15 max Water wt % 27-33 Viscosity, centistokes @ 49° C (120° F) = 800 Density = 1.09 kg/l Flash point = 182° C Pour point = 0° C (32° F) Corrosion rate (carbon steel at 49° C) = 5 Odor, ammoniacal
Cosurfactants:			
Amoco Cosurfactant 120	an oxyalkylated alcohol w/ "unusual" phase distribution coefficient in oil/water systems	for the preparation of micellar injection fluids, can be used w/ most sulfonates at sulfonate/cosurfactant ratios up to 20/1	Density = 1.01 kg/l Pour point = 2° C Flash point = 1260° C Viscosity cp = 77

[a]This table describes the commercially available EOR injection chemicals. Ancillary chemicals such as biocides, corrosion inhibitors, and steam-drive additives are not reported on in this table. Further documentation of these products is available from the Manufacters.

TABLE 13 (CONT.)

	Description	Use	Physical Properties
Amoco Cosurfactant 122	an oxyalkylated alcohol w/ "unusual" phase distribution coefficient in oil/water systems	for the preparation of micellar injection fluids, can be used w/ most sulfonates at sulfonate/cosurfactant ratios as high as 80/1 or as low as 1/1	Density = 8.60 lb/gal Pour point = 40° F Flash point = 205° F Viscosity cp = 35.4° F
Polymers:			
Sweepaid 103	high molecular weight copolymer, a liquid emulsion form containing 25% polymer, 25% oil, and 50% water and is supplied with an emulsion breaker	specially developed for EOR, to improve mobility ratios	Specific gravity = 8.33 lb/gal Pour point = -20° C Viscosity = 900 cps pH = 7.2

D. Allied Colloids Incorporated

	Description	Use	Physical Properties
Polymers:			
Alcoflood 1200	anionic acrylamide copolymer w/ ultra high molecular weight; dry, white granular powder	mobility control in the driving fluid	Particle size = 100% through #12 mesh Bulk density = 40 lb per ft^3 pH in distilled water 1% solution @ 25° C = 5.5-6.5 In oxygen-free brine less than 10% loss in viscosity over 5 days at 175° F.
Various alsomer-polymers 507	polyacrylamides; sodium polyacrylate polymer in "micro-bead" form	for use in drilling fluids, fluid loss reducer for fresh water based drilling systems in bentonite, etc.	Particle size = 100% through #12 mesh Bulk density = 802 kg/m^3 pH of 1% solution @ 25° C = 5.5 to 6.5
Other:			
Antiprex A	a polymeric scale inhibitor - sodium salt of a synthetic polycarboxylic acid	for control of scale & deposit formation which restricts flow through injection & flow lines & filtering systems	Solid content = 45 ± 1% pH = 7.0-7.5 Specific gravity = 1.30 Viscosity @ 25° C = 1,400 cps

TABLE 13 (CONT.)

	Description	Use	Physical Properties
C. <u>Nalco Chemical Division</u>			
Polymers:			
Nalfo F	is 30% by weight polymer solids	for mobility control in EOR flooding	
Nal-flo F	high molecular weight, is unstabilized, develops liquid polymers	mobility-control agents	
Surfactants:			
ADOFOAM BF-1 Anionic	alcohol ether sulfate	foaming agent	N.A.
D. <u>DOW</u>			
A wide variety of EOR polymers:			
XD (series)	acrylamide polymers of various molecular size, in which 30% of the carboxamide groups have been replaced by carboxylate groups	mobility-control agents	
Pushers/dry polymers:			
Pusher 500 Oil	an intermediate-molecular-weight anionic polyelectrolyte	mobility-control agent	
Pusher 700 Oil	a high-molecular-weight anionic polyelectrolyte	mobility-control agent	
Pusher 1000 Oil	an extremely high-molecular-weight anionic polyelectrolyte	mobility-control agent formulated as a hydrocarbon emulsion of water-soluble polymers	
Surfactants:			
PEI 1000	cationic polymer; polyethylenamine	foaming agent	N.A.
PEI 400	cationic polymer; polyethylenamine	foaming agent	N.A.

TABLE 13 (CONT.)

	Description	Use	Physical Properties
E. Pfizer Chemical Division			
Polymers:			
Biopolymer 1035	solution of xanthan gum: a high molecular weight heteropoly-saccharide produced by the *Xanthomonas campestris* fermentation of carbohydrates	mobility-control agent for enhanced oil recovery	Tan gelatinous fluid Polymer activity = 2.8-3.2% Viscosity = 7,000-10,000 cp Specific gravity = 25° C 0.95 1.00 g/cc Stabilizer, formaldehyde 2000 ppm min
F. American Cyanamid			
Polymers:			
Cyanatrol the 900 series	anionic liquid polyacrylamides	mobility-control agents developed specifically for EOR	Bulk density 25° C = 8.43 lb/gal Bulk viscosity 25° C = 1,200 cps Freezing point = 18° C Flash point = 3982° C
Surfactants:			
Aerosol A-102	nonionic and anionic; disodium ethoxylated alcohol half ester of sulfosuccinic	foaming agent	N.A.
G. Aerosol OT (75% Alo)	anionic; sodium dioctyl sulfosuccinite	foaming agent	N.A.
Polymers:			
Xanthan Broth	a polysaccharide made by fermentation by *Xanthomonas campestris*	mobility-control agent for EOR	Xanthan gum % = 2.5-3.0 Viscosity = 10,000-20,000 cp pH = 6.0-7.0 Preservative = 3,000 ppm formaldehyde

TABLE 13 (CONT.)

	Description	Use	Physical Properties
H. CORT (Hercules) N-Hance (series)	polyacrylamides manufactured "to produce" higher & more uniform molecular weights and greater polymer linearity	mobility-control agents	Viscosity = Range 6-100 cp @ 1,000 ppm
Natrosol 250 HHR	hydroxyl cellulose (HEC)	mobility-control agents	
Other EOR chemicals supplied by Hercules through CORT are cellulosic & polysaccharide chemicals.			
I. Witco Chemical Corporation			
Surfactants:			
TRS 10-80	petroleum sulfonate	foaming agent	N.A.
TDA-100	ethoxylated alcohol	foaming agent	
J. Stepan Chemical Company			
Surfactants:			
Petrosep 465	petroleum sulfonate	foaming agent	N.A.
Petrosep 450	petroleum sulfonate	foaming agent	
Petrosep 420	petroleum sulfonate	foaming agent	
K. Alcolac Inc.			
Surfactants:			
Siponate DS-10	dodecyl benzene sulfonate	foaming agent	N.A.
L. Exxon Chemical Co.			
Surfactants:			
$MEAC_{12}$ OXS	Orthoxylene sulfonate	foaming agent	N.A.

TABLE 13 (CONT.)

	Description	Use	Physical Properties
M. GAF Corporation			
Surfactants:			
Igepal CO-530	ethoxylated phenol	foaming agent	N A.
Igepal CO-610	ethoxylated phenol	foaming agent	N.A.
N. Suntech			
Suntech 1	mixed xylenes and C_{12} olefin	foaming agent	N.A.
Suntech 2	mixed xylenes and C_{15} olefin-narrow	foaming agent	N.A.
Suntech 3	toluene and C_{15} olefin-narrow	foaming agent	N.A.
Suntech 4	toluene and C_{15} olefin-narrow	foaming agent	N.A.
Suntech 5	toluene and C_{15} olefin-broad	foaming agent	N.A.
Suntech 6	benzene tower feed and C_{15} olefin-broad	foaming agent	N.A.
Suntech 7	benzene tower feed and C_{15} olefin-narrow	foaming agent	N.A.
Suntech 8	benzene tower bottoms and C_{12} olefin	foaming agent	N.A.

TABLE 13 (CONT.)

	Description	Use	Physical Properties
O. MILEHEAA			
Surfactants:			
Ampli foam"	coco amine betaine	foaming agent	N.A.
P. MAGCOBAR			
Surfactants:			
Magcofoamer 44		foaming agent	N.A.
Q. Armour Industrial Chemical Company			
Surfactants:			
ARQUAD T-2C	cationic; quaternary ammonium salt		N.A.
ARMOMIST #1	cationic		N.A.
R. Dupont			
Surfactants:			
BCO	amphoteric, C-alkyl betaine		N.A.
S. General Mills			
Surfactants:			
ALFOAM 3			N.A.
T. Shell Chemical			
Surfactants:			
Shell foam	sulfonate (probably no benzene)	foaming agent	N.A.

TABLE 13 (CONT.)

	Description	Use	Physical Properties
U. Halliburton			
Surfactants:			
HC-2		foaming agent	N.A.
HOWCO SUDS			N.A.
V. Rohm & Haas			
Surfactants:			
TRITON QS-15	amphoteric; oxyethylated sodium salt	foaming agent	N.A.
TRITON GR-S	anionic; sodium alkylester sulfonate	foaming agent	N.A.
W. Petrolite Corp.			
Surfactants:			
Tret-O-lite J-9005		foaming agent	N.A.
Tret-O-lite TD-8		foaming agent	N.A.
X. Adomite			
Surfactants:			
Adofoam	50% active anionic surfactant	foaming agent	N.A.
Y. Kelco, Division of Merck & Co., Inc.			
Polymers:			
Xanflood	xanthan gum	mobility-control agent	N.A.

TABLE 13 (CONT.)

	Description	Use	Physical Properties
Z. Hercules Incorporated			
Polymers:			
Natrosol 250 HHR	hydroxyethyl cellulose (HEC)	mobility-control agent	N.A.
AA. Union Carbide Chemical Co.			
Polymers:			
Polyox WSR N-3000	polythylene oxide (REO)	mobility-control agent	N.A.
Polyox WSR 301	polythylene oxide (REO)	mobility-control agent	N.A.
Polyox coagulant	polythylene oxide (REO)	mobility-control agent	N.A.

TABLE 14 (CONT.)

Chemical Category for EOR Use	Chemical Group	Nonspecific Analytical Technique	Specific Analytical Technique	Technique Protocol Listing	Precision %	Threshold Value (detection limit)	Environmental Standard or Guideline	Cost per Sample[a]	Level of Operator Training Required
	monopolymeric sugars		paper chromatography		m	m			
	polysac-charides	manual analysis by cleavage enzyme hydrolysis				n			
E. Biocides	aldehydes	GC/FID		EPA Level I recommended			p	$50-100	4 yr college
	alkyl phosphates	phosphate colorimetric tests		ASTM D-515		.01-10 ppm		$5-10	H.S. tech.
	alkyl phosphates		GC/MS		j	50 mg injected		$50-200	4 yr college
	quaternary amines		ion chrom-atography		q	q		$15-25	tech. or 4 yr college
	alkyl amines		GC/MS	EPA Level II recommended	j	50 mg injected		$50-200+	4 yr college
	acetate salts of amines		GC/MS	EPA Level II recommended	j	50 mg injected		$50-200+	4 yr college
	calcium sulfate		titration		e	e		$5-10	H.S. tech.
	sodium hydroxide	alkalinity titration		ASTM D1067-1070				$5-10	H.S. tech.
	heavy met-al salts	atomic absorption[r]			s	s		u	4 yr college
	heavy met-al salts	inductively coupled argon plasma			t	t		$100[w]	4 yr college
	phenols	chloroform extraction		ASTM-D1783	h	h	x	$5-10	H.S. tech.
	phenols		GC/MS	EPA Level II recommended	j	50 mg injected	x	$50-200+	4 yr college
F. Chemicals used to block ex-change sites	quater-nary am-monium salts	NH_3 titration		ASTM D1426	y	y		$5-10	H.S. tech.
	quater-nary am-monium salts		ion chromatography		q	q		$15-25	tech. or 4 yr college.

TABLE 14. MATRIX OF MONITORING PARAMETERS

Chemical Category for EOR Use	Chemical Group	Nonspecific Analytical Technique	Specific Analytical Technique	Technique Protocol Listing	Precision %	Threshold Value (detection limit)	Environmental Standard or Guideline	Cost per Sample[a]	Level of Operator Training Required
A. Surfactants	all surfactants		direct probe mass spectrometry[b]		$\geq$100	low ppb range[c]		$25-100	4 yr college
	sulfonates	titration[d]		ASTM D-2330	e	e	f	$5-10	H.S. tech.
B. Cosurfactants	alcohols		GC/FID	EPA Level II recommended	10	50 mg injected	g	$50-100	4 yr college
	phenols	chloroform extraction		ASTM-D 1783	h	h	i	$5-10	H.S. tech
	phenols		GC/MS	EPA Level II recommended	j	50 mg injected	i	$50-200+	4 yr college
	aldehydes	GC/FID		EPA Level I recommended				$50-100	4 yr college
	amides		GC/MS	EPA Level II recommended		50 mg injected		$50-200+	4 yr college
	amines		GC/MS	EPA Level II recommended		50 mg injected		$50-200+	4 yr college
	amines		GC/MS[k]	EPA Level II recommended	j	50 mg injected		$50-200+	4 yr college
	esters		GC/MS	EPA Level II recommended	j	50 mg injected		$50-200+	4 yr college
	ketones		GC/MS	EPA Level II recommended	j	50 mg injected		$50-200+	4 yr college
C. Hydrocarbons	aryl compounds (incl. benzene)		GC/MS[e]		j	50 mg injected		$50-200+	4 yr college
	alkyl phenols	chloroform extraction		ASTM-D 1783	h	h		$5-10	H.S. tech.
	aliphatic hydrocarbons		GC/FID[l]	EPA level II recommended	10	5 mg injected		$50-100	4 yr college
D. Mobility buffers	amines		GC/MS[k]	EPA Level II recommended	j	50 mg injected		$50-200+	4 yr college
	monopolymeric sugars		GC/MS of trimethylsilyl derivatives					$50-200+	4 yr college

SAMPLING PARAMETERS

To design a monitoring program requires information about eight sampling parameters shown in Table 14. These eight parameters include information about the appropriate chemical tests--

1. Nonspecific Analytical Technique
2. Specific Analytical Technique
3. Technique Protocol Listing--

information concerning the ability of the techniques to detect environmental hazards--

4. Precision
5. Threshold Value/Detection Limit
6. Environmental Standard or Guideline--

and information about the effort required to carry out the tests--

7. Cost Per Sample
8. Level of Operator Training Required.

Nonspecific Analytical Technique

Each chemical group cited in the table includes a number of individual chemicals, each with its own molecular composition, physical and chemical properties, and toxicity. For some of these groups, a convenient "nonspecific" test exists that will detect the presence of some member of the group in a sample, without being able to identify specific chemicals and their concentrations. These general tests are often an appropriate screening tool, to determine inexpensively whether more detailed sampling is required at a particular sampling station and time.

Specific Analytical Technique

Techniques included in this category will detect the presence or absence of specific chemicals within a group.

Technique Protocol Listing

Techniques that are routine enough to be standardized are described by analytical protocols. The appropriate protocol references are provided in the matrix. Some of the protocols refer to techniques that are undergoing rapid development, such as GC/MS analysis. These protocols will provide only general guidelines for the analytical procedures,

SECTION 6

GROUNDWATER SAMPLING AND ANALYSIS PROCEDURES

INTRODUCTION

Enhanced oil and gas recovery processes use and create a diversity of chemicals. To monitor the discharge of these chemicals to the environment requires many specific analytical tests and procedures. The parameters associated with these tests have been summarized in a master matrix of water-quality tests for EOR/EGR chemicals. This matrix is displayed in Table 14.

It would be desirable to reduce the number of required tests, at least initially, by performing simple screening tests which would indicate whether or not more specific testing is likely to show presence of contaminants. To that end, nonspecific tests are noted in the matrix that can serve as general indicators of the presence of a class of chemicals. Even more general screening tests are not cited in the matrix. Those general tests that might be used include:

- Total Organic Carbon - The total organic carbon (TOC) test will generally detect all organic carbon compounds. This will include not only polymers but also oils and other oil-based hydrocarbons. Thus, TOC can indicate oil or working-fluid contamination. However, interpretation of TOC data is complicated.

- Total Dissolved Solids (TDS) - The measurement of high TDS levels will indicate the presence of brine contamination in a sample. This can be an initial indicator of escape of reinjected or surface-disposed wastewaters.

- pH - A sudden change in the pH values occurring at a sampling station can provide an indication of contamination by surfactants, sulfur-containing compounds, and other EOR-related chemicals.

TABLE 14 (CONT.)

Chemical Category for EOR Use	Chemical Group	Nonspecific Analytical Technique	Specific Analytical Technique	Technique Protocol Listing	Precision %	Threshold Value (detection limit)	Environmental Standard or Guideline	Cost per Sample[a]	Level of Operator Training Required
	fluoride solutions	distillation and colorimetric test		ASTM D1179	y	10 ppb		$5-10	H.S. tech.
	potassium permanganate		titration		e	e		$5-10	H.S. tech.
	sodium hydroxide	alkalinity titration		ASTM D1067-1070				$5-10	H.S. tech.
G. Electrolytes	acids and bases	pH titration		ASTM D1067-1070				$5-10	H.S. tech.
	salts		ion chromatography		q	q		$15-25	tech. or 4 yr college
	sodium salts	flame atomic absorption			s	s		$8-15	4 yr college
H. Chemicals used to increase efficiency of thermal methods	quinoline		GC/MS	EPA Level II recommended	j	10 mg injected		$50-200+	4 yr college
	sodium hydroxide	alkalinity titration		ASTM D1067-1070				$5-10	H.S. tech.
	toluene		GC/MS	EPA Level II recommended	j	50 mg injected		$50-200+	4 yr college

FOOTNOTES:

[a]Cost per sample assuming 10 or more similar samples run at one time.

[b]Direct probe mass spectrometry achieves poor separation, so specific identification is possible only if individual peaks are not greatly superimposed on one another.

[c]Assuming a large sample is collected and concentrated in the laboratory.

[d]Colorimetric titration with methylene blue measures detergent as equivalent ppm of linear alkyl sulfonate.

[e]For titration tests in general:

Threshold Values	Precision (%)
10^{-2} M in solu.	0.01
10^{-5} M in solu.	0.1
10^{-6} M-10^{-7} M in solu.	0.2-1.0

(continued)

FOOTNOTES TO TABLE 14 (continued)

[f]Petroleum sulfonates are considered flammable and therefore might be hazardous under RCRA. They should also be treated as potential carcinogens.

[g]hexanol	- marginal for RCRA hazardous rating on the basis of ignitability
octanol	- aquatic toxicity over 96 hours - LC_{50} = 10-100 ppm
n-butanol	- OSHA limit 100 ppm
	- threshold limit value (skin) - 50 ppm
	- aquatic toxicity at 96 hours - LC_{50}>1000 ppm
	- hazardous under RCRA on the basis of ignitability
tert-butanol	- OSHA limit 100 ppm
	- hazardous under RCRA on the basis of ignitability
iso-butanol	- threshold limit value - 100 ppm
	- hazardous under RCRA on the basis of ignitability
sec-butanol	- OSHA limit 100 ppm
	- threshold limit value - 150 ppm
	- aquatic toxicity at 96 hours - LC_{50}>1000 ppm
	- hazardous under RCRA on the basis of ignitability
cyclohexanol	- OSHA limit 50 ppm
	- threshold limit value - 50 ppm
	- aquatic toxicity at 95 hours - LC_{50} = 10-100 ppm

[h]Detection limit - 5 ppb

Threshold Values	Precision (%)
93.5 ppb	4
48.3 ppb	6
9.61 ppb	10

[i]phenol	- OSHA limit (skin) 5 ppm
	- threshold limit value - 5 ppm
	- drinking water standard (1962) - <1 ppb

[j]35% precision for GC/MS is typical, though experienced operators can obtain somewhat greater precision.

[k]GC/PID is an alternative for preliminary analysis.

[l]Handling problems can be expected with lighter-gravity hydrocarbons.

[m]Threshold value for paper chromatography is significantly higher than other chromatography techniques mentioned here. Similarly, precision is lower.

[n]polyacrylamides	- 1 ppm in potable water (ACGIH)
	- threshold value limit 0.1 ppm (skin tentative)

[p]glutaraldehyde	- threshold value limit - 2 ppm
formaldehyde	- threshold value limit - 2 ppm

FOOTNOTES TO TABLE 14 (continued)

[q]Detection limit: low ppb range - up to 50 ppb precision is 1-10%.

[r]*Flame atomic absorption or graphite-furnace atomic absorption, for example, depending on which metals are being examined.*

[s]Flame AA detection limit: low ppm to high ppb range - at 1-10 ppm, precision is 1-2%; graphite furnace AA - at 20-100 ppb, precision is 5%.

[t]Inductively coupled argon plasma detection limit: 10-20 ppb - at 100-300 ppb, precision is 3%.

[u]*Flame AA - $8-15/sample, graphite furnace AA - $12-25/sample.*

[w]ICAP is a multi-element technique. Several elements can be measured in a single analysis, so for a wide scan it can be cheaper than AA.

[x]2,4,5-trichlorophenol	- threshold limit value - low (very toxic)
pentachlorophenol	- aquatic toxicity at 96 hours - LC_{50}<1 ppm
phenol	- OSHA limit - 55 ppm (skin) - threshold limit value - 5 ppm - drinking water standard (1962) - 1 ppb

[y]At 0.5 ppm, precision is 3%.

[z]Precision was 9% at 0.81 ppm.

leaving the details of the analysis to the judgment of the chemist. For other sophisticated tests, such as inductively coupled argon plasma, standard protocols are not appropriate, since the technique is too new and complicated. Thus, analytical procedures are standardized only to a limited extent, depending for the validity of the data on the training and experience of the analyst.

Precision

The techniques differ in their precision. Precision can be affected by the operator experience and training.

Threshold Value

The threshold value of a test usually must be less than or equal to one-half of the applicable environmental guideline for the technique to be a useful monitoring tool.

Environmental Standard or Guideline

Environmental standards have not yet been developed for many of the chemicals of concern. (See Beck et al., 1980, and Silvestro et al., 1980). This information gap is a problem in the development of effective monitoring programs.

Cost Per Sample

Costs per sample have been developed assuming: a) 1980 prices, 1980 dollars; b) commercial laboratories perform the testing; c) samples are run in batches of at least ten samples. Costs for sample transport are not included.

Level of Operator Training Required

The quality of the operators performing the chemical tests is a principal variable controlling the value of monitoring data. Use of inexperienced or undertrained technicians can invalidate monitoring data. Required training levels included in the matrix are the generally recognized minimums. Use of operators with several years of experience can result in better accuracy and consistency. Laboratories should be under the supervision of a Ph.D. chemist or the equivalent. Laboratories should meet appropriate state and EPA laboratory-approval tests.

APPLICABILITY OF THE TECHNIQUES

Sample volume and cross-constituent interference limit the applicability of some of the techniques. Required sample volumes will increase rapidly as desired detection limit decreases, so that no simple values could be entered into the matrix. Presence of a complicated hydrocarbon component in the sample may necessitate multiple solvent separations and extracts to isolate the sample fraction to be analyzed. Presence of a high total-dissolved-solids component can decrease the sensitivity of other tests.

SECTION 7

MONITORING PROGRAM DESIGN CONSIDERATIONS

Design of an effective yet realistic groundwater monitoring program is a difficult analytical problem and is impeded by the lack of information about the baseline quality of aquifers and the pollutant pathways that are required in making informed decisions. Generally, it is much easier to design a monitoring program on the basis of a specific type of pollutant event or track to a specific pollutant incident. Unfortunately, often a pollutant event will remain undetected for long periods of time, being noticed only after an aquifer has been subjected to low levels of pollution over several years. Thus, it is necessary to conduct some form of regular monitoring of aquifers that may be affected by an EOR project.

DESIGN ISSUES

The major problems to be addressed in the enhanced-recovery environmental monitoring manual are as follows:

1. How should monitoring stations be located to ensure an acceptable probability that any discharges from the recovery processes are detected?

2. What combination of measurements, number of stations, and frequency of sampling provides the best information value per dollar expenditure?

3. How can all of the various monitoring variables be standardized sufficiently so that different recovery projects can be compared, and so that time-series analysis can be carried out?

4. Which procedures need to be followed to ensure that the measurements taken constitute meaningful information?

BENEFITS MEASURES

The design of an efficient monitoring program requires that the benefits of monitoring be identified. Benefits of EOR groundwater monitoring will include detection and prevention of environmental risks and evaluation of environmental control investments. To each general benefits category (Table 15) a variety of indices and variables can serve as measures to meet that monitoring need. For example, indices of cancer mortality per 1,000,000 individuals may serve as a measure of human health risk.

The first step in specifying these benefits is an evaluation of the enhanced-recovery processes and the nature of the pollutant events that may be expected. This first step was carried out as part of the recently completed project performed by MERL (Beck et al., 1980). This tells us the types of risks that a monitoring program should be designed to detect. The next step is to identify measurements that can be made to characterize the pollutant events. An enumeration of measures is provided in Section 6. The next step is to determine range of values, variability and statistical characteristics of contamination events using a body of historical data relative to past pollutant events. This cannot now be adequately carried out due to lack of historical data.[1] A substitute analysis, carried out on an a priori basis, makes up the body of Section 8 of this report. This tells us how intensively the risk indices should be measured to obtain meaningful information.

Table 15 summarizes the categories of costs and benefits that enter into the design of an EOR/EGR monitoring program. In addition to the benefits identified in Table 15, there is another purpose for monitoring investments, which does not appear in that list because it is an "intermediate" benefit; that is, it is a tool for the accomplishment of the other purposes. That benefit is the development of Baseline Information.

Dollar values and manpower values can easily be placed on the cost elements, as has been done in Section 6. The measures that should be used for the other benefits are less straightforward. Some of the possible uses of a monitoring program and the way to express their benefits are discussed below. The objectives discussed are: (1) baseline data assembly, (2) detection of trends and violations of standards and (3) detection of previously unrecognized pollutants.

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[1]Historical data that could be used for this work are lacking mainly because (1) few significant pollutant events have been identified and (2) no environmental monitoring programs are in place with EOR or EGR projects.

TABLE 15. EOR/EGR ENVIRONMENTAL MONITORING COSTS AND BENEFITS

Costs	Benefits
Dollar costs of monitoring tests	Identification of public-health risks
Manpower costs of monitoring	Detection of violations of regulations
	Identification of ecosystem risks
	Identification of other environmental risks (aesthetics, resource preemption, synergistic effects, intermedia effects)
	Identification of previously unrecognized pollutants
	Detection of degradation trends at levels below currently recognized risk thresholds
	Detection of chemical or hydrocarbon losses (economic benefit)
	Evaluation of the effectiveness of control investments

DEVELOPMENT OF BASELINE DATA

There are two alternate strategies for the development of a baseline for EOR/EGR environmental studies. One is to evaluate environmental insults on a site-specific basis; the other is to look at the national or regional picture. To some extent, both must be done. Environmental control of EOR/EGR activities merits significant attention if the potential overall impacts are significant, compared with other energy alternatives. Also, violations of regulations at any site cannot be ignored. Regulatory agencies -- i.e., those of the DOE, EPA, and California Air Quality Control Board -- will mainly require regional and national data to evaluate the effectiveness of their programs. Operators will only have use for an approach applicable to their own specific projects. Each approach will have different statistical and information requirements.

Regional Approach

The regional approach requires the development of average values and spatial and temporal variabilities for a relatively small number of key stations. The key stations are selected to represent the range of conditions relevant to the technology and medium of interest. The conditions that need to be represented are as follows:

Geological characteristics

Connate-water chemistry

Aquifer characteristics

Types of disposal formations

Technology options

Age of field operations

Generally, a minimum number of observations will be required to characterize each condition, depending on the variability of the parameter being considered. This minimum number can be achieved by some combination of repeat observations at a station and synoptic measurements at several stations. Once the basic statistics have been statistically characterized, additional stations or observations will provide minimal informational benefit.

Site-Specific Approach

The site-specific approach involves investigation of possible routes of contamination and directions of contaminant flow. The approach includes reservoir and aquifer dynamics. A synoptic data set covering the area influenced by the project is required; a time series adequate to characterize local patterns is also required for several key stations. Baseline data gathering should be kept to the minimum required to characterize levels of indicator parameters. Without specific cause for carrying out detailed monitoring at specific stations, large bodies of useless data could easily be assembled.

DETECTION OF TRENDS AND VIOLATION OF STANDARDS

Violations of regulations are usually measured as frequency of observations exceeding a reference level. The statistics that govern trends in frequency of occurrences of a condition are different from the statistics that govern trends in annual means.

No reference levels (i.e., standards or criteria) currently exist for most of the chemicals identified in Table 13 and Appendix A. The lack of firm reference criteria makes the use of these benefits measures difficult. Thus, development of usable reference values should be undertaken by the monitoring agencies. The status of reference values is as follows:

Public-Health Risk. Drinking-water standards and water-quality criteria exist. However, these standards do not cover most of the organics relevant to EOR/EGR. The NAS (1977) lists of suspected carcinogens came closest to considering the relevant variables. U.S. DOE research is currently under way on this topic. Air-quality standards exist, but these standards do not cover the trace organics.

Reinjection, Subsurface, Waste-Injection Regulations do not specify quality criteria.

RCRA. Guidelines for drilling muds and oilfield brines are currently being developed by the U.S. EPA.

Ecosystem Risks. No guidelines exist relative to subsurface waters. Water-quality criteria cover few of the relevant chemicals. Visibility criteria exist.

Other Environmental Risks are difficult to quantify.

IDENTIFICATION OF PREVIOUSLY UNRECOGNIZED POLLUTANTS

A monitoring program that is intended to identify previously unrecognized pollutants involves broad-based measurements with low expectation for informational benefits. Indices of the informational value of such a monitoring plan include:

1. Classes of chemicals measured: A monitoring program is beneficial to the extent that it provides measurements of a wide range of chemicals: detection of presence/absence is the main criterion.

2. Media sampled: A monitoring program is beneficial to the extent that it provides a scan of the range of possibly polluted media with a spatial coverage of each medium.

3. Temporal Sampling: A monitoring program is beneficial to the extent that it can detect pollutants that may be subject to irregular occurrence at sampling stations.

A suitable measure of of the potential informational benefits of a program designed to screen for new pollutants would be of the following form:

$$I = F_1(C)^{w_1} (MN)^{w_2} (f)^{w_3}$$

where $w_1 >> w_2 + w_3$

I = index of likelihood of detecting previously unrecognized pollutants

$F_1(C)$ = index of the classes of chemicals measured

M = number of aquifers sampled (of total aquifers bodies impacted)

N = average number of samples per aquifer

f = average frequency of sampling per station
w_1, w_2, w_3 = weighting factors for the three indices.

The best monitoring strategy will yield a maximum value of I within a given budgetary constraint.

DETECTION OF CHEMICAL OR HYDROCARBON LOSSES

Some monitoring strategies screen for potential pollutant events by monitoring chemical and/or hydrocarbon losses from the oil reservoir. These strategies include monitoring of well pressure, monitoring of movements of tracer chemicals, and development of data for periodic mass-balance accounting. Benefits of these monitoring activities may be measured as the dollar savings caused by reduced-volume consumption of chemicals and increased recovery of oil or gas. Estimated savings are calculated in terms of a site-by-site assessment of risks of losses that are usually calculated during the project engineering; or they can be calculated generally, as in the 1976 EPA study (Braxton et al., 1976).

EVALUATION OF THE EFFECTIVENESS OF CONTROL INVESTMENTS

Monitoring programs to evaluate effectiveness of control investments will compare the performance of controls with regulating standards and/or design criteria. This will involve the statistical issues discussed above. Making comparisons requires pairs of observations "upstream" and "downstream" of controls before and after their application. For controls aimed at maintenance of groundwater quality, "upgradient" and "downgradient" pairs may not be easy to establish, and groups of stations may be required to define the "up" and "down" gradient conditions.

POLLUTANT INDICATORS

Enhanced-recovery activities use a wide variety of chemicals. Comprehensive monitoring for each potential pollutant (including primary pollutants, degradation products, and synergistic pairs) will require extensive budgetary commitments. The measurement of indicator parameters rather than specific chemicals provides less detailed and less precise information; but it is a more certain way of obtaining useful returns for a given level of investment.

Various indicators that might be used to detect relevant pollutants are as follows:

1. Total Organic Carbon. Total organic carbon provides a measure of the presence of all chemicals soluble in a given solvent, such as methylene chloride. Monitoring TOC in the vicinity of EOR projects can be expected to detect the presence of organic polymers, organic biocides, hydrocarbons, and miscellaneous other

organic additives used in oil operations. The TOC measure could be used as a screening tool; if adverse trends are observed, then further, more specific analytical tests would be triggered.

2. Methylene Blue Active Substances. The MBA test quantifies the presence of methylene blue active chemicals, which mainly include a large class of surfactants. Monitoring MBA in the vicinity of EOR projects can be expected to detect the presence of surfactants. The MBA test is a general screening tool, aimed at a more restricted list of pollutants than the first test.

3. Conductivity. The conductivity test is a surrogate measure to determine the general presence of salts. The measurement of conductivity in the vicinity of EOR/EGR projects can serve as a screening tool to detect the presence of brines in water bodies.

4. Reservoir Pressure. The pressure maintained within the oil-bearing formation provides a monitor on escape of fluids away from the intended pathways. These monitoring activities are usually carried out as part of good reservoir engineering practices.

SECTION 8

PLACEMENT OF MONITORING STATIONS AND FREQUENCY OF SAMPLING

INTRODUCTION

This section adopts two separate approaches for determining appropriate placement and sampling-frequency designs for underground monitoring stations. The first method applies to detection systems, or systems designed to monitor before and just after a pollutant event occurs. The second method applies to event-monitoring systems that are designed to monitor the progress or extent of a contaminant plume. While detection-system monitoring stations must be operational before the event, an event-monitoring methodology is likely to be applied after the event to determine where to drill new wells or take above-ground measurements and how frequently to do so.

The following outlines the three subsections below that address issues of sampling frequency and station placement:

1. The first section discusses the differences in emphasis between systems designed before and after the pollutant event has occurred.

2. The second section discusses the proposed methodology for designing a pollution-event detection system.

3. The third section discusses the methodology for monitoring in response to pollutant events and the equations for the chemical-fate modeling of water-miscible and -immiscible pollutants in groundwater.

BEFORE VS. AFTER A POLLUTANT EVENT

The considerations affecting spatial placement of monitoring stations are different before and after a pollutant event has occurred. Before a pollutant event occurs, the emphasis is on early detection leading to monitoring for contamination close to possible sources, whereas after an event the emphasis is on determining the extent of contamination, which may require monitoring far from the source.

Similarly, for detection capability the density of monitoring stations should be high, whereas for delineating the extent of contamination the stations should be more widely spaced.

For these reasons, the design of a detection and an event-monitoring system have only a weak linkage. As a detection system requires greater accuracy, higher sampling frequencies, and fewer stations than an event-monitoring system, data collection by well samples is appropriate. For an event system, however, less expensive methods will suffice. This is not to say, of course, that an event-monitoring system should not use detection techniques, particularly if there are water wells in the field that can easily be used for monitoring. The point is that monitoring techniques are likely to be more cost-effective than drilling new wells.

The use of less expensive data-collection techniques for event-monitoring systems should be more than compensated for by a program of computer-based miscible or immiscible transport models. As it is doubtful whether these models can be adequately calibrated without a pollutant event, they play a less prominent role in "detection" systems.

Chemical-fate mathematical models fall into two categories: miscible and immiscible pollutant models. While brines and biocides are soluble in water, oil and surfactants are not. Briefly, the latter (immiscible case) equations must be written for the movement of both the water and nonwater phases, while in the former (miscible case) an equation for transport in the water phase only is developed.

DESIGN OF A POLLUTION-EVENT DETECTION SYSTEM

The design of a detection system has two phases: the first is a "baseline" analysis, characterizing TDS, BOD, organic-carbon, etc., and other levels before an event, and the second phase is the design of the monitoring system itself.

The purpose of the first phase is to take out all "trends" or explainable variations in groundwater quality, so that residual variation is uncorrelated (a white noise).

Seasonal trends in groundwater quality have been noted frequently in the literature; other possible trends include a straight-line time dependence, correlation among levels of chemical constituents, correlations among nearby wells, and relations of concentrations to the level of the groundwater table and volume of water pumped.

Once all trends have been removed, the standard deviation of the residuals is taken to serve as an indication of the reliability of sampling. A well with a standard error of σ on a given pollutant measure would yield a standard deviation of $\sigma/\sqrt{n}$ if sampling results were averaged over n time periods.

The second phase of monitoring station design takes as input the expected value of an indicator at a given time, $\mu(t)$, and the calculated standard deviation σ. These parameters are used to set up threshold levels for detection; as only upper thresholds are likely to be useful, a value of $\mu + (S\sigma/\sqrt{n})$ represents the threshold level, where S = a factor between 2 and 4. The value selected will reflect a judgement on the importance of early detection and the degree of inconvenience you wish to bear from false alarms due to random variation.

The following outlines the aspects of detection systems to be discussed in the next few pages:

A. The model to be used for determining spatial arrangement and sampling frequency, its limitations and data requirements.

B. Issues of detection power.

C. Formulas for spacing and frequency of monitoring.

D. Refinements to the model.

A. <u>The Model</u>

The subsurface dispersion model equations developed in Appendix B are based on a second-order, linear differential equation which depicts underground convection-diffusion phenomena. This analysis assumes that aquifer flow is constant in direction and magnitude and also that underground diffusion properties are uniform in the region of the spill. Since detection monitoring stations are to be placed close together, each covering only a small zone, variations in flow and diffusion may be neglected without seriously affecting results.

The purpose of the detection monitoring system is to detect contamination as soon as possible. The model permits prediction of the length of time, t_o, required to detect a leak depending upon values of spill size and concentration, spacing of stations, groundwater flow, local diffusion rates and the time interval between samples. Because the concentration profile could range from an initial burst to a slow leak, a worst-case approach is adopted. An initial-burst leak that quickly damps out is the hardest to detect. Consequently, the solutions for monitoring system design drawn from the model will be fitted to the detection of this case.

Data Requirements--

The parameters of the model are given in Table 16. It is seen that considerable geological and production information is needed to specify the model parameters. However, as detection stations are likely to be placed close to sources and as geological and production information should be available for existing wells, collection of necessary data should not require additional geological measurements.

The concentration of a pollutant at a given point in space C(x,y,t) is illustrated as a function of time and model parameters in Figure 9. The x-coordinate signifies the direction of aquifer flows and the y-coordinate, its perpendicular in the horizontal plane.

TABLE 16. MODEL PARAMETERS

Parameter	Physical measurements that must be made to determine parameter
V - velocity of groundwater motion	Transmissibility, level of groundwater table near pollutant surface
D - diffusion coefficient	Pollutant mobility; for immiscible fluids, water saturation viscosity; porosity; permeability of area near source
P - level of initial burst	In an injection well, volume of fluids injected per second; or in a producing well, volume of produced fluids per second

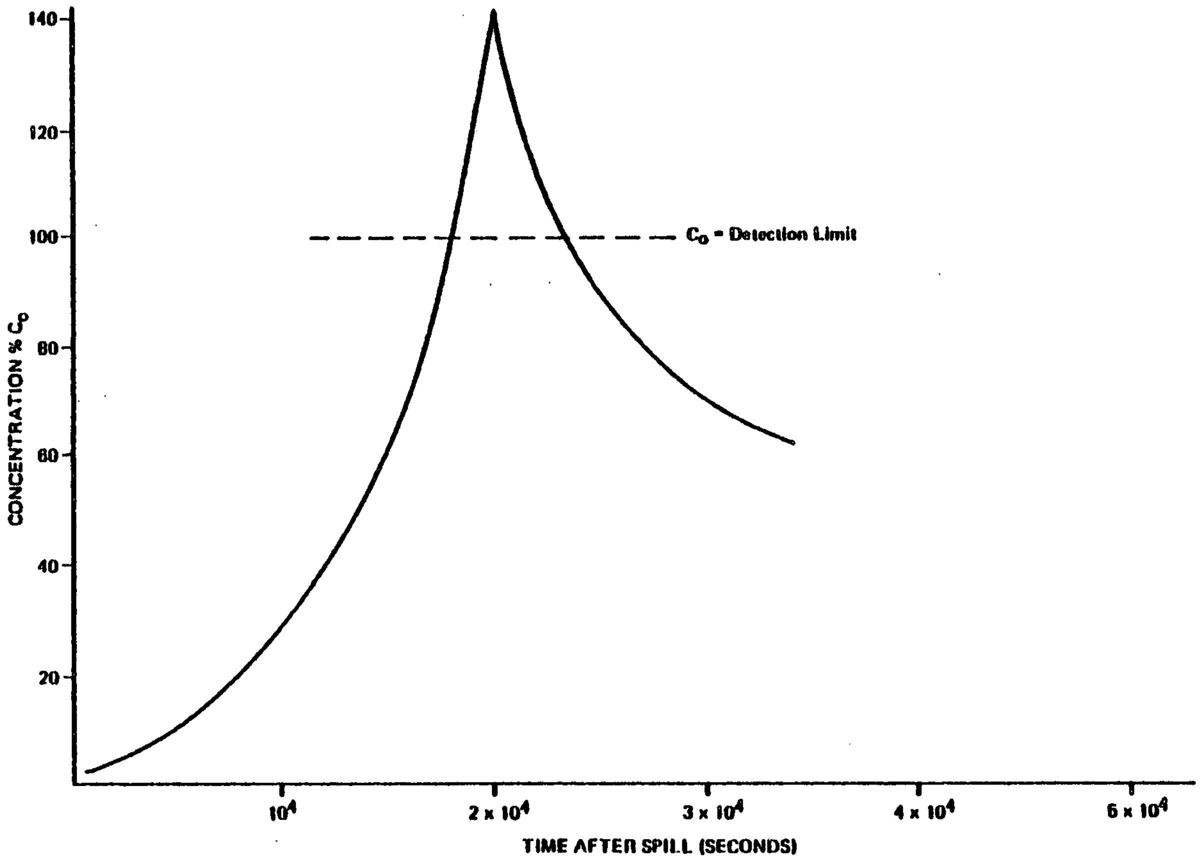

Figure 9. Concentration as a function of time for a groundwater sampling well 500 m downstream from a burst leak source; Groundwater Velocity=.01 cm/sec; Dispersion Rate=5 times groundwater velocity. Example chosen is a sand aquifer with relatively fast transport.

Limitations--

It should be stressed that while the modeling developed in equations B-1, -2, -3 and -4 of Appendix B and illustrated in Figures 10 and 11 is inadequate for the modeling of pollutant fates to be conducted in an event-monitoring system, it gives considerable insight into considerations for detection-system design. The model does not take into account possible variations in permeability and porosity nor, more seriously, variations in directions or magnitude of groundwater flow. As is shown in Subsection D below, once an understanding of the basic forces influencing system design is achieved, solutions to these objections will suggest themselves.

B. Detection Power

As has been mentioned in the introduction, baseline sampling provides us with an expected value for a measured variable and a standard deviation. Levels more than $S\sigma/\sqrt{\eta}$ above the baseline mean μ are cause for sounding an alarm, where η is the number of samples averaged for the purposed of reducing false alarms.

The approach taken in the following sections is to design a system that will be likely to detect levels above the mean of $S\sigma$ or greater, within a time of t_o after the event, using only one sample. An added benefit is that levels of $S\sigma/\sqrt{\eta}$ or greater may be detected by averaging over η samples. As a result, a graph of the minimum deviation detectable within a given period after the event, with confidence factor S, would plot $S\sigma/\sqrt{\eta}\Delta t$ versus $\eta\Delta t$, where Δt is the sampling interval.

C. Derivation of Spatial and Frequency Relations

The progress of a contamination plume will resemble Figure 12.

As can be seen, the "center of gravity" of the plume progresses at a speed of V in the x direction, while the width of the plume in the y direction is proportional to the dispersion coefficient D.

Equation B-4, which generated the plots in Figure 12, is reproduced below.

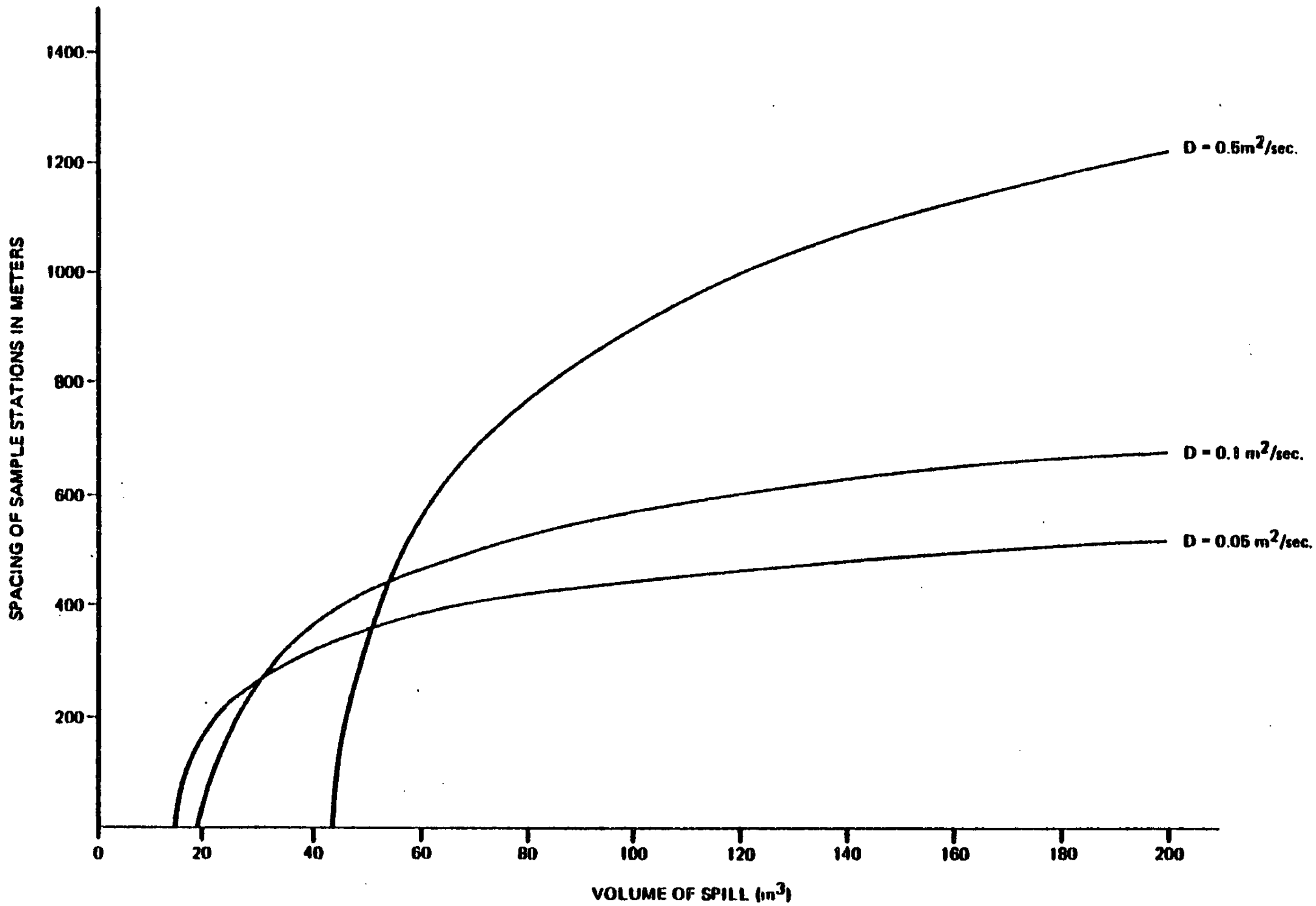

Figure 10. Spacing of sampling stations as a function of spill volume and dispersion rate, D.

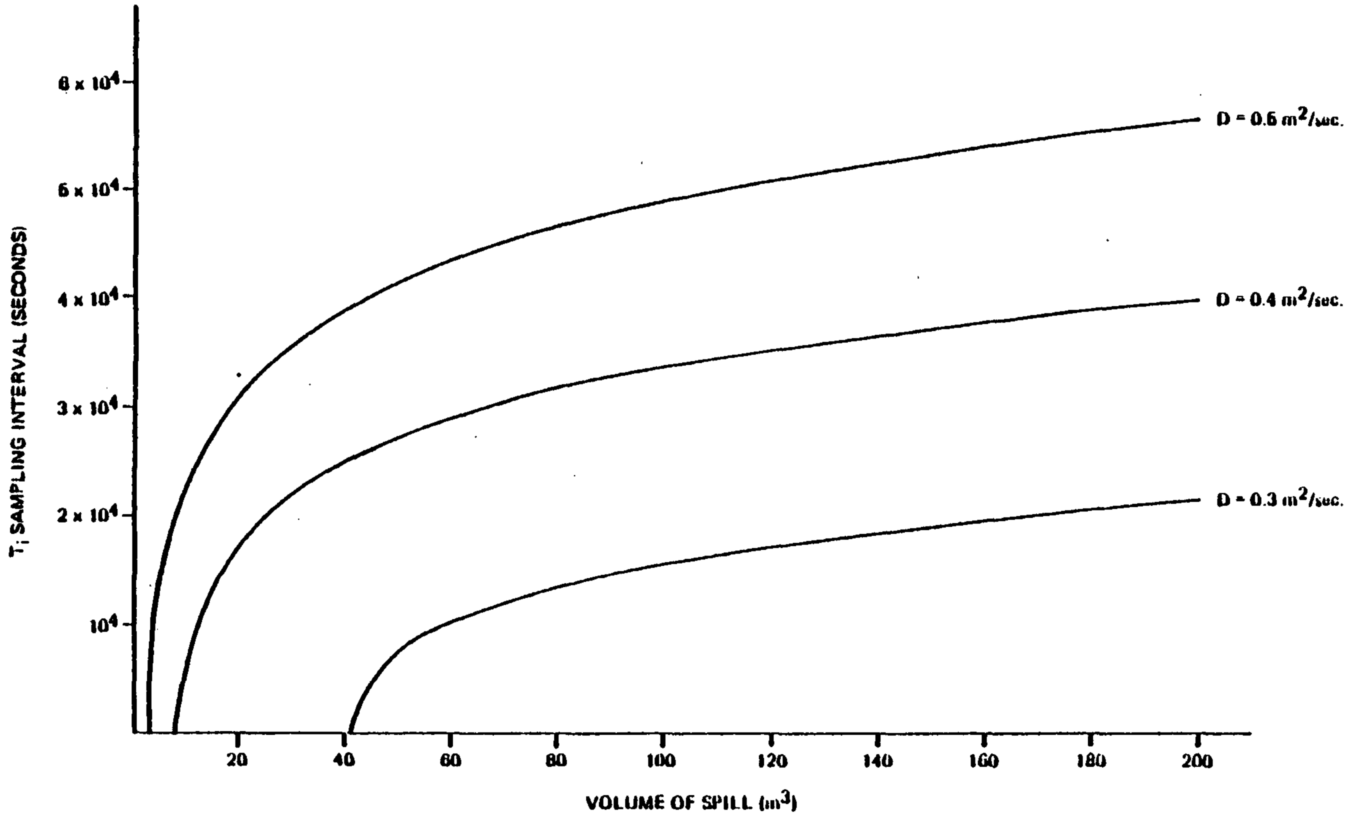

Figure 11. Sampling frequency as a function of spill volume and dispersion rate, D.

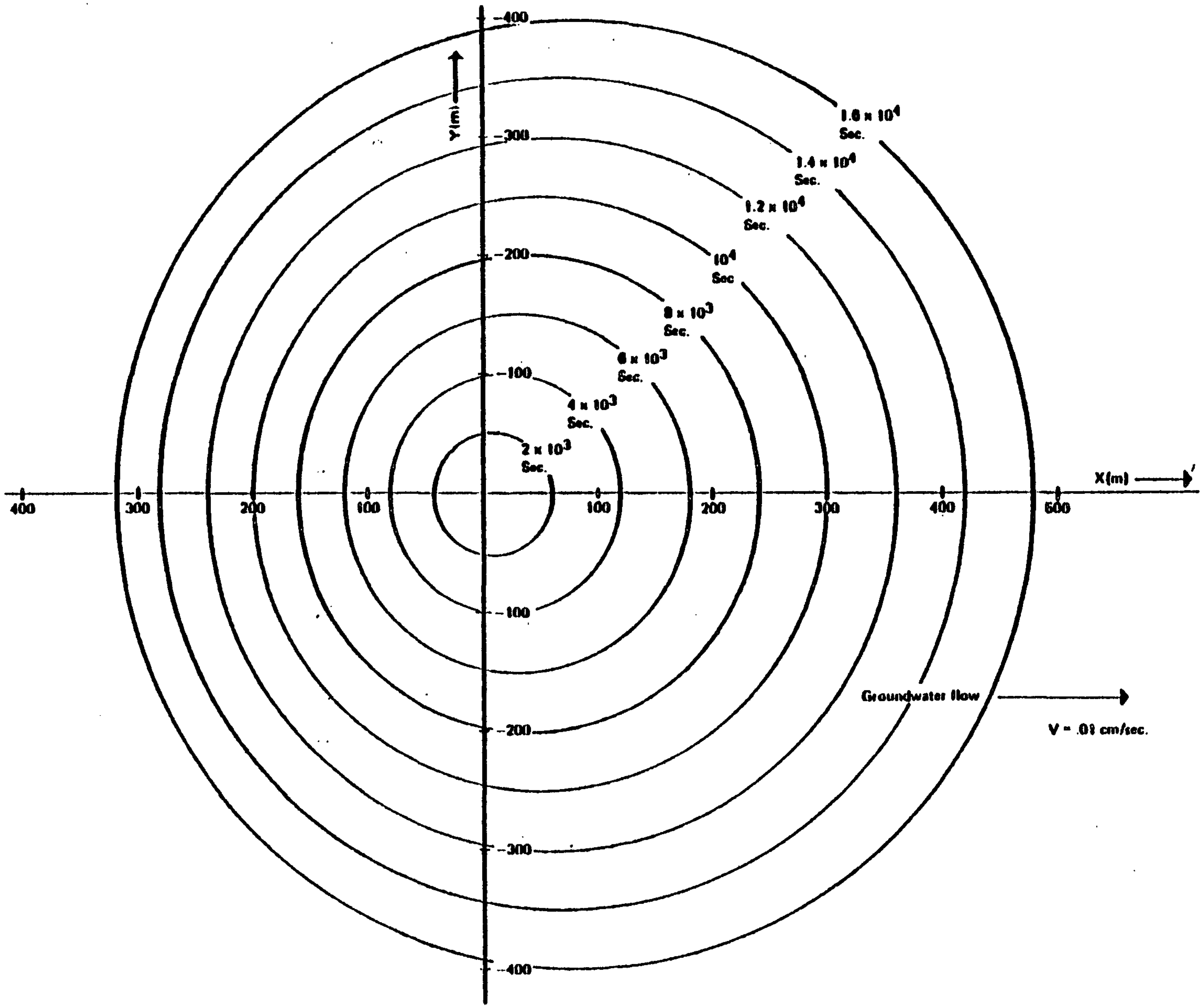

Figure 12. Progression of burst leak; dispersion rate = 5 times groundwater velocity.

$$C(x,y,t) = \frac{P}{(2\pi)^2 Dt} e^{-[(x-Vt)^2 + y^2]/2Dt} \qquad \text{(B-4)}$$

Our goals in detection-system design are:

1. To detect a minimum concentration above baseline of $S\sigma$ in one sample.
2. To do so before time t_o.

As was shown in Figure 9, a principal problem in accomplishing these objectives is inadequate density of monitoring stations, so that contaminant plumes "slip through." If we can calculate the width of the contaminant plume in the x and y directions at time t_o, and we space monitoring at one-half this width, our problem is solved.

Based on the derivation of equations B-5 to B-10 in Appendix B, an initial array of monitoring stations, suitable for delimiting the contaminant plume at time t_o, may be developed. Table 17 gives station locations and sampling frequencies. Figures 10 and 11 illustrate the variations in locations and frequencies as a function of spill volume and diffusion rate for a set of hypothetical conditions.

Consult Aris (1978) for background information.

D. Justification of Results

It is important to check whether the results we have developed agree with intuition. Let us consider the formula for the x spacing,

$$\Delta x = 1/2 \sqrt{2WDt - y^2} \qquad \text{(B-8)}$$

W is the parameter that represents the accuracy of detection; as C_o, the minimum concentration detectable, decreases, W increases, although slowly. Because of this increased accuracy, stations may be placed farther apart, and Δx increases. As y increases, and we get farther from the source, stations must be placed closer together. This is because the plume becomes narrower in the x direction as y increases. Beyond $y^2 = 2WDt_o$, stations become useless, as contaminant levels are undetectable.

TABLE 17. STATION LOCATIONS AND SAMPLING FREQUENCIES
(See Fig. B-1 on pg. 127)

Station Location	Sampling Interval
$(Vt_o, 0)$	$\frac{1}{V^2}\sqrt{4W^2D^2 - 8Vt_oW^2D}$
$\left(Vt_o, 1/2\sqrt{2WDt_o}\right)$	$\frac{1}{V^2}\sqrt{4W^2D^2 - 10V\ W^2Dt_o}$
$\left(Vt_o, -1/2\sqrt{2WDt_o}\right)$	$\frac{1}{V^2}\sqrt{4W^2D^2 - 10V\ W^2Dt_o}$
$\left(Vt_o + \sqrt{2WDt_o}, 0\right)$	$\frac{1}{V^2}\sqrt{4W^2D^2 - 8VWD\ [Vt_o + 1/2\ \ 2WDt_o]}$
$\left(Vt_o - 1/2\sqrt{2WDt_o}, 0\right)$	$\frac{1}{V^2}\sqrt{4W^2D^2 - 8VWD\ [Vt_o - 1/2\ \ 2WDt_o]}$

The formula for y spacing may be similarly interpreted. For values of x such that $(x-Vt_o)^2 > 2WDt_o$, stations become useless. From another point of view, for values of t such that the equality no longer holds, sampling stations at point x with $y > \Delta y$ become useless. Thus, for monitoring of a burst leak, stations have a finite useful life.

The formula for Δt is seen to decrease in V^2, and to increase in D and W. This is intuitively correct, as quicker sampling is required to "catch" events in quicker flowing aquifers. As accuracy increases, aquifers need not be sampled so often.

MONITORING IN RESPONSE TO POLLUTANT EVENTS

Enhanced recovery groundwater pollutant events will involve diverse pollutant-transport routes. Contamination may occur as a result of well-casing leaks, spills of chemicals or oils in holding tanks, or communication between subsurface formations, for example. Each pollutant event will require a unique detection and monitoring program, in which sampling stations are selected to conform with the expected speed and direction of travel of the pollutants, sampling intervals conform to the expected rate of degradation of the pollutant, and analytical procedures are selected according to the chemical nature of the pollutant. This discussion presents an overview of the transport models that can be used in the design of a sampling program to track a pollutant event.

Information Needs

The detection of groundwater pollutant events should not be a statistical question. That is to say, chemical tests should be chosen so as to delimit very clearly between pollutant events and normal circumstances, such that it is unnecessary to filter out "noise." To determine which chemical tests should be performed to detect EOR chemicals for accidents at site, it is important to collect the following information:

- A table of "likely" concentration levels of EOR chemicals in every EOR process in injected and produced waters, in addition to levels in the reservoir formation.

- A table of contamination scenarios, listing for each scenario the groups of pollutants that are likely to be released together, concentration estimates, and relative mobilities. For example, a leaky injection well will result in pollution by EOR chemicals at full strength, but little brine or oil contamination; fractures in the formation will result in higher levels of brine and oil and less of EOR chemicals. Brine contamination travels much more quickly than polymer does.

- A summary of the relevant EOR chemical degradation processes and by-products.

- A table of "likely" background values for TDS, BOD, TOC, Methylene Blue Active Substances, etc., in the local aquifers.

The above information will allow one to discern which chemical tests have high detection power for a particular pollutant event.

It is important to realize that once this information is assembled and tests are selected for the monitoring program, little attention will have to be paid to the collection of baseline data.

Classing EOR Pollutants According to Physical Properties

Surfactants and polymers are used in enhanced oil recovery because they decrease the mobility of injected water (and therefore the rate of flow through porous rock), thereby better matching the mobility of injected fluids with that of the reservoir oil. Because of the alteration in fluid properties brought about by even the small concentrations of polymers and surfactants in conventional water, models of contaminant transport in aquifers are inappropriate for modeling pollutant events involving these chemicals. Conventional models of miscible transport, such as those developed by Pinder (Bredehoeft and Pinder, 1973; Gray and Pinder, 1976; Bender et al.) can be applied to brine and biocide contamination. A summary of the classes of models (miscible, immiscible, fluid-altering) is provided in Table 18.

TABLE 18. POLLUTANTS AND CLASSES OF TRANSPORT MODELS

Classes of Models	Miscible	Immiscible	Fluid-Altering
Pollutants	Biocides	Oil	Polymers
	Brines		Surfactants

It is important to realize that these models may be combined to model any combination of pollutants escaping together or separately.

In the next few pages, the following information will be given for each of these models:

1) A summary and explanation of the mathematical equations

2) References for computer codes, numerical solutions, and in-depth explanations

3) A summary of the data necessary to operate the models

Overview of the Equations

From a physical perspective, all the models to be discussed are derived from three equations: those of (1) mass conservation, (2) Darcy's law, and (3) convection-diffusion. Mass conservation is a physical law, while Darcy's law is an empirically verified principle (not unlike Ohm's law); the convection-diffusion equation resembles a mathematical model, as it combines several diffusion mechanisms in one equation.

Definition of Terms

The effective porosity maximum $\phi_e(x)$ of porous rock is defined as the fraction of rock volume that may be filled by a fluid. Only connected pores contribute to effective porosity.

The pores may be filled wholly or partially by fluids. In an oil-bearing formation, these would be brine and oil; in an aquifer, water. The saturation $S(x)$ with respect to a given fluid is defined as the fraction of available pore space occupied by the fluid at point X.

The capillary pressure Pc is defined as the total pressure within the pores due to all fluids.

The relative permeability κ_{ri} is a function of the saturations of other fluids present in the pores, which ranges from 0 to 1. It must be determined experimentally from cores.

Immiscible Flow Equations

Overview--

To model the flow of immiscible fluids in porous media (oil in water or water in oil), two mass-conservation and Darcy's-law equations are used, one of each for the miscible and immiscible phases. The equations are coupled by relations between the pressure and saturations of the wetting and nonwetting phases. It is important to remember that there are only two free variables in the equations. These may be thought of as S_w, the water saturation, and P_w, the pressure due to water. These two variables are determined by two partial differential equations. The equations are developed in Appendix C.

Equations C-6 and C-7 are combined mass-conservation and Darcy's-law equations; equation C-9 says that between the wetting and nonwetting phases, all available pore space is filled. Equation C-8 states that the capillary pressure is a function of the water and nonwater saturations, and that the water and nonwater pressures contribute to it with opposing signs. This has been experimentally verified.

Together, equations C-6 to C-9 make up two equations in two unknowns.

Uses --

Equations C-6 to C-9 are used to model oil pollution of aquifers. Solving the equations gives the water saturation in the formation, which can be used as an element in a miscible-flow equation if there are pollutants dissolved in the water.

Data Needs--

A summary of the parameters that need to be determined to specify the model is given in Table 19.

Of all the parameters, q is the most difficult to determine.

References--

The book by Peaceman (1977) contains a complete explanation of the immiscible-flow equations.

TABLE 19. DATA NEEDS FOR IMMISCIBLE-FLOW MODEL

Parameter	How Determined
α (thickness of formation)	Geologic maps and cores
D (depth of formation)	Geologic maps and cores
$P_c(S_w)$ (capillary pressure)	Determined experimentally from cores
$\kappa_{rw}(S_w)$ (relative permeability)	Determined experimentally from cores
$q(\underset{\sim}{x})$ (source or sink term)	Must identify sources of contamination (fractures, bad wells, etc.), from geologic and hydrologic maps and pressure test cores
ϕ_e (effective porosity)	Determined experimentally from cores

Miscible-Flow Equations

Overview--

The miscible-flow models couple one mass-conservation-Darcy's-law equation with a convection-diffusion equation. The mass-conservation-Darcy's-law equation is used to establish the distribution of groundwater velocity within the aquifer, and the water saturation. These two variables are then used as input to the convection-diffusion equation that models the concentration of pollutant within the groundwater. It is important to realize that the miscible-flow equations assume that water mobility and density are constant -- that is, that increasing concentrations of pollutant do not change these values. This assumption does not hold true for surfactant and polymer pollutants. The equations are developed in Appendix C.

These relations must be empirically determined for the polymers and surfactants under consideration. The result is that equations C-10 (Darcy's Law equation) and C-13 (convection-diffusion equation) must now be solved simultaneously instead of independently. The mobility effects of equations C-14 and C-15 are likely to be important, as the presence of polymer in groundwater will slow its movement through rock. It must be realized that this effect may well be permanent; i.e., groundwater flow after a pollutant event is likely to be slower than before the event, even after polymer levels have subsided. This is because polymer clogs rock pores, decreasing permeability. This is the essence of equation C-14.

Uses --

Equations C-10 to C-13 are used to model brine and biocide pollution of aquifers. With equations C-14 and C-15 added, polymer and surfactant pollutant events may be modeled.

Data Needs--

A summary of the parameters that need to be determined to specify the model are given in Table 20.

References--

The book by Collins (1976) describes the miscible-flow model, including polymer-mobility effects.

Fluid Altering Equations

Where the pollutant is polymer or surfactant, equations C-14 and C-15 must be added to account for changing water mobility and density. Data are obtained from laboratory flooding simulations employing the polymer or surfactant.

TABLE 20. DATA NEEDS FOR MISCIBLE-FLOW MODEL

Parameter	How Determined
<u>Normal Case</u>	
α (thickness)	Geologic maps and cores
D (depth of formation)	Geologic maps and cores
$P_c(S_w)$ (capillary pressure)	Determined experimentally from cores
κ (permeability)	Determined experimentally from cores
μ (viscosity of groundwater)	Water samples
ϕ_e (effective porosity)	Cores
S_w (water saturation)	Hydrologic maps and cores
<u>Polymer and Surfactant Case</u>	
$\kappa(c)$ permeability	Experimentally from cores
$\mu(c)$ (viscosity of groundwater)	Viscometer

SECTION 9

BASELINE DATA ON GROUNDWATER QUALITY

INTRODUCTION

To establish a baseline for the groundwater-quality monitoring of EOR projects, data representative of the areas in which present or future EOR activity is taking place are needed. Rather than raw data, the required information is in the form of regional statistics. Such statistics can be used in the assessment of problems at specific oilfields. The steps in the development of useful regional statistics are as follows:

1. The selection of counties in which groundwater-monitoring data are to be collected.
2. The display, on 1:500,000 scale hydrologic unit maps, of the spatial placement of monitoring stations within each county.
3. The selection of a statistic to estimate the "average" groundwater quality within a particular cluster of stations.
4. The taking out of seasonal and other trends in the selection of a statistic, to produce a residual variance, σ.

A discussion of the procedures to be used in each of these steps follows.

SELECTION OF COUNTIES

From the Oil and Gas Journal EOR Annual Report of March 28, 1980, four counties were selected as representative areas of present or future EOR activity for initial tabulation in this report:

Osage, Oklahoma
Stephens, Texas
Wayne, Mississippi
Kern, California

The USGS National Water Data Exchange (USGS/NWDE) provided a retrieval of the locations and monitoring frequencies of all groundwater monitoring stations in these counties. That information is tabulated in Appendix D.

DISPLAY OF SPATIAL PLACEMENT

The USGS can provide printouts that include latitude and longitude, monitoring frequency, and station ID numbers. From this information, the USGS/NWDE can provide plots of the spatial location of the stations within selected counties. This information can be obtained from the USGS in Reston, Virginia.

SELECTION OF A STATISTIC

The "average" water quality from samples taken at irregular spacings and times (as is likely for the data of concern here) is estimated in a geostatistical procedure known as "kriging."

Kriging involves the selection of λ_i's in an estimator of the form:

$$\bar{\mu} = \sum_{i=1}^{N} \lambda_i W(X_i, Yd_i, t_i),$$

so as to estimate

$$\mu = \frac{1}{A} \int_A W(X,Y,t^*)dXdY$$

That is, the average concentration of W over the area A at time t*.

The characteristics of the kriging estimator are:

1. unbiasedness under the assumption of W = a constant.

2. least variance among linear estimators.

See the David et al. (1976) reference for "hands-on" use.

TREND ANALYSIS

Groundwater literature indicates that seasonal trends are a possibility. These trends have been observed on several occasions in nonpolluted groundwater and have increased in severity after a pollutant event; that is, these trends may well be better expressed as a percent change from the average rather than as an additive factor. A trial regression might be:

$$\mu_{ij} = \bar{\mu}\alpha_j\beta_i + e_{ij},$$

where

μ_{ij} = the kriging estimator in year i, month j.
$\bar{\mu}$ = the average value for concentration
α_j = the month effect
β_i = the year effect
e_{ij} = an additive error term (the literature supports the idea that the term is in fact additive).

SECTION 10

RECOMMENDATIONS

This report sets up a framework for statistically valid monitoring of enhanced recovery projects. Monitoring conducted in accordance with this framework at geographically separated sites will be comparable for the purposes of evaluating regional and national conditions and trends. However, this report presents only a preliminary outline for groundwater monitoring programs.

The following are recommendations for further work needed regarding the assembly of groundwater quality information for enhanced recovery projects:

- Identify Projects That Require Monitoring: Review ongoing and planned EOR, EGR, and tar sands projects. Select those projects that are most likely to impose groundwater quality degradation. Rank the remaining projects according to potential groundwater quality impacts. Obtain a complete prioritized listing of EOR, and tar sands projects in order of need for monitoring.

- Identify Susceptible Regions: Review the regional* distribution of EOR, EGR and tar sands projects. Evaluate the regional environmental issues, existing environmental quality and groundwater use. Prioritize regions regarding the need for monitoring. Organize the prioritized listing of project by region.

- Select Trend Monitoring Sample: Develop a statistically based sample of projects, based on compartmentalization of the sample by region and by inferred pollution potential.

- Select Initial Sample: Select a small set of projects for sampling. This initial set of from one to five sites should be selected based on the accessibility of the site, the availability of existing wells to use in the sampling effort, and the anticipated costs of sampling at that site.

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*Regions to be defined in terms of oil production areas.

- Develop Sampling Plans for Sample Set: Design site specific sampling plan for the initial set of sites based on the monitoring guidelines presented in this report. These plans should account for the engineering and geological peculiarities, if any, for the selected projects.

- Develop Cooperative Sampling Procedure: Working with the DOE and the industry, the EPA should develop a workable plan for conducting monitoring at the initial sample of stations and on a nationwide basis.

- Training: EPA and DOE should jointly develop training programs for federal, state and industry personnel who will be responsible for carrying out the EOR monitoring programs.

In addition to the work recommended for the implementation of a groundwater monitoring program, the following more general activities should be undertaken to complement the topics covered by this report:

- Water Usage Monitoring: A program needs to be developed to account for the water usage by EOR and EGR projects. This will need to take the form of monthly tabulations of water usage by projects as compared with unallocated water supplies at that locality.

- Produced Water Disposal Formations: An information base needs to be developed and kept updated regarding the usage of subsurface formations for produced water disposal, and the volumes disposed of at each formation.

- Monitoring Programs for Related Technologies: Tar Sands, Heavy Oil Mining. The EPA Las Vegas laboratory has developed detailed protocols for the monitoring of wastewater from oil shale projects (Todd et al., 1976, Slawson, 1979). These protocols, together with this report need to be extended to the tar sands and heavy oil mining technology areas.

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APPENDIX A

WORLD OIL'S 1979-80 GUIDE TO DRILLING, WORKOVER AND COMPLETION FLUIDS[1]

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[1]Note: These are generally oilfield fluids, used in conventional as well as enhanced recovery, many of which are common harmless chemicals. This list is included for completeness.

World Oil's 1979-80 Fluids Guide

Product Tradename	Description of Material	Recommended for These Systems: Water-base, Low pH: Fresh Water	Water-base, Low pH: Brackish Water	Water-base, Low pH: Sat. Salt Water	Water-base, Low pH: Gyp Treated	Water-base, High pH: Lime Treated	Water-base, High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil-base: Oil Mud	Air, Gas, Mist	Functioning As: Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat.	Shale Control Inhib.	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from:
ACE-BEN	Flocculant and bentonite Extender	X					X	X									P							S				American Mud
ACL	Organo metallic compound	X	X	X	X	X	X											S			S		P					CECA
ADOFOAM BF-1	Brine & freshwater foamer										X								P			S						Nalco
ADOMALL	Bactericide-surfactant	X	X		X	X	X				X		P									S						Nalco
AEROSOL	Surface active agent	X	X	X	X	X	X	X			X				P				S			P						Am. Cyanamid
AD-4	Oil-soluble fluid-loss additive for brines	X	X	X	X	X	X											P										Western
AFROX	Foaming agents	X	X	X							X						P			S								Aquaness
AIRFOAM AP-50	Freshwater foamer										X								P			S						Aqua-Flo
AIRFOAM B	Brine & freshwater foamer										X								P			S						Aqua-Flo
AKTAFLO-E	Nonionic emulsifier	X	X		X		X	X							P							S						Baroid
AKTAFLO-S	Nonionic mud surfactant, shale and solids control.	X	X		X	X	X	X			X										S	P						Baroid
ALCOMER 80	Selective flocculant	X	X	X			X										P											Allied
ALCOMER 90	Selective flocculant of low yield drill solids	X	X	X				X									P											Allied
ALCOMER 100	Clay flocculant	X	X	X	X	X	X	X									P											Allied
ALCOMER 120	Shale inhibitor	X	X	X			X	X									S				P							Allied
ALCOMER 507	Sodium polyacrylate	X		X		X	X	X									S	P					S					Allied
ALCOMER 525	Bentonite extender	X	X				X	X	X								P							P				Allied
ALCOMER 72L	Dispersant, thinner	X	X	X	X	X	X	X															P					Allied
ALCOPOL	Surface active agent	X	X	X	X	X	X	X							P				S			P						Allied
ALDACIDE	Microbiocide	X	X	X	X	X		X					P															Baroid
ALKA-LIG 007	Causticized lignite	X	X	X		X	X	X							S			S					P					American Mud
ALUMINUM STEARATE	Aluminum stearate	X	X	X	X			X						P														Most companies
ALWATE	High specific gravity granular powder (4.7 sq)	X	X	X	X	X	X		X	X																P	S	Messina
AM-9	Chemical grout										X									P								Am. Cyanamid
AM-9 GROUT	Mixture of acrylic monomers w/catalysts										X									P								Am. Cyanamid
AMERICAN BAR	Barite	X	X	X	X	X	X	X	X	X																P		American Mud
AMERICAN GEL	Wyoming bentonite	X	X	X	X	X	X	X										S						P				American Mud
AMI-TEC	Water base mud corrosion inhib.	X	X	X	X	X	X	X			X																P	Milchem
AMOCO DRILLAID 402	Wetting agent for shale-seal, gilsonite & asphaltic materials	X	X	X	X	X	X	X							S	S	S				P	P						Amoco
AMOCO DRILLAID 403	Surface active agent diff. press. sticking	X	X		X	X	X	X							S	P	S					P						Amoco
AMOCO DRILLAID 405	Biodegradable, non-fluorescent oil substitute	X	X	X	X	X	X	X	X							P						S						Amoco
AMOCO DRILLAID 412	Corrosion inhibitor (Filming amine)	X	X	X	X	X	X	X																			P	Amoco
AMOCO DRILLAID 450	Oxygen scavenger.	X	X	X	X	X	X	X																			P	Amoco
AMOCO DRILLAID SPA	Sodium polyacrylate fluid loss reducer	X	X	X	X	X	X	X										P										Amoco
AMOCO FLO-TREAT	Gel reducing agent—low solids non-dispersed muds	X	X					X															P		P			Amoco
AMOCO KLA-FREE	Organic biopolymer blend	X	X	X	X	X	X	X							P			S		S	S			P				Amoco
AMOCO LO-SOL	Bentonite extender & selective flocculant	X	X				X	X									P							P				Amoco
AMOCO SELECT-FLOC	Selective flocculant of low yield drilled solids	X	X	X				X									P											Amoco
AMPLI-FOAM	Gen. purpose foaming agent										X								P									Milchem
ANHIB	Completion fluid inhibitor	X	X	X																							P	Halliburton
ANTI-FOAM B	Foam inhibitor	X	X	X	X	X	X	X			X			P														Completion
ANTIPREX A	Scale inhibitor	X	X	X	X	X	X	X																	P			Allied
APC	Nonpolluting lubricant	X	X	X	X	X	X	X								P		S										Chemco
APS-1	Water external emulsion spacer fluid	X	X	X	X	X	X	X	X	X																		Western
APS-2	Water based spacer fluid	X	X	X	X	X	X	X	X	X																		Western
AQUAGEL	Wyoming bentonite	X	X	X	X	X	X	X										P						S				Baroid
AQUARI	Polymeric for clay free fluids	X	X	X				X										P			P			P				Brinadd
AQUA-TEC	Nonionic blend w/organic amine salt										X																P	Milchem
ARCOBAN	Higher alcohol compound		X	X	X	X								P														Arnold & Clarke
ARCOBAR	Barite	X	X	X	X	X	X	X	X	X																P		Arnold & Clarke
ARCO BLEND	Blended lignosulfonate compound	X	X	X	X	X	X	X							S			P										Arnold & Clarke
ARCOCHROME	Chrome lignosulfonate	X	X	X	X	X	X	X										P			S		P					Arnold & Clarke
ARCO CHROME	Chrome lignosulfonate	X	X	X	X	X	X	X							S			S			S		P					Delta Mud
ARCOCHROME MODIFIED	Ferrochrome lignosulfonate	X	X	X	X	X	X	X										P			S			P				Arnold & Clarke
ARCOCLAY	Sub-bentonite	X					X											P										Arnold & Clarke
ARCODET	Detergents	X	X	X	X	X	X	X							P							P						Arnold & Clarke
ARCO DMS, DME	Non ionic surfactants	X	X	X	X	X	X	X							P							P						Arnold & Clarke
ARCO DMS	Liquid surfactant	X	X	X	X	X	X	X							S			S				P						Delta Mud
ARCOFIBER	Fibrous material	X	X	X	X	X	X	X	X	X										P								Arnold & Clarke

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Product Tradename	Description of Material	Recommended for These Systems: Water-base, Low pH: Fresh Water	Brackish Water	Sat Salt Water	Gyp Treated	Lime Treated	Water-base, High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Functioning As: Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
ARCO FLOC	Flocculating agent							X									P											Arnold & Clarke
ARCO FOS	Sodium tetraphosphate	X	X			X	X	X															P					Arnold & Clarke
ARCO FREE	Oil soluble surfactants	X	X		X	X		X														P						Arnold & Clarke
ARCO GEL	Bentonite	X	X		X	X	X	X										S						P				Arnold & Clarke
ARCOLIG	Mined lignite	X	X		X	X	X	X							S								P					Arnold & Clarke
ARCOLOID	Pregelatinized starch		X	X	X	X	X	X										P										Arnold & Clarke
ARCOLUBE	Extreme pressure-lubricants	X	X	X	X	X	X	X								P												Arnold & Clarke
ARCOMERSE	Sodium alkylaryl sulfonate	X	X	X	X	X	X	X						P														Arnold & Clarke
ARCOMICA F	Ground mica, fine	X	X	X	X	X	X	X	X	X										P								Arnold & Clarke
ARCOMICA C	Ground mica, coarse	X	X	X	X	X	X	X	X	X										P								Arnold & Clarke
ARCOMUL	Primary emulsifier for invert muds								X	X					P													Arnold & Clarke
ARCOPARA	Paraformaldehyde	X	X	X	X			X					P															Arnold & Clarke
ARCO PERMALOID	Non-fermenting starch		X	X	X	X	X	X										P										Arnold & Clarke
ARCO PLUG: F.M.C	Ground Walnut Shells	X	X	X	X	X	X	X	X	X										P								Arnold & Clarke
ARCOSEAL	Cellophane	X	X	X	X	X	X	X	X	X										P								Arnold & Clarke
ARCOSOL	Non-ionic anionic emulsifier	X	X		X	X	X	X							P													Arnold & Clarke
ARCOTAN	Quebracho compound	X	X	X	X	X	X	X										P					P					Arnold & Clarke
ARCOTONE	Causticized lignite	X	X				X	X	X									P					P					Arnold & Clarke
ARCOTRIM	Blend of surfactants	X	X	X	X	X	X									P												Arnold & Clarke
ARCOTROL	Stabilizer for oil muds								X	X					P													Arnold & Clarke
ARCO VAN	Hi-temperature stabilizer for oil muds								X	X					P													Arnold & Clarke
ARCO VIS	Viscosity and gel builder for oil muds								X	X														P				Arnold & Clarke
ARCOWATE	Calcium carbonate								X	X																P		Arnold & Clarke
ARCOWOOL	Fibrous mineral wool	X	X	X	X	X	X	X												P								Arnold & Clarke
ARGISIL 5 6	Attapulgite clay or sepidlite		X	X														P						P				S.F.D.B.
ASBENIT EXTRA	Crysotyil	X	X	X	X	X	X	X																P				UBM
ASBENIT XP	Fine Asbestos	X	X	X	X	X	X	X												P				S				UBM
ASBESTOS LC	Fibrous asbestos	X	X	X	X	X	X	X												P								Drillsafe
ASBESTOS SL	Inorganic viscosifier	X	X	X	X	X	X	X												S				P				Drillsafe
ASP-222	Corrosion inhibitor	X	X	X	X	X	X	X			X																P	Visco
ASPHA-GEL CONCENTRATE	Gelatinous casing recovery pack								X	X				P														Mizell
ASPHA-MUL CONCENTRATE	Basic emulsifier								X	X					P													Mizell
AT-GEL	Attapulgite		X	X	X	X		X												S				P				Drillsafe
ATLOSOL	Anionic-nonionic surfactant, emulsifier	X	X		X	X	X	X							P							P					S	Milchem
ATLOSOL	Low solids emulsifier	X	X		X	X	X	X							P							P						Aquaness
ATLOSOL S	Low solids brine emulsifier		X	X	X										P							P						Aquaness
ATLOSOL S	Nonionic emulsifier		X	X	X										P												S	Milchem
ATTAPULGUS DRILLING CLAY 40	Attapulgite Clay for for oil mud								X	X														P				Engelhard
ATTAPULGUS DRILLING CLAY 150	Attapulgite Clay		X	X	X	X		X																P				Engelhard
ATTAPULGUS DRILLING FLUID	Predispersed attapulgite clay liquid		X	X	X	X		X																P				Engelhard
BACTIRAM	Bactericide	X	X	X	X	X	X	X					P															CECA
BACTIRAM 443	Bactericide (sulfate reducing)	X	X	X	X	X	X	X					P															CECA
BACTIRAM 471	Corrosion inhibitor and bactericide	X	X	X									S														P	CECA
BACTRON K-22	Bactericide	X	X	X	X	X	X	X					P															Champion
BACTRON K-31	Bactericide			X		X		X	X		X		P															Champion
BACTRON KM-4	Bactericide	X	X	X	X	X	X	X					P															Champion
BACTRON KM-5	Bactericide	X	X		X		X	X	X	X	X		P															Champion
BACTRON KM-7	Bactericide for high wt. brine			X		X		X	X		X		P															Champion
BANSLUFF	Asphaltic Compound	X	X	X	X	X	X	X							P	P		S			P							Drigmud
BARABUF	pH buffer for clay free fluids	X	X	X			X	X			X	P																Baroid
BARACARB	Acid soluble graded calcium carbonate	X	X	X	X	X	X											S		P						P		Baroid
BARACOR A	Corrosion inhibitor	X	X	X	X	X	X	X					S														P	Baroid
BARA DEFOAM 1	Surface active defoamer	X	X	X	X	X	X	X						P														Baroid
BARAFLOC	Clay flocculant							X									P											Baroid
BARAFOS	Sodium tetraphosphate	X	X					X				S											P		S			Baroid
BARAVIS	Synthetic cellulose	X	X	X	X	X	X	X																P				Baroid
BARAZAN	Suspension agent	X	X	X	X	X	X	X							P									P				Baroid
BAR-GAIN	High specific gravity weighting agent	X	X	X	X	X	X		X	X																P		Baroid
BARITE	Or barytes, offered under many tradenames, native barium sulfate	X	X	X	X	X	X	X	X	X																P		Most companies
BARITE MUDBAR	Barium sulphate and barite	X	X	X	X	X	X	X	X	X																P		Edemsarda
BARITE MUDHEMA	Barite and hematite	X	X	X	X	X	X	X	X	X																P		Edemsarda
BARIUM CARBONATE	Barium carbonate	X	X	X	X	X	X	X																	P			Most companies

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Product Tradename	Description of Material	Recommended for These Systems										Functioning As:																Available from:
		Water-base							Oil-base																			
		Low pH					High pH																					
		Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Lime Treated	Fresh Water	Low Solids	Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat.	Shale Control Inhib.	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	
BASCO 50	Nonfermenting starch	X	X	X	X	X	X	X										P						S				Barium
BASCO 300	Chrome lignosulfonate	X	X	X	X	X	X	X							S			S			S		P					Barium
BASCO BEN	Clay extender	X	X				X	X									P							P				Barium
BASCO BESTOS	Inorganic viscosifier	X	X	X	X	X	X	X																P				Barium
BASCO CAU-LIG	Causticized lignite	X	X	X		X	X	X				S			S			S					P					Barium
BASCO CELLOPAC	High molecular weight poly-anionic cellulose polymer	X	X	X	X	X	X	X			X					S		P			P			P				Barium
BASCO DEFOAMER	Hi alcohol	X												P														Barium
BASCO DEFOAMERS			X	X										P								S						Barium
BASCO DOUBLE-YIELD	Hi yield bentonite	X						X										P						P				Barium
BASCO DRILFAS	Drilling mud detergent	X	X	X	X	X	X	X						S	S							P						Barium
BASCO DRILFLO	Ferrochrome lignosulfonate	X	X	X	X	X	X	X							S			S					P					Barium
BASCO DRIFLOC	Clay flocculant							X									P											Barium
BASCO DRILMUL	Anionic-nonionic surfactant	X	X	X	X	X	X	X							P							S						Barium
BASCO DRILUBE	Diesel substitute	X	X	X	X	X	X	X								P						P						Barium
BASCO FILTER RATE	Asphaltic compound	X	X	X	X	X	X	X							S	P		S			P		S					Barium
BASCO FIBER	Shredded cane fiber	X	X	X	X	X	X	X												P								Barium
BASCO FLAKE	Fragmented cellophane	X	X	X	X	X	X	X	X	X										P								Barium
BASCO GEL	Bentonite	X	X	X	X	X	X	X										P		S				P				Barium
BASCO LIG	Lignite	X	X		X	X	X	X							S			S					P					Barium
BASCO LUBE-X	High pressure lubricant	X	X	X	X	X	X	X								P												Barium
BASCO MUD	Sub-bentonite	X	X	X	X	X	X	X										P						P				Barium
BASCOIL	Oil base mud stabilizer								X	X								P						P				Barium
BASCO PIPE FREE	Surfactant-mix w/diesel to free pipe	X	X	X	X	X	X	X	X	X																		Barium
BASCO PLUG	Processed nut hulls	X	X	X	X	X	X	X	X	X										P								Barium
BASCO PRESERVATIVE	Starch preservative	X	X		X		X	X					P															Barium
BASCO SALT MUD	Attapulgite clay		X	X																				P				Barium
BASCO SURF	Drilling mud detergent	X	X	X	X	X	X	X						S	S							P						Barium
BASCO T	Oil mud stabilizer								X	X					P									S				Barium
BASCO WATE	BArite (barytes)	X	X	X	X	X	X	X	X	X																P		Barium
BASCO Y	Oil mud gel additive								X	X								S						P				Barium
BC 10	Compound chromo . lignosulfonate	X	X	X	X	X	X	X										P			S		P					Avebene & CECA
BDO	Bentonite diesel oil slurry																			P								Halliburton
BEN-EX	Polymer, flocculant and clay extender	X	X				X	X									P							P				RDSI and ECCO
BENGUM	Gum-bentonite-diesel oil																			P								Halliburton
BENTOBLOC	Time setting compound	X	X	X	X	X	X	X	X	X	X									P								CECA
BENTONE 34	Ogranophilic clay								X	X														P				CECA
BENTONIL C.	Bentonite	X	X		X	X		X		X					P			P						P				S.F.D.B
BENTONITA VISC. MPL EXTRA	Extreme high yielding	X	X	X	X	X	X											S						P				UBM
BEX	Polymeric clay free fluids	X	X	X				X																P				Brinadd
BICARBONATE OF SODA	Sodium bicarbonate	X	X	X	X	X	X	X				S													P			Most companies
BIOHIBIT B-711	Biocide	X	X	X			X	X	X		X		P													S	S	C-E Natco
BIOHIBIT B-712	Biocide	X	X	X	X		X	X	X		X		P															C-E Natco
BIOHIBIT B-717	Biocide			X		X		X	X		X		P															C-E Natco
BIOTROL	Liquid biocide	X	X	X	X	X	X	X					P															Montello and ECCO
BIT LUBE	Extreme pressure lubricant	X	X	X	X	X	X	X								P												Magcobar
BLACK MAGIC	Basic oil base mud conc. (mfgr. mixed)							X		X					S	S		P			S	S	S				S	Oil Base
BLACK MAGIC PREMIX	Basic oil base mud conc. (mfgr. mixed)							X		X					S	S		P			S	S	S				S	Oil Base
BLACK MAGIC SUPERMIX	Basic oil base mud conc. for hi wt. and temp. (mfgr. mixed)							X		X					S	S		P			S	S	S				S	Oil Base
BLACK MAGIC SUPERMIX	Sacked oil base mud conc. for wt. and temp. (location mixed)							X		X					S	S		P			S	S	S				S	Oil Base
BLACK MAGIC SUPERMIX-SFT	"Sacked fishing tools," oil base concentrate, location mixed	X	X	X	X	X	X	X	X							S		P				S						Oil Base
BLACK MAGIC UNIVERSAL	Sacked oil base mud conc. for location mix							X		X					S	S		P			S	S	S				S	Oil Base
BLANOSE	Sodium carboxymethyl cellulose available in high and low viscosity, technical and pure grade	X	X	X	X	X	X	X			X							P						S				CECA
BLANOSE CMHEC	Carboxymethyl hydroxyethyl cellulose	X	X	X	X	X	X	X			X				S			P						S				Hercules
BLOCK BUSTER	Surfactant																					P						Magcobar
BM-NITE	Chrome lignite	X	X	X		X	X	X										P			P		S					Telnite
BORE-TROL	Shale, hole, HT/HP fluid loss control agent	X	X	X	X	X	X	X			X				P	P		P			P							Messina
BREAK	Defoamer for clay free fluids													P														Brinadd
BRIDGE-SAL	Polymer dispersant and sized salt blend			X																P								Texas Brine

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Product Tradename	Description of Material	Fresh Water (Water-base, Low pH)	Brackish Water	Sat. Salt Water	Gyp Treated	Lime Treated (High pH)	Fresh Water (High pH)	Low Solids	Water-in-Oil (Invert) (Oil-base)	Oil Mud (Oil-base)	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
BRINE-GARD	H_2S scavenger	X	X	X	X	X	X	X																			P	Brinadd
BRINE-OX	Oxygen scavenger	X	X	X	X	X	X	X																			P	Brinadd
BRINE-PAC	Corrosion inhibitor for solids free packer fluids		X	X																							P	Milchem
BRINE SAVER	Oil-soluble fluid-loss additive for brines	X	X	X	X	X	X											P										Dowell
BRINEFOAM	Surfactant										X											P						Brinadd
BRISTEX	Pig hair bristles	X	X	X	X	X	X	X	X	X										P								Bristex
BRIXEL	Ferrochrome lignosulfonate	X	X	X	X	X	X	X										S			S		P					Avebene CECA
BRIXEL 2E	Ferro-lignosulfonate modified	X	X	X	X	X	X	X							S			S					P					Avebene CECA
BRIXEL 3E	Sodium FerroChrome Lignosulfonate modified	X	X	X	X	X	X	X										S					P					Avebene & CECA
BRIXEL ECO	Ferro-lignosulfonate modified	X	X	X	X	X	X	X							S			S					P					Avebene CECA
BRIXEL NF 2	Ferrochrome lignosulfonate	X	X	X	X	X	X	X							S			S			S		P					Avebene CECA
BUCAL	Shale control reagent	X						X													P							Arnold & Clarke
BW BAR	Barytes	X	X	X	X	X	X	X	X	X																P		BW Mud
BW CHROME-FREE	Dechromed lignosulfonate	X	X	X	X	X	X	X										S					P					BW Mud
BW CLAY	Wyoming bentonite	X	X		X	X	X	X										S						P				BW Mud
BW CLN	Chrome lignite	X	X			X	X	X							S			P					P					BW Mud
BW DT	Concentrated mud detergent	X	X	X	X	X	X	X							S							P						BW Mud
BW EMUL	Invert emulsifier								X	X					P													BW Mud
BW EMUL-FL	Supplementary emulsifier & filtration control agent for invert emulsions								X	X					S			P										BW Mud
BW EMUL-VIS	Gelling agent for invert emulsions								X	X								S						P				BW Mud
BW EXHI-CELL	Purified, high molecular weight carboxymethyl cellulose	X	X		X	X	X	X										P						P				BW Mud
BW FCL	Ferro-Chrome lignosulfonate	X	X	X	X	X	X	X										S					P					BW Mud
BW HEC	Hydroxy ethyl cellulose	X	X	X	X	X	X	X										S						P				BW Mud
BW HI-CELL	High molecular weight sodium carboxymethyl cellulose	X	X		X	X	X	X										P						P				BW Mud
BW HT-LOID	Temperature stable modified starch	X	X	X	X	X	X	X										P										BW Mud
BW INHIBITOR 351	Corrosion inhibitor and bactericide	X	X	X	X	X	X	X			X																P	BW Mud
BW LO-CELL	Medium molecular weight sodium carboxymethyl cellulose	X	X		X	X	X	X										P						S				BW Mud
BW LUBE	Biodegradable lubricant	X	X	X	X	X	X	X								P												BW Mud
BW PIPE-LOOSE	Surfactant to be mixed with diesel oil to free stuck pipe	X	X	X	X	X	X	X																				BW Mud
BW POLYSEALER	Non-viscosifying fluid loss reducer	X	X	X	X	X	X	X										P										BW Mud
BW RESINOIL	Oil soluble resin, fluid loss control agent	X	X	X														P										BW Mud
BW RHEOCAP	Polymeric shale encapsulator	X	X	X			X	X													P			S				BW Mud
BW RHEOCELL	High molecular weight polyanionic cellulosic polymer	X	X	X	X	X	X	X							S	S		P			S			P				BW Mud
BW RHEODRILL	Polymeric viscosifier	X	X	X	X	X	X	X										S						P				BW Mud
BW RHEOFLOW	High molecular weight polyanionic cellulosic polymer	X	X	X	X	X	X	X							S	S		P			S			P				BW Mud
BW SAFESEAL	Particle sized calcium carbonate	X	X	X	X	X	X	X	X	X								P								S		BW Mud
BW SALT CLAY	Attapulgite clay		X	X	X	X		X																P				BW Mud
BW SCALEFREE	Scale inhibitor	X	X	X	X	X	X	X																			P	BW Mud
BW S-LOID	Pregelatinised starch	X	X	X	X	X	X	X										P										BW Mud
CALCIUM BROMIDE	Calcium bromide/calcium chloride (liquid blend)																									P	S	Delta Mud
CALCIUM CARBONATE	Calcium carbonate	X	X	X	X	X	X	X	X	X										P						P		Most companies
CALCIUM CHLORIDE	Calcium chloride		X	X	X			X	X	X		P					S				P					P		Most companies
CALGON X-9	Oxygen scavenger-powdered	X	X	X	X	X	X	X	X		X																P	Water Tech
CALGON X-10	Powdered inorganic metallic compound	X	X	X	X	X	X	X	X		X																P	Water Tech
CALGON X-100	Liquid inorganic metallic compound	X	X	X	X	X	X	X	X		X																P	Water Tech
CALGON X-901T	Oxygen scavenger-liquid	X	X	X	X	X	X	X	X		X																P	Water Tech
CALGON X-330	Organic inhibitor	X	X	X	X	X	X	X	X	X																	P	Water Tech
CALGON Y-55LT	Liquid salt inhibitor			X																							P	Water Tech
CALIG	Calcium lignosulfonate	X	X		X	X	X	X										S			S		P					CDA/HMC
CAL-SEAL	Gypsum cement																			P								Halliburton

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Product Tradename	Description of Material	Recommended for These Systems: Water-base, Low pH: Fresh Water	Brackish Water	Sat Salt Water	Gyp Treated	Water-base, High pH: Lime Treated	Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Functioning As: Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib.	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
CALTROL	Shale control inhibitor					X															P							Milchem
CANAFLEX	Shredded cane fibers	X	X	X	X	X	X	X												P								UBM
CARBOCEL	CMC	X	X	X	X	X	X				X				S			P			S			S				Lamberti
CARBO-FREE	Variable density oil phase spotting fluid concentrate to free stuck pipe	X	X	X	X	X	X	X								P						S						Milchem
CARBO-GEL	Invert suspending agent, viscosifier								X	X													—	P				Milchem
CARBO-MUL	Liquid oil phase mud emulsifier and wetting agent								X	X					P							S						Milchem
CARBONOX	Lignitic material	X	X			X	X	X							S			P					P					Baroid
CARBO-SEAL	Modified hydrocarbon								X											P								Milchem
CARBOSE	Sodium carboxymethyl cellulose	X	X		X	X	X	X							S			P			S			S				BASF Wyandotte
CARBO-TEC L	High temp. w/o emulsifier for oil phase muds								X						P													Milchem
CARBO-TROL	Filtration control agent for oil phase muds								X	X								P										Milchem
CARBOX S	Carboxilic polycarbonate dispersant	X	X	X	X	X	X	X										P			S	S	P					Drilsafe
CARBWATE	Calcium carbonate (particle sized) for clay free fluids																									P		Brinadd
CARNA-MUL	Supplemental additive for oil muds while drilling carnallite salt								X	X					P													Mizell
CASCANIT	Processed nut hulls	X	X	X	X	X	X	X												P								UBM
CAUSTICIZED LIGNITE	North Dakota lignite (causticized)	X	X	X		X	X	X															P					Wyo-Ben
CAUSTIC POTASH	Potassium hydrate	X	X	X	X		X	X				P																Most companies
CAUSTIC SODA	Sodium hydroxide	X	X	X	X	X	X	X	X			P	S												S			Most companies
CAUSTI-LIG	Causticized lignite	X	X	X	X	X	X	X															P					Magcobar
CC-16	Sodium salt of lignitic material	X	X			X	X	X							S			P					P					Baroid
CEASCAL	Acid soluble sealer for lost circulation	X	X	X			X	X												P								Magcobar
CEASTOP	Acid soluble lost circulation material	X	X	X			X	X										P		P				S				Magcobar
CECA D.D.	Drilling mud detergent	X	X	X	X	X	X	X													S	P						CECA SA
CECA DETERGENT	Drilling mud detergent	X	X	X	X	X	X	X									S				S	P						CECA
CECABAR	Barite	X	X	X	X	X	X		X	X																P		CECA
CECAL	Ground almond hulls	X	X	X	X	X	X	X	X	X										P								CECA
CECALIG	Chrome lignosulfonate	X	X	X	X	X	X	X										S			S		P					CECA
CECAMIANTE	Inorganic viscosifier	X	X	X	X	X	X	X	X															P				CECA
CECAMIDON	Pregelatinized starch	X	X	X	X	X	X	X										P			S			S				CECA
CECAPERL	Expanded perlite	X	X	X	X	X	X	X	X	X										P								CECA
CECARB	Calcium carbonate	X	X	X	X	X	X	X	X	X										S						P		CECA
CECBRINE A	Acid soluble workover	X	X	X		X	X	X							S			S						P				CECA
CECBRINE B	Acid soluble filtrate reducer for cecbrine A	X	X	X		X	X	X										P										CECA
CECFLOC	Clay flocculant	X	X				X	X									P	S										CECA
CECFLOC HT	Clay flocculant-high temp.	X	X	X			X	X									P	S										CECA
CECGUM	Natural polymer	X	X	X				X									S				S			P				CECA
CECLUB EP	Extreme pressure lubricant	X	X	X	X	X	X	X								P												CECA
CECMER	Carboxymethyl cellulose		X					X										P						S				CECA
CECNUT	Ground walnut hulls (fine and coarse)	X	X	X	X	X	X	X	X	X										P								CECA
CECOL	Ground olive stones (fine and coarse)	X	X	X	X	X	X	X	X	X										P								CECA
CECPAO	Combination of granules, and fibers																			P								CECA
F	Fine																											
G	Coarse																											
CECPAO S	Acid soluble lost circulation material																			P								CECA
CECPHANE	Shredded cellophane	X	X	X	X	X	X	X	X	X										P								CECA
CECTAN	Atomized quebracho	X	X		X	X	X	X										S					P					CECA
CECWOOD	Shredded wood fiber	X	X	X	X	X	X	X	X	X										P								CECA
CEDAR SEAL	Processed cedar fiber	X	X	X	X	X	X	X												P								Most companies
CEGAL	Lead sulfide powder	X	X	X	X	X	X		X	X																P		CECA
CELATEX	Ground rubber (fine, medium and coarse)	X	X	X	X	X	X	X												P								CECA
CELATEX N	Ground neoprene (fine, medium & coarse)								X	X										P								CECA SA
CELFLAKE	Fibrous cellulose	X	X	X	X	X	X	X	X	X										P								Drilsafe
CELLEX	Sodium carboxymethyl cellulose	X	X		X	X	X	X			X							P						S				Baroid
CELLOFLAKE	Shredded cellophane	X	X	X	X	X	X	X	X	X										P								Drilsafe and ECCO
CELL-O-SEAL	Shredded cellophane	X	X	X	X	X	X	X												P								Magcobar
CELL-O-SEAL	Cellophane flakes	X	X	X	X	X	X	X	X	X										P								Western

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Product Tradename	Description of Material	Fresh Water (Water-base, Low pH)	Brackish Water (Water-base, Low pH)	Sat Salt Water (Water-base, Low pH)	Gyp Treated (Water-base, Low pH)	Lime Treated (Water-base, High pH)	Fresh Water (Water-base, High pH)	Low Solids	Water-in-Oil (Invert) (Oil-base)	Oil Mud (Oil-base)	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib.	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Remover	Weighting Materials	Corrosion Inhibitors	Available from:
CELLOSIZE	Hydroxyethyl cellulose																	S						P				Magcobar
CELOFLEX	Shredded cellophane	X	X	X	X	X	X	X												P								UBM
CELPOL	Long chain polyanionic cellulosic polymer	X	X	X	X	X	X	X			X				S	S		P			P			S				Nyma
CELPOL SL	Polyanionic cellulose polymer	X	X	X	X	X	X	X							S	S		P			P							Nyma
CF-1	Anionic foaming agent	X	X	X															P			P						Cardinal
CF-2	Neutral fluorolhydrocarbon foamer	X	X	X															P			P						Cardinal
CHALKSEAL	Acid soluble fibers	X	X	X																P								Origmud
CHALK-SEAL	Select blend of acidizable lost circulation materials	X	X	X	X	X	X	X	X		X									P								Mizell
CHEMCO APC MUD LUBE	Non-polluting lubricant	X	X	X	X	X	X	X								P		S										Chemco
CHEMCOBAR	Barite	X	X	X	X	X	X	X	X	X																P		Chemco
CHEMCO FREE LUBE	Surfactant material to be mixed with diesel oil to free stuck pipe	X	X	X	X	X	X	X	X							P												Chemco
CHEMCO GEL	Wyoming bentonite	X	X		X	X	X	X										S						P				Chemco
CHEMCO LDD	Fluid detergent	X	X	X	X	X	X	X							P							P						Chemco
CHEMCOLIG	Lignite	X	X			X	X	X							S			P					P					Chemco
CHEMCO LIGNO-SULFONATE 727	Lignosulfonate	X	X	X	X	X	X	X	X						S		P				S		P					Chemco
CHEMCO NO FOAM	Liquid antifoam agent	X	X	X	X	X	X	X	X					P														Chemco
CHEMCO NO SLUFF	Sulfonated asphalt	X	X	X	X	X	X	X							S	S		P		S	P							Chemco
CHEMCO PLUG	Ground nut hulls	X	X	X	X	X	X	X	X	X										P								Chemco
CHEMCO SALT GEL	Attapulgite clay		X	X																				P				Chemco
CHEMHIB #3	Filming amine																										P	Brinadd
CHEMICAL V	Non-viscous organic lqd. to improve gel and combat crude oil contamination in Black Magic							X	X	X					S			S			S		S	P				Oil Base
CHEMICAL W	Non-viscous organic lqd. and Black Magic thickening agent							X	X	X								S		S	S		S	P				Oil Base
CHEMICAL WASH 7	Mud preflush for cementing	X	X	X	X	X	X	X										S					P					Dowell
CHEMICAL WASH 100	Mud preflush for cementing	X	X	X	X	X	X	X			X							S					P					Dowell
CHEMTROL X	Selected polymer blend	X	X	X	X	X	X											P			S							Milchem
CHIP-SEAL	Shredded Cedar Fiber	X	X	X	X	X	X	X												P								Magcobar
CHROMBLEND	Blend of dispersant	X	X	X	X	X	X	X										P					P					Arnold & Clarke
CHROME-FREE	Chrome free lignite for high temperature service	X	X	X	X	X	X	X														P						T.I.M.
CHROMELIG	Chrome lignite	X	X	X		X	X	X										S			P		P					Arnold & Clarke
CI8	*Filming amine*	X	X	X	X	X	X	X					P														P	*Texas Brine*
CIDE-COR	Biocide-corrosion inhibitor	X	X	X	X	X	X	X					P														P	Messina
CIRCOTEX	Sized carbonates	X	X	X	X	X	X	X	X	X										P						S		Texas Brine
CIRCOTEX-MAX	Sized carbonates	X	X	X	X	X	X	X	X	X										P						S		Texas Brine
CKCIDE L	Non-polluting bactericide (liquid)	X	X	X	X	X	X	X					P															CECA
CKCIDE P	Non-polluting bactericide (powder)	X	X	X	X	X	X	X					P															CECA
CKCL	Inhibitive complex polymer	X	X	X				X									S	S			P			S				CECA
CKMIX	Oil-in-water emulsion workover and completion system							X							S			S						P				CECA SA
CL 11	Potassium salt of lignite material	X	X	X	X	X	X	X										P			P		S					Avebene
CLAR O CEL	Cellulose fiber	X	X	X	X	X	X	X	X	X										P								CECA
CLARSOL ATC	Attapulgite clay		X	X																				P				CECA
CLARSOL FB 2	Medium yield bentonite	X	X	X	X	X	X	X			X							S						P				CECA
CLARSOL FB 5	High yield bentonite	X	X	X	X	X	X	X			X							S						P				CECA
CLARSOL FB 7	Sepiolite clay		X	X																				P				CECA
CLARSOL THR	Super-bentonite	X	X	X	X	X	X	X			X							S						P				CECA
CLARSOL WY	Wyoming bentonite	X	X	X	X	X	X	X			X							S						P				CECA
CLA-STAY	Completion & perforating fluid																				P							Halliburton
CLAY-EX	Bentonite extender	X	X				X	X									P							P				Arnold & Clarke
CLAY MASTER	Low M.W. polymer	X	X	X	X	X	X	X			X										P							Western
CLAY STABILIZER L42	Zirconium salt solution to prevent clay migration																P											Dowell
CL-CLS	Chrome lignite-chrome lignosulfonate	X	X	X	X	X	X	X							S			P			S		P					Dixie
CL-CLS	Chrome lignite-chrome lignosulfonate.	X	X	X	X	X	X	X							S			S			S		P					Delta Mud
CLEAR S20	Surfactant for removal of oil mud lost to formation								X	X												P						Baroid
CLEARATRON 7	Flocculant	X	X	X	X	X	X	X			X						P											Champion
CLEARTRON B-24	Flocculant sulfide scavenger	X	X	X	X	X	X	X									P											Champion
CLINTON FLAKES	Shredded cellophane	X	X	X	X	X	X	X	X	X										P								Dowell
C-LOX	Liquid oxygen scavenger	X	X	X	X	X	X	X																			P	Wyo-Ben
CLS	Chrome lignosulfonate	X	X	X	X	X	X	X							S			P			S		P					Most companies

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		Recommended for These Systems										Functioning As																
		Water-base							Oil-base																			
		Low pH					High pH																					
Product Tradename	Description of Material	Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Lime Treated	Fresh Water	Low Solids	Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
CMC	Sodium carboxymethyl cellulose (offered under many tradenames and in many grades)	X	X		X	X	X	X										P						S				Most companies
CMHEC	Dry or liquid viscosifier & filter reducer for salt muds and cement slurries	X	X	X	X	X	X	X			X				S			P						S				Drillsafe
CM-TH	Cement decontaminant	X	X	X				X				P													P			Brinadd
COAT-45	Sulfide scavenger	X	X	X	X	X	X	X																			P	Baroid
COAT-110	Atmospheric corrosion inhibitor																										P	Baroid
COAT-113	Oxygen corrosion inhibitor	X	X	X	X	X	X	X			X																P	Baroid
COAT-122	Corrosion inhibitor for treating solids free packer fluids																										P	Baroid
COAT-190	Atmospheric corrosion inhibitor																										P	Baroid
COAT-311	Oxygen corrosion inhibitor	X	X	X	X	X	X	X			X																P	Baroid
COAT-415	Filming amine	X	X	X	X	X	X	X			X																P	Baroid
COAT-777	Oxygen scavenger (liquid)	X	X	X	X	X	X	X																			P	Baroid
COAT-888	Oxygen scavenger (solid)	X	X	X	X	X	X	X																			P	Baroid
COAT B-1400	Corrosion inhibitor and biocide for treating solids free packer fluids												S														P	Baroid
COLMACEL	Cellulose fiber	X	X	X	X	X	X	X	X	X										P								CECA
COMP-PLUG	Acid soluble particulate suspension	X	X	X	X	X	X													P								Completion
CON DET	Mud detergent							X							S							P						Baroid
CORBAN	Organic corrosion inhibitors	X	X	X				X																			P	Dowell
COREXIT 7648	Inorganic scale dissolver	X					X																					Exxon Chem
COREXIT 7652	Anionic surfactant blend	X	X	X	X	X	X	X	X		X					P						P						Exxon Chem.
COREXIT 7671	Bactericide, concentrated sodium trichlorophenate solution	X	X	X	X	X	X	X					P															Exxon Chem
COREXIT 7720	Corrosion inhibitor	X	X	X	X	X	X	X	X	X																	P	Exxon Chem
COREXIT 7754	Corrosion inhibitor	X	X	X	X	X	X	X	X	X																	P	Exxon Chem.
COREXIT 7767	Inorganic oxygen scavenger	X	X	X			X																				P	Exxon Chem
COREXIT 7815	Paraffin dispersent														P								P					Exxon Chem
CORTRON R-174	Organic corrosion inhibitor	X	X	X	X	X	X	X	X	X																	P	Champion
CORTRON R-2207	Organic corrosion inhibitor	X	X	X	X	X	X	X																			P	Champion
CORTRON R-2264	Complete brine packer fluid treatment	X	X	X	X	X	X	X			X											S					P	Champion
CORTRON RDF-18	Corrosion inhibitor for mud	X	X	X	X	X	X	X	X	X	X																P	Champion
CORTRON RDF-21	Filming amine corr. inh.	X	X	X	X	X	X	X	X	X	X																P	Champion
CORTRON RDF-100	Catalyzed powdered oxygen scavenger	X	X	X	X		X	X			X																P	Champion
CORTRON RDF-101	Oxygen scavenger	X	X	X	X	X	X	X																			P	Champion
CORTRON RDF-109	Organic filming inhibitor	X	X	X	X	X	X	X	X	X																	P	Champion
CORTRON RDF-115	Corrosion inhibitor	X	X	X			X				X																P	Champion
CORTRON RDF-128	Oxygen scavenger	X	X	X	X		X	X			X																S	Champion
CORTRON RDF-132	Aerated corrosion inhibitor	X	X	X	X	X	X	X	X		X																P	Champion
CORTRON RDF-137	Sulfide scavenger corrosion inhibitor	X	X	X	X	X	X	X																			S	Champion
CORTRON RDF-138	Corrosion inhibitor for aerated muds	X	X	X	X	X	X	X			X																P	Champion
CORTRON RU-70	Complete mud packer fluid	X			X	X																					P	Champion
CORTRON RU-135	Aerated corrosion inhibitor	X	X	X	X	X	X	X																			P	Champion
CORTRON RU-137	Low solids corrosion inhibitor	X	X	X	X	X	X	X																			P	Champion
COTTONSEED HULLS	Cottonseed hulls	X	X	X	X	X	X													P								Most companies
COUROFLEX	Shredded leather flakes	X	X	X	X	X	X	X												P								UBM
CRACKCHEK-97	Sulfide cracking inhibitor	X	X	X	X	X	X	X	X	X																	P	Halliburton
CRODACAP	Encapsulating polymer	X	X	X	X		X	X										P						S				CDA/HMC
CRODACELL	Viscosifying polymer	X	X	X	X		X	X			X							S						P				CDA/HMC
CRODAN	Sodium polyacrylate	X		X		X	X	X									S	P					S					CDA/HMC
CRODAPOL 15	Polyacrylamide dispersion	X	X	X			X	X			X										P			S				CDA/HMC
CRONOX-235	Drilling corrosion inhibitor	X	X	X	X	X	X	X																			P	Aquaness
CS-1	Polymer clay stabilizer	X	X	X				X															P		P			Cardinal
CS-3	Clay and silt suspending agent	X	X	X				X														S						Western
CSD-50	One sack additive spotting fluid for freeing stuck pipe								X	X						P												Mizell
CSD-50 SPACER	One sack cement spacer								X	X																		Mizell
CUTTINGS WASH	Detergent							X	X	X								P										Am. Cyanamid
CYANAMER 244 A	Drilling fluid additive	X	X	X	X	X	X	X															P					Am. Cyanamid
CYANAMER 292	Low solids mud additive	X	X				X	X									P							P				Am. Cyanamid
CYFLOC	Synthetic flocculant	X	X	X	X	X	X	X									P					S						Am. Cyanamid
CYFLOC 4000	Flocculant	X	X	X	X		X	X									S				P							Am. Cyanamid
CYFLOC 4500	Flocculant	X	X	X	X	X	X	X									S				P							Am. Cyanamid
CYPAN	Sodium polyacrylate	X		X		X	X	X			X						S	P					S					Am. Cyanamid and ECCO
D-AIR-1	Powdered antifoam agent													P														Halliburton

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Product Tradename	Description of Material	Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Lime Treated	Fresh Water (High pH)	Low Solids	Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
		Recommended for These Systems: Water-base, Low pH				High pH			Oil-base			Functioning As																
D-AIR-2	Liquid antifoam agent													P														Halliburton
DAKOLITE	North Dakota lignite	X	X			X	X	X							S			S			S		P					Wyo-Ben
D-D	Drilling mud detergent	X	X	X	X	X	X	X							S							P						Magcobar
DEFOAM	Clay free fluids defoamer													P														Brinadd
DEFOAMER	Liquid-non alcohol base defoamer													P														RDSI
DEFOAMER NO. 15	Higher alcohol compound	X			X	X	X	X						P														Telnite
DEFOAMER NO. 20	Sodium alkyl aryl sulfonate		X	X	X	X	X	X						P														Telnite
DEFOAMER RL23	General purpose defoamer	X	X	X	X	X	X	X						P														CDA/HMC
DEFOAMER RL53	Sodium alkyl aryl sulfonate		X	X	X	X	X	X						P														CDA/HMC
DEFOAMER RL83	Branched higher alcohol		X	X	X	X								P														CDA/HMC
DEFOAMER VDF-135	Defoamer	X	X	X	X	X	X	X			X			P														Champion
DEFOMEX	Defoamer													P														Lamberti
DEL-BAR	Barite (barytes)	X	X	X	X	X	X	X	X	X																P		Delta Mud
DEL-BRIDGE-B	Blended $CaCO_3$ for brine fluids	X	X	X														S		P								Delta Mud
DEL-CIDE-B	Film forming amine and bactericide	X	X	X	X	X	X	X					P														P	Delta Mud
DEL DEFOAMER	Alcohol defoamer	X	X	X	X	X	X	X						P														Delta Mud
DEL-DET	Mud detergent	X	X	X	X	X	X	X							S							P						Delta Mud
DEL-FIBER	Shredded cane fiber blend	X	X	X	X	X	X	X												P								Delta Mud
DEL-FLAKES	Shredded cellophane	X	X	X	X	X	X	X												P								Delta Mud
DEL-GEL	Wyoming bentonite	X	X	X	X	X	X	X										S						P				Delta Mud
DEL-HYVIS-B	Blended HEC for brine fluids	X	X	X												S			S					P				Delta Mud
DEL-LIGNITE C	Chrome lignite	X	X	X		X	X	X							S			P					P					Delta Mud
DEL PAK	Calcium bromide/calcium chloride (liquid blend)																									P	S	Delta Mud
DEL PEL	Calcium chloride (pellet or flake)							X	X	X											P					P	S	Delta Mud
DEL-PILL-B	Hec-lignosulfonate-$CaCo_3$ slurry blend for brine fluids	X	X	X														S		P								Delta Mud
DEL-PLUG	Ground walnut or pecan hulls	X	X	X	X	X	X	X	X	X										P								Delta Mud
DEL-SEAL-B	HEC-lignosulfonate-carbonate blend for brine fluids	X	X	X														P						S				Delta Mud
DEL-S-GEL	Attapulgite clay		X	X				X																P				Delta Mud
DEL-VIS-B	Blended HEC $CaCo_3$ for brine fluids	X	X	X														S						P				Delta Mud
DESCO	Organic mud thinner	X	X	X	X	X	X	X						S							S		P					Drill Spec. and ECCO
DESILTA	Selective flucculant	X	X	X				X									P											American Mud
DETERGENT JD-1	Mud detergent	X	X	X	X	X	X	X							S						P							UBM
DETERGENT #7	Drilling detergent (dry)	X	X	X	X	X	X	X	X												P							Wyo. Ben
DETERGENT #139											X								P					S				King
DEXTRID	Organic polymer	X	X	X	X		X	X										P						S				Baroid
DFM	Polyalcohol defoamer	X	X	X										P														Texas Brine
DICASORB	Shredded oil absorbing material								X	X																		Delta Mud
DIAPLUG	Filter aid material	X	X	X	X	X	X	X	X	X										P								Messina
DIASEAL M	Mixture of filter aid materials	X	X	X	X	X	X	X	X	X										P								Drill Spec.
DICKS MUD SEAL	Shredded organic fiber	X	X	X	X	X	X	X	X	X										P								Wyo-Ben and ECCO
DEARTH	Diatchaceous earth-graded	X	X	X	X	X	X	X	X	X	X									P								CDA/HMC
DIPEL 421	Polymer for calcium control	X					X	X																		P		Am. Colloid
DISPERSOL C	Modified lignosulfonate	X	X	X																			P					Avebene & CECA
DISPERSOL N	Modified lignosulfonate	X	X	X	X	X																	P					Avebene & CECA
DMA LIGNITEC	Causticized lignite	X	X			X	X	X							S			P					S					Drill. Add.
DML-2	Water soluble biodegradable non-polluting lubricant	X	X	X	X	X	X	X								P												Delta Mud
DMS	Drilling mud surfactant	X	X	X	X	X	X	X								S		S				P						Aquaness
DMS	Drill mud surfactant	X	X	X	X	X	X	X								S		S				P						RDSI
DOS-3	Diesel oil substitute	X	X	X	X	X	X	X							S							P						Magcobar
DOS-22	Drilling mud lubricant	X	X	X	X	X	X	X								P					S							Drigmud
DOW CORNING	Silicones	X	X				X							P														Tretolite
DOWELL BACTERICIDE 400	Bactericide surfactant	X	X			X	X	X			X		P									S					S	Dowell
DOWELL BACTERICIDE 500	Bactericide	X	X		X	X	X	X			X		P														S	Dowell
DOC	Diesel oil cement																			P								Halliburton
DRILLBAR	Barite	X	X	X	X	X	X	X	X	X																P		Drillsafe
DRILLBAR C	Coarse barite	X	X	X	X	X	X	X	X	X																P		Drillsafe
DRILLGEL	Bentonite	X	X	X	X	X	X	X			X							S						P				Drillsafe
DRILLING DETERGENT	Drilling mud detergent	X	X	X	X	X	X	X							S							P						
DRILLING DETERGENT	Mud detergent	X	X	X	X	X	X	X							S	P						P						CDA/HMC
DRILLWATE	Acid soluble weighting mat.	X	X	X	X	X	X		X	X																P		Drillsafe
DRILL-X	Torque reducer (liquid)	X	X	X	X	X	X	X								P												Wyo-Ben
DRIL-SOL	Flocculant (liquid)	X	X	X	X	X	X	X									P											Wyo-Ben
DRILTAL 131	Drilling mud detergent	X	X	X	X	X	X	X						S	P							P						Lamberti

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Product Tradename	Description of Material	Recommended for These Systems: Water-base, Low pH: Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Water-base, High pH: Lime Treated	Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Functioning As: Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat.	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from:
DRILTEX	Polymer & sized carbonate blend	X	X	X			X											P							S			Texas Brine
DRILTREAT	Oil mud stabilizer								X	X					P			S				S	S					Baroid
DRILTRON B-24	Flocculant/sulfide scavenger	X	X	X	X	X	X	X									P											Champion
DRILTRON B-27	Chromate corrosion inhibitor	X	X	X			X	X			X																P	Champion
DRILTRON B-143	Sulfide scavenger inhibitor	X	X	X	X	X	X	X																			P	Champion
DRISCOSE	Pure grade CMC	X	X		X	X	X	X			X				S	S		P			S			S				Drill. Spec
DRISCOSE HIGH VISCOSITY	Pure grade CMC	X	X		X	X	X	X			X				S	S		P			S			S				Baker Chem.
DRISCOSE, REG. &HV	CMC	X	X		X	X	X	X			X				S	S		P			S			S				ECCO
DRISPAC, REG. SUPERLO	Polyanionic cellulose	X	X	X	X	X	X	X			X				S	S		P			P			P				ECCO
DRISPAC	Polyanionic cellulose	X	X	X	X	X	X	X			X				S	S		P			P			P				Drill. Spec.
DRISPAC SUPERLO	Polyanionic cellulose	X	X	X	X	X	X	X							S	S		P			P							Drill. Spec.
DRLGBAR	Barite	X	X	X	X	X	X	X	X	X																P		Drlgmud
DRLGDET	Drilling mud detergent	X					X	X						S								P						Drlgmud
DRLGGEL	Bentonite	X	X	X	X	X	X	X										P		S				P				Drlgmud
DRLGX	Polymer flocculant-clay extender	X	X																									Drlgmud
DS 403	Corrosion inhibitor for clayfree & water base mud and CO_2, H_2S	X	X	X	X	X	X	X																			P	Drilsafe
DS 495	Corrosion inhibitor for workover & completion	X	X	X	X	X	X	X																			P	Drilsafe
DS 495 E	Filming amine w/biocide	X	X	X	X	X	X	X					P														P	Drilsafe
DS PS	H_2S scavenger	X	X	X	X	X	X	X																			P	Drilsafe
DS-PEC	Shale control agent	X	X	X			X											S			P							Drilsafe
DS-PH	Liquid pH regulator for H_2S and shale control	X	X	X	X	X	X	X				P									S							Drilsafe
DS-PRESERVATIVE	For starch and gums	X	X	X	X	X	X	X			X		P														S	Drilsafe
D-TRON S-18	Drilling detergent	X	X	X	X	X	X	X														P						Champion
DUOVIS	Xanthum gum biopolymer	X	X	X	X	X	X	X							S			S						P				Magcobar
DURATONE HT	Oil mud filtration control agent								X	X								P										Baroid
DURANEX	Temperature stable fluid loss additive	X	X	X	X	X	X											P										Baroid
DV-22	Fluid loss control agent for oil base and invert emulsion muds									X	X				S			P										Magcobar
DWA-768	Dispersant/wetting agent								X	X													P					UBM
DV-33	Oil wetting agent for oil continous & invert emulsion muds								X	X					P			S				S						Magcobar
DWA-76	Dispersant/wetting agent								X	X													P					Mizell
ECCO-BANOX	Oxygen scavenger	X	X	X	X	X	X	X			X																P	ECCO
ECCO-BAR	Barite	X	X	X	X	X	X	X	X	X																P		ECCO
ECCO-CLAYLUBE	Biodegradable & Nontoxic lubricant	X	X	X	X	X	X	X			X				S	P					S	S						ECCO
ECCO-DEFOAMER	All purpose defoamer	X	X	X	X	X	X	X			X			P								S						ECCO
ECCO-DRILLING DETERGENT	Drilling mud detergent	X						X							S							P						ECCO
ECCO-FILMINE	Filming amine	X	X	X	X	X	X	X			X																P	ECCO
ECCO-GEL	Sodium bentonite	X	X	X	X	X	X	X										S						P				ECCO
ECCO-PARACIDE	Microbiocide	X	X	X	X	X		X					P															ECCO
ECCO-SEAL	Shredded organic fiber	X	X	X	X	X	X	X												P								ECCO
ECCO-SORBIDE	H_2S scavenger	X	X	X	X	X	X	X																			P	ECCO
ECCO-SPERSE	Chrome lignosulfonate	X	X	X	X	X	X	X							S			P					P					ECCO
ECCO-SPOTFREE	Surfactant for mixing w/diesel oil to free stuck pipe	X	X	X	X	X	X	X														P						ECCO
ECCO-YP	Bentonite extender	X					X	X									S							P				ECCO
ECCO-SHALEBOND	Modified asphaltic powder	X	X	X	X	X	X	X	X		X				S			P			P	S						ECCO
ECONOMAGIC	Crude oil emulsifier and thixothropic property adjuster							X		X					P	S		S			S	S	S	S			S	Oil Base
EMULFOR BH	Organic compound									X														P				CECA
EMULFOR EP	Emulsifier, stabilizer								X	X					P								P					CECA
EMULFOR ER	Filtrate reducer								X						S			P										CECA
EMULFOR GE	Gelling agent								X	X														P				CECA
EMULFOR MO	Wetting agent for high complex salt content								X												P	P	S					CECA
EMULFOR NK	Basic material, filtrate reducer									X					S			P							S			CECA
EMULFOR ST	Stabilizer, emulsifier								X	X					P			S			S	S	P					CECA
EMULFOR TX	Viscosifier								X									S						P				CECA
EMULGO	Emulsifier for clay free fluids								X									P						P				Brinadd
EMULGO PILL	Clay free fluids emulsifier								X									P		P				P				Brinadd
E P MUDLUBE	Extreme pressure lubricant	X	X	X	X	X	X	X								P												Baroid
ESAPAL KT 177	Drill mud liquid surfactant	X	X	X			X	X							P				S			S						Lamberti
ESAPAL NP 187	Nonionic emulsifier	X	X	X	X	X	X	X								S		S				P	S					Lamberti

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Product Tradename	Description of Material	Water-base, Low pH: Fresh Water	Water-base, Low pH: Brackish Water	Water-base, Low pH: Salt Water	Water-base, Low pH: Gyp Treated	Water-base, High pH: Lime Treated	Water-base, High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil-base: Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from:
EXCELLO-GEL	Polymeric water gel spacer fluid	X	X	X	X	X	X	X																				Western
EXTRA HI-YIELD GEL	Polymerized Wyoming bentonite	X		X	X	X	X																	P				Wyo-Ben
EZEFLO	Low pour-point surfactant	X	X	X																		P						Dowell
E Z MUL	Oil mud emulsifier								X	X					P							S						Baroid
E. Z OUT	Oil soluble surfactant to free stuck pipe	X	X	X	X	X	X	X	X																			Delta Mud
EZ SPOT	Oil mud concentrate	X	X	X	X	X	X	X	X	X						P												Baroid
F-552	Nonionic foaming agent	X	X	X			X												P			S						CE-Natco
FB 1	Silicone defoamer	X	X	X	X	X	X	X						P		S												Delta Mud
FB 2	Concentrated silicone defoamer	X	X	X	X	X	X	X						P		S												Delta Mud
FCL	Modified chrome lignosulfonate	X	X	X	X	X	X	X							S			P			S		P					CDA/HMC
F.D.S. 69	Drilling detergent	X	X	X	X	X	X	X	X	X					P													Trinity Mud
FER-O-BAR	Weighting material	X	X	X	X	X	X	X	X	X																P	S	Sachtleben
FERRO-CAL	Iron complexed lignosulfonate	X	X	X	X	X	X	X										S					P					Milchem
FERROWATE	Iron carbonate	X	X	X	X	X	X	X	X	X																P		Brinadd
F-FLOW	Mud removal agent								X	X												P						Western
FIBERTEX	Shredded cane fiber blend	X	X	X	X	X	X	X												P								Baroid
FL-1 (Refined)	Improved organic polymer	X	X	X	X	X	X	X								S		P			S							Montello
FL-3	Polymeric for clay free fluids	X	X	X														P										Brinadd
FL-4	Polymeric for clay free fluids	X	X	X														P										Brinadd
FLOBEST	Inorganic viscosifier	X	X	X	X	X	X	X	X															P				Messina
FLOCCULENT	Clay flocculant							X									P											Wyo-Ben
FLOCELE	Cellophane flakes	X	X	X	X	X	X	X												P								Halliburton
FLOCGEL	Pregelatinized starch	X	X	X	X	X	X	X										P						S				Scholten
FLOCGEL HV/TA	Modified natural polymer	X	X	X	X	X	X	X										P						P				Scholten
FLOCGEL LV	Pregelatinized potato starch	X	X	X	X	X	X											P						S				Scholten
FLOCGEL LV-NR	Pregelatinized starch, low viscosity	X	X	X	X	X	X	X										P						S				Scholten
FLOCGEL NLV	Pregelatinized corn starch	X	X	X	X	X	X											P						S				Scholten
FLOCGEL ST	Shredded high swelling flakes	X	X	X	X	X	X	X	X	X	X									P								Scholten
FLOCGEL W	Carboxymethyl polymer bentonite extender	X	X				X	X										S			P			P				Scholten
FLOCHEK	Two-phase polymer and cement																			P								Halliburton
FLOSAL	Inorganic viscosifier	X	X	X	X	X	X	X												S				P				Drill Spec. and ECCO
FLOTEX	Lignosulfonates, carbohydrates & sized carbonate blend	X	X	X			X											P		S								Texas Brine
FLOXIT	Clay flocculant							X									P											Magcobar
FOAMATRON V-12	Foaming agent	X	X	X	X	X	X	X																				Champion
FOAMATRON V-14	Foaming agent	X	X	X			X				X								P									Champion
FOAM BRAKE	Liquid antifoam agent	X	X	X	X	X	X	X						P														Montello
FOAMER OP14	Non-ionic foaming agent	X	X	X							X								P									CDA/HMC
FOAMER OP15	Foaming agent for high electrolyte fluids	X	X	X	X	X	X	X			X								P									CDA/HMC
FOAMEX PP	Foaming agent										X					S			P			S						Lamberti
FOAM FREE	Versatile non-polluting defoamer	X	X	X	X	X	X	X						P														Messina
FOAMING AGENT G-2	Nonionic foaming agent	X	X	X							X									P								Dowell
FORAGUM C	Organic compound	X	X	X				X												P								CECA
FORAGUM HM	Natural polymer	X	X	X				X									S				S			P				CECA
FORAMOUSSE D	Freshwater foaming agent										X								P									CECA
FORAMOUSSE FW	Fresh and sea water foaming agent										X								P									CECA
FORAMOUSSE S	Salt water foaming agent										X								P									CECA
FORAQUITAINE 10	Bactericide	X	X	X	X	X	X	X					P														S	CECA
FORAQUITAINE 35	Bactericide	X	X	X	X	X	X	X					P															CECA
FORMASEAL	Oil sol. lost circ. material and temp. plugging agent							X	X	X								S		P				S				Oil Base
FORMASEAL-HT	Oil sol. lost circ. material and temp. plugging agent for high temp.							X	X	X								S		P				S				Oil Base
FREE HOLE	Surface active agent for freeing stuck drill pipe	X	X	X	X	X	X	X	X																			Montello
FREE LUBE	Surfactant material to be mixed with diesel oil to free stuck pipe	X	X	X	X	X	X	X	X							P												Chemco
FRACSEAL	Finely ground $CACO_3$	X	X	X																P								Drigmud
FRESH-FLO	Modified tree extract	X	X	X	X	X	X	X							S			S			S		P					Messina
FS-F	Low surface tension foaming agent	X	X	X															P			P						Western
F & W PILL	Oil soluble "temporary" plugging agent for producing zones	X	X	X	X	X	X	X	X	X										P								Oil Base

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Product Tradename	Description of Material	Water-base, Low pH: Fresh Water	Water-base, Low pH: Brackish Water	Water-base, Low pH: Sat. Salt Water	Water-base, Low pH: Gyp Treated	Water-base, High pH: Lime Treated	Water-base, High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil-base: Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
GABROSA	Sodium carboxymethylcellulose (Low, Med, Hi, Ext Hi vis technical grade)	X	X	X	X	X	X	X			X				S			P			S			P				Montedison
GALACTASOL 413	Nonionic polymer viscosifier	X	X	X			X	X			X										S			P				Henkel
GALACTASOL 416	Nonionic polymer viscosifier	X	X	X			X	X			X										S			P				Henkel
GALACTASOL 615	Anionic polymer viscosifier	X	X					X																P				Henkel
GALENA	Lead sulfide powder	X	X	X	X	X	X		X	X																P		Baroid
GEL-AIR	Anionic foaming agent										X								P									Milchem
GELOMERE EAV	High molecular weight polymer	X	X	X	X	X	X											S			S			P				UBM
GELTONE II	Low shear, oil mud gellant								X	X														P				Baroid
GENDRIL FLO	Natural polymer and fluid loss additive	X	X	X			X	X										S						P				Henkel
GENDRIL THIK	Natural polymer viscosifier	X	X	X			X	X																P				Henkel
GEN DRIL THIK	Guar gum	X	X					X										S						P				American Mud
GEO-GEL	High temperature stable viscosifying agent	X	X	X	X	X	X	X										S						P				Magcobar
GILSONITE	Natural hydrocarbon	X	X	X	X	X	X	X								S				P	P							Most companies
GRAPHITE	Graphite	X	X	X	X	X	X	X	X	X						P												Most companies
GUFCOBAR	Barite (barytes)	X	X	X	X	X	X	X	X	X																P		GH Gulco
GUFCO BIOCIDE B-12	Bactericide	X	X	X	X	X	X	X					P															GH Gulco
GUFCO BIOLUBE	Nonpolluting lubricant	X	X	X	X	X	X	X								P												GH Gulco
GUFCO BROMICAL	Water solution of calcium chloride and calcium bromide																									P		GH Gulco
GUFCO BROMICAL HD	Water solution of zinc bromide and calcium bromides																									P		GH Gulco
GUFCO BROMICON	Calcium bromide powder (fine, medium & coarse)																									P		GH Gulco
GUFCO CLS	Chrome lignosulfonate	X	X	X	X	X	X	X										S					P					GH Gulco
GUFCO D-FOAM 40	Defoamer	X	X	X	X	X	X	X						P														GH Gulco
GUFCO DMD	Drilling mud detergent	X	X	X	X	X	X	X							S	S						P						GH Gulco
GUFCO FILMKOTE C-33	Corrosion inhibitor	X	X	X	X	X	X	X																			P	GH Gulco
GUFCOGEL	Wyoming bentonite	X	X	X	X	X	X	X										S						P				GH Gulco
GUFCO HD GEL	Viscosifier for Bromical HD																							P				GH Gulco
GUFCO LIG	Mined lignin	X	X	X	X	X	X	X							S			S						P				GH Gulco
GUFCO OXBAN S-10	Oxygen scavenger	X	X	X	X	X	X	X																			P	GH Gulco
GUFCO PLUG	Ground pecan shells	X	X	X	X	X	X	X	X	X										P								GH Gulco
GUFCO POLYJEL	Pure synthetic polymer	X	X	X			X																	P				GH Gulco
GUFCO POLYSEAL	LCM for clear water fluids (Reg. & Coarse)		X	X																P								GH Gulco
GUFCO POLYVIS	Polymer and calcium carbonate blend	X	X	X			X												P		S			P				GH Gulco
GUFCO PREGEL	Invert mud gelling agent								X	X														P				GH Gulco
GUFCO PREMUL	Inverted emulsion								X	X																		GH Gulco
GUFCO PREMUL EMA	Invert mud emulsifier								X	X					P													GH Gulco
GUFCO PREMUL EMB	Invert mud emulsifier								X	X					P													GH Gulco
GUFCO PREMUL EMC	Invert mud wetting agent								X	X												P						GH Gulco
GUFCO PREMULX	Invert mud fluid loss control agent								X	X					S			P						S				GH Gulco
GUFCO SALT GEL	Attapulgite clay		X	X																				P				GH Gulco
GUFCO WALLFREE	Surfactant material to be mixed with diesel oil to free pipe	X	X	X	X	X	X	X	X													P						GH Gulco
GUFCO WALLKOTE	Liquid asphalt	X	X	X	X	X	X	X								S		S	P		P							GH Gulco
GYPSOL III	Gypsum disintegrator	X	X	X																					P			Cardinal
GYPSUM	Gypsum (plaster of paris)		X		X			X										S				P						Most companies
GYPTRON TDF-113	Scale control	X	X	X	X	X	X	X																	P			Champion
HALLIBURTON-GEL	Wyoming bentonite	X			X	X	X	X																P				Halliburton
HEVIWATER ANTI-OXIDANT M129	Oxygen scavenger (solid)	X	X	X	X	X	X	X																			P	Dowell
HEVIWATER DRY CONCENTRATE 555	Weighting agent for solids-free fluid	X					X	X													S					P		Dowell
HEVIWATER GELLING AGENT J164	Gelling agent	X	X	X	X	X	X	X										S						P				Dowell
HEVIWATER IC PACKER AND COMPLETION FLUID	Water solution of calcium chloride with density range of 9 to 11.6 ppg including inhibitor and fluid loss control																									P		Dowell
HEVIWATER IIC PACKER AND COMPLETION FLUID	Water solution of calcium chloride and calcium bromide with density range of 11.7 to 15.1 ppg including inhibitor and fluid loss control																									P		Dowell
HEVIWATER IIIC PACKER AND COMPLETION FLUID	Water solution of CaBr with density of 15.2-17.2 ppg, including inhibitor																	P								P	S	Dowell

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Product Tradename	Description of Material	Water-base, Low pH: Fresh Water	Water-base, Low pH: Brackish Water	Water-base, Low pH: Sat. Salt Water	Water-base, Low pH: Gyp Treated	Water-base, High pH: Lime Treated	Water-base, High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil-base: Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
HEVIWATER IVC INHIBITED BRINE	Water solution of zinc bromide, calcium bromide and calcium chloride, 15.2 to 19.2 ppg																									P		Dowell
HICELL	Polyanionic cellulose	X	X	X	X	X	X	X			X				S	S		P			P			P				CDA/HMC
HICELL DS	Polyanionic cellulose	X	X	X	X	X	X	X							S	S		P			P							CDA/HMC
HIDENSE	Weighting agent																									P		Halliburton
HIMUL Y	Organophilic colloid								X	X														P				CDA/HMC
HIPOL X	High molecular weight xanthan gum	X	X	X	X	X	X	X										S						P				Messina
HI-WATE	Extra high density powder for blowout control	X	X	X	X	X	X		X	X																P		Messina
HME	Selective, nonionic surface active agent	X	X	X	X	X	X	X														P						Chemco
HME ENERGIZER	Selective, nonionic surface active agent	X	X	X	X	X	X	X														P						Montello
HOLE-CONTROL	Modified hydrocarbon compound for shale control	X	X	X	X	X	X	X			X				S	S		P			P		S					Mizell
HOLEMAKER FLOC	Nonionic, selective flocculant	X	X	X	X	X	X	X									P											Montello
HOTGEL	Stable high temperature viscosifying agent	X	X	X	X	X	X	X										S						P				Messina
HOWCO BAR	Weighting agent																									P		Halliburton
HOWCO SUDS	Nonionic foaming agent	X	X			X	X	X			X								P									Halliburton
HOWCO SUDS STICKS	Solid foaming agent										X								P									Halliburton
HS GUARD	Hydrogen sulfide scavenger	X	X	X	X	X	X	X																			P	Arnold & Clarke
HS-I	Sulfide cracking inhibitor	X	X	X	X	X	X	X																			P	Western
HTT 450	Polymeric high temperature dispersant, fluid loss control agent	X	X	X	X	X	X											P					P					CDA/HMC
HUMIC 333	Oil in water emulsion system	X	X	X				X							P			S						S				CECA
HUMIC NF	Acid soluble oil-in-water emulsion workover and completion system	X	X	X				X							P			S						S				CECA
HYDROGEL	Wyoming bentonite	X	X	X	X		X	X										S						P				Wyo-Ben
HYDRO-SPOT	One drum additive spotting fluid for freeing stuck pipe								X	X						P												Mizell
HYDROWATE	Weighted completion fluid																											Halliburton
HY-SEAL	Shredded organic fiber	X		X	X	X	X	X												P								Baroid
HYTEX	Lignosulfonates, synthetic polymer & sized carbonate blend	X	X	X			X													P								Texas Brine
IDF ANTIFOAM L-500	Defoamer for polymeric systems	X	X	X	X	X	X	X						P														IDF
IDF AP-21	Polymeric fluid loss reducer	X	X	X			X									P						S						IDF
IDF BACTERIOCIDE D3T	Non-phenolic bactericide	X	X	X	X	X	X	X					P															IDF
IDF B-FREE	Spotting fluid for freeing stuck pipe	X	X	X	X	X	X	X								P						S						IDF
IDF CL-11	Chrome lignite	X	X	X	X	X	X											S					P					IDF
IDF CORROSION INHIBITOR A/C	Coating amine corrosion inhibitor	X	X	X	X	X	X	X																			P	IDF
IDF CORROSION INHIBITOR A/S	Sulfide resistant-amine base corrosion inhibitor	X	X	X	X	X	X	X																			P	IDF
IDF CORROSION INHIBITOR O/S	Oxygen scavenger	X	X	X	X	X	X	X																			P	IDF
IDF CORROSION INHIBITOR PHT	Coating amine for production wells	X	X	X	X	X	X	X																			P	IDF
IDF DEFOAMER	Alcohol blend	X	X	X	X	X	X	X						P														IDF
IDF DF-19	Selective flocculant	X	X					X									P											IDF
IDF DF-20G	Flocculant	X	X					X									P											IDF
IDF D-FOAM	Long chain alcohol	X	X	X	X	X	X	X						P														IDF
IDF DF-VIS	Polymeric viscosifier	X	X	X	X		X	X							S			S						P				IDF
IDF DI-PLUG	Filter aid material	X	X	X	X	X	X	X	X	X										P								IDF
IDF DRILLING DETERGENT DX-10	Drilling mud detergent	X	X	X	X	X	X	X							S							P						IDF
IDF DV-68	Bentonite extender	X						X	X															P				IDF
IDF DYNA LUBE	Drilling lubricant	X	X	X	X	X	X	X								P						S						IDF
IDF EASY DRILL	Torque reducer	X	X	X	X	X	X	X								P						S						IDF
IDF EML LUBRICANT	Drilling lubricant	X	X	X	X	X	X	X								P						S						IDF
IDF FLR-100	Polymeric fluid loss reducer	X	X	X	X	X	X	X							S			P						S				IDF
IDF HI-FOAM	Foaming agent	X					X	X											P			S						IDF
IDF HI-TEMP	High temperature fluid loss reducer	X	X	X	X	X	X	X										P		S								IDF
IDF HY-MUL	High temperature fluid loss stabilizer	X	X	X			X	X										P				S						IDF
IDF IDBREAK	Surface active defoamer	X	X	X	X	X	X	X						P														IDF
IDF IDBRIDGE	Oil soluble graded resin	X	X	X			X	X																				IDF
IDF IDCARB-75	Acid soluble graded calcium carbonate	X	X	X	X	X	X	X	X	X								S		S						P		IDF
IDF IDCARB-150	Acid soluble graded calcium carbonate	X	X	X	X	X	X	X	X	X								P		S						S		IDF

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Product Tradename	Description of Material	Recommended for These Systems: Water-base, Low pH: Fresh Water	Water-base, Low pH: Brackish Water	Water-base, Low pH: Sat. Salt Water	Water-base, Low pH: Gyp Treated	Water-base, High pH: Lime Treated	Water-base, High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil-base: Oil Mud	Air, Gas, Mist	Functioning As: Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat.	Shale Control Inhib.	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from:
IDF IOCIDE-L	Non-phenolic bactericide liquid	X	X	X	X	X	X	X	X				P															IDF
IDF IOCIDE-P	Non-phenolic bactericide powder	X	X	X	X	X	X	X	X				P															IDF
IDF IDFAC	Non-ionic fluoro-surfactant	X	X	X			X	X														P						IDF
IDF IDFILM-120	Filming amine inhibitor	X	X	X	X	X	X	X			X																P	IDF
IDF IDFILM-220	Filming amine inhibitor	X	X	X							X																P	IDF
IDF IDFILM-320	Filming amine inhibitor																										P	IDF
IDF IDFILM-620	Atmospheric corrosion inhibitor																										P	IDF
IDF IDFLO	Non viscosifying fluid loss reducer	X	X	X	X	X	X	X										P										IDF
IDF IDHEC	Synthetic cellulose polymer	X	X	X			X	X																				IDF
IDF IDSCAV 110	Oxygen corrosion scavenger	X	X	X	X	X	X	X																			P	IDF
IDF IDSCAV 110X	Catalysed oxygen corrosion scavenger	X	X	X	X	X	X	X																			P	IDF
IDF IDSCAV-210	Oxygen corrosion scavenger	X	X	X	X	X	X	X																			P	IDF
IDF IDSCAV-310	Oxygen and sulphite scavenger	X	X	X			X	X			X																P	IDF
IDF IDWATE	Acid soluble graded iron compound	X	X	X			X	X										S								P		IDF
IDF INTERDRILL EMUL	Invert emulsifier								X						P													IDF
IDF INTERDRILL FL	Invert fluid loss reducer								X						S			P										IDF
IDF INTERDRILL MULTIMUL	Invert system base mixture								X						P			P										IDF
IDF INTERDRILL O.W.	Invert system oil wetting agent								X													P						IDF
IDF INTERDRILL SF	Invert fluid loss reducer								X									P										IDF
IDF INTERDRILL VISOL	Polymeric invert viscosifier								X						S									P				IDF
IDF INTERDRILL VISTONE	Invert viscosifier								X						S									P				IDF
IDF INTERLOK	Blended lost circulation material	X	X	X	X	X	X	X												P								IDF
IDF MUD FIBER	Fibrous material	X	X	X	X	X	X	X												P								IDF
IDF POLY MUL	o/w emulsifier	X					X	X							P							S						IDF
IDF POLY PLASTIC	Shale stabilizer	X					X	X										S			P							IDF
IDF PTS-100	pH buffer for clay free fluids	X	X	X			X	X				P																IDF
IDF RHEOPOL	Polymeric fluid loss reducer	X	X	X	X	X	X	X										P						S				IDF
IDF SAFEGUARD 5000	Amine base corrosion inhibitor	X	X	X	X	X	X	X																			P	IDF
IDF SAFEGUARD 5500	Oxygen scavenger	X	X	X	X	X	X	X																			P	IDF
IDF SAFEGUARD 6000	Amine base corrosion inhibitor	X	X	X	X	X	X	X																			P	IDF
IDF SM(X)	Polymeric viscosifier	X	X	X			X	X																P				IDF
IDF SPUD MUD (R)	Polymeric viscosifier	X	X	X			X																	P				IDF
IDF SS-100	Polymeric shale encapsulator	X	X	X			X	X													P							IDF
IDF TARGARD		X	X	X	X	X	X	X										P										IDF
IMA #2	Salt mud blend system (dry)		X	X	X	X									P			P										Wyo-Ben
IMA CONCENTRATE	Defoaming & wetting agent	X	X	X	X	X	X	X			X			P		S					S	P						Wyo-Ben
IMCO BAR	Barite (barytes)	X	X	X	X	X	X	X	X	X																P		IMCO
IMCO BRINEGEL	Attapulgite clay		X	X																				P				IMCO
IMCO CIDE	Blended carbamate solution, bactericide	X	X	X	X	X	X	X					P															IMCO
IMCO CRACK CHEK	Sulfide cracking inhibitor	X	X	X	X	X	X	X																			P	IMCO
IMCO DEFOAM	Salt water defoamer		X	X										P														IMCO
IMCO DRIL-S	Polymer biocide and sized carbonate blend	X	X	X			X	X										P						P				IMCO
IMCO DRILLTHERM	High temperature fluid loss control	X	X	X			X	X										P					S					IMCO
IMCO DUROGEL	Viscosifier	X	X	X	X	X	X	X																P				IMCO
IMCO EP LUBE	Extreme pressure lubricant	X	X	X	X	X	X	X								P												IMCO
IMCO FLAKES	Shredded cellophane flakes	X	X	X	X	X	X	X	X	X										P								IMCO
IMCO FLOC	Clay flocculant							X									P											IMCO
IMCO FOAMANT	Foaming agent										X								P			S						IMCO
IMCO FOAMBAN	All purpose liquid defoamant	X	X	X	X	X	X	X						P														IMCO
IMCO FREEPIPE	Oil sol. surfactant	X	X		X	X		X														P						IMCO
IMCO FYBER	Shredded fiber blend	X	X	X	X	X	X	X	X	X										P								IMCO
IMCO GEL	Wyoming Bentonite	X	X		X	X	X	X										S						P				IMCO
IMCO GELEX	Bentonite extender	X	X				X	X									S							P				IMCO
IMCO HOLECOAT	Water dispersable asphaltic blend	X	X	X	X	X	X	X								P		S										IMCO
IMCO HYB	Extra hi yield bentonite	X						X																P				IMCO
IMCO IE PAC	Inhibition enhancer	X	X	X			X											S			P							IMCO
IMCO KEN CAL-L	Powdered dispersing agent							X	X														P					IMCO

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Product Tradename	Description of Material	Recommended for These Systems: Water-base, Low pH: Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	High pH: Lime Treated	High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Functioning As: Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat.	Shale Control Inhib.	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
IMCO KEN-GEL	Organophilic clay								X															P				IMCO
IMCO KENOL-S	Emulsifiers for formulating invert emulsions								X						P			S						S				IMCO
IMCO KENOX	Quick lime								X	X					P													IMCO
IMCO KEN-PAK	Conc. for gelatinous oil packs								X	X					P													IMCO
IMCO KEN SUPREME	Fatty acid emulsifier									X					P													IMCO
IMCO KEN-X CONC. 1	Basic invert oil emulsifier								X						P													IMCO
IMCO KEN-X CONC. 2	Stabilizer; weight suspension agent								X						P													IMCO
IMCO KEN-X CONC. 3	Stabilizer; hi temp filtrate control								X						P													IMCO
IMCO KLAY	Sub-bentonite	X	X	X	X	X	X	X										S						P				IMCO
IMCO KWIKSEAL	Blended LCM	X	X	X	X	X	X	X	X	X										P								IMCO
IMCO LIG	Lignitic material	X	X		X	X	X	X							S								P					IMCO
IMCO LOID	Pregelatinized starch		X	X	X	X	X	X										P						S				IMCO
IMCO LUBE-106	Lubricant	X	X	X	X	X	X	X								P												IMCO
IMCO LUBRIKLEEN	Non-polluting organic lubricant	X	X	X	X	X	X									P												IMCO
IMCO MD	Mud detergent	X	X	X	X	X	X	X						S	P							P						IMCO
IMCO MUDOIL	Oil dispersed asphalt	X	X		X	X	X									P												IMCO
IMCO PERMAFILM	Corrosion inhibitor	X	X	X	X	X	X	X																			P	IMCO
IMCO PERMALOID	Pregelatinized starch		X	X	X	X	X	X										P										IMCO
IMCO PHOS	Phosphate	X	X			X	X	X															P					IMCO
IMCO PLUG	Ground walnut hulls (fine, med. and coarse grades)	X	X	X	X	X	X	X	X	X										P								IMCO
IMCO POLY Rx	Synergistic polymer blend	X	X	X	X	X	X	X							S			P			P		P					IMCO
IMCO POLYSAFE	Polymer for fluid loss control	X	X	X	X	X	X	X										P			S			S				IMCO
IMCO PRESERVALOID	Paraformaldehyde	X	X	X	X			X					P															IMCO
IMCO QBT	Quebracho based thinner	X	X			X	X	X															P					IMCO
IMCO RD-111	Processed mod. lignosulfonate	X	X	X	X	X	X	X							S			P					P					IMCO
IMCO RD-2000	Dispersant	X	X	X	X	X	X	X										S			S		P					IMCO
IMCO SAFE-PAC	Blended polymers	X	X	X	X	X	X	X	X	X	X													P				IMCO
IMCO SAFE PERFSEAL	Blended synthetic polymers	X	X	X			X	X										P		S				P				IMCO
IMCO SAFE-SEAL	Sized carbonates	X	X	X	X	X	X	X	X	X										P						S		IMCO
IMCO SAFE-SEAL X	Sized carbonates	X	X	X	X	X	X	X	X	X										P						S		IMCO
IMCO SAFE-TROL	Lignosulfonates, carbohydrates and sized carbonate blend	X	X	X			X	X										P										IMCO
IMCO SAFE-VIS	Synthetic polymer and sized carbonate blend	X	X	X				X										S						P				IMCO
IMCO SAFE-VIS X	Synthetic polymer	X	X	X				X																P				IMCO
IMCO SCALECHEK	Scale inhibitor	X	X	X			X	X																	S		P	IMCO
IMCO SCR	Shale control reagent					X																P						IMCO
IMCO SHURLIFT	Wet processed calcium magnesium silicate	X	X	X			X																	P				IMCO
IMCO SP-101	Sodium polyacrylates	X	X				X	X										P										IMCO
IMCO SPOT	Dry blend emulsifier								X						S	P												IMCO
IMCO SULF-X II	Hydrogen sulfide scavenger	X	X	X	X	X	X	X			X																P	IMCO
IMCO SUPER GELEX	Bentonite extender	X	X				X	X									S							P				IMCO
IMCO SWS	Anionic-nonionic surfactant	X	X	X	X	X		X							S							P						IMCO
IMCO THIN	Causticized lignite	X	X			X	X	X							S		P						P					IMCO
IMCO VC-10	Chrome lignosulfonate	X	X	X	X	X	X	X							S			P			S		P					IMCO
IMCO VR	Gel-builder for invert emulsion								X	X					S									P				IMCO
IMCO WATE	Calcium carbonate								X	X																P		IMCO
IMCO XC	Bacterially produced polymer	X	X	X	X		X	X																P				IMCO
IMCO X-CORR	Corrosion inhibitor	X	X	X	X	X	X	X					P														P	IMCO
IMCO XO_2	Oxygen scavenger	X	X	X	X	X	X	X																			P	IMCO
IMPERMEX	Pregelatinized starch	X	X	X	X	X	X	X										P										Baroid
IMVIGEL	Magnesium smectite	X	X		X	X	X	X										S						P				IMV
INDUSCRUB	Heavy duty cleaner														S							P						CE-Natco
INICOR B	Corrosion inhibitor	X	X	X	X	X	X	X																			P	Lamberti
INIPOL S 33	Surfactant mixed with diesel for freeing stuck pipe	X	X	X	X	X	X	X	X	X						S						P						CECA
INVERMUL	Oil mud stabilizer								X	X					P			S						S				Baroid
INVERPOL	Magnesium smectite	X	X		X	X	X	X										S						P				IMV
IROBAR	Synth. hi density, acid sol. weighting material	X	X	X	X	X	X	X	X	X																P		Drillsafe
IRONITE SPONGE	Synthetic oxide H_2S scavenger	X	X	X	X	X	X	X	X														S			S	P	Ironite
J-2	Natural gum viscosity builder and fluid-loss control agent	X	X	X	X			X										S						P				Western
JEL-O-GEL	Hydroxyethylcellulose	X	X	X				X										S						P				Completion services
JELFLAKE	Shredded cellophane	X	X	X	X	X	X	X												P								Baroid
KANE FIBER	Processed cane fiber	X	X	X	X	X	X	X												P								Wyo-Ben
KARI	Polymeric for clay free fluids	X	X	X				X								S						P						Brinadd
KATHON WT	Biocide	X	X	X	X	X	X	X					P															Drillsafe

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KELZAN XC POLYMER	Xanthum gum biopolymer	X	X	X	X	X	X	X							S			S						P				Kelco
KEMBREAK	Calcium lignosulfonate	X	X		X	X	X	X										S			S		P					Arnold & Clarke
K-FLO	Non-ionic surfactant	X						X													S	P						Baroid
KIM-MUD	Polymeric for clay free fluids	X	X	X				X										P			P			P				Brinadd
KLEARFAC	Phosphate ester of alcohol alkoxylate								X	X	X				P				P			P	P					BASF Wyandotte
KLEEN-BLOCK	Non-damaging sized carbonate	X	X	X	X	X	X	X	X	X										P						S		Messina
KLEEN-BLOCK X	Non-damaging sized carbonate	X	X	X	X	X	X	X	X	X										P						S		Messina
KLEEN-DRILL	Non-damaging polymer/filtration control compound	X	X	X			X	X										P						P				Messina
KLEEN-MIX	One bag mixture of non-damaging viscosifiers/ filtration agents.	X	X	X	X	X	X	X										P						P				Messina
KLEEN-PAK	Non-damaging synthetic polymer blend	X	X	X			X	X										P						P			S	Messina
KLEEN-PIL	Non-damaging synthetic polymer blend	X	X	X			X	X										P			S			P				Messina
KLEEN-SEAL	Non-damaging filtration control blend	X	X	X			X	X										P										Messina
KLEEN-SPOT	Non-polluting, invert emulsion spotting fluid for stuck pipe	X	X	X	X	X	X	X	X	X					P	P					P					S		Delta Mud
KLEEN UP	Heavy duty detergent and degreaser	X	X	X																								Magcobar
KLEEN-VIS	Non-damaging synthetic polymer	X	X	X				X										S						P				Messina
KLEEN-VIS X	Non-damaging synthetic polymer	X	X	X				X																P				Messina
K-LIG	Potassium lignite derivative	X						X								P			P									Baroid
KOLITE	Ground coal	X	X	X	X	X	X	X	X	X	X									P								Dowell
KONTOL	Corrosion inhibitor	X	X	X	X	X	X	X	X	X	X											S					P	Tretolite
KOROHIBIT C-100K	Atmospheric corrosion inhibitor																										P	C-E Natco
KOROHIBIT C-115K	Corrosion inhibitor	X	X	X	X	X	X	X			X																P	C-E Natco
KOROHIBIT C-122K	H_2S scavenger	X	X	X	X	X	X	X																			P	C-E Natco
KOROHIBIT C-675	Corrosion inhibitor	X	X	X	X	X	X	X			X																P	C-E Natco
KWIK-THIK	Extra hi yield bentonite	X						X										S						P				Magcobar
KWIK SEAL	Combination of granules, flakes and fibers	X	X	X	X	X	X	X												P								RSDI and ECCO
KWIK VIS	Polymer	X					X	X																P				Wyo-Ben
L 10	Pure, dried lignite for geothermal drilling	X	X	X				X										S			S		P					CECA & Avebene
L 19	Causticized soluble lignite	X	X	X			X	X										S			S		P					Avebene & CECA SA
LAMCOBAR	Barite (barytes)	X	X	X	X	X	X	X	X	X																P		Louisiana Mud
LAMCO CLAY	Sub-bentonite	X	X	X	X	X	X	X										S						P				Louisiana Mud
LAMCO DRILLFAS	Mud detergent	X	X	X	X	X	X	X						S	P							P						Louisiana Mud
LAMCO E	Emulsifier	X	X	X	X	X	X	X							P													Louisiana Mud
LAMCO FIBER	Shredded cane fibers	X	X	X	X	X	X	X												P								Louisiana Mud
LAMCO FLAKES	Shredded flakes	X	X	X	X	X	X	X												P								Louisiana Mud
LAMCO GEL	Wyoming bentonite	X	X		X	X	X	X										S						P				Louisiana Mud
LAMCO HYDROPROOF	Colloidal asphalt	X	X	X	X	X	X	X							S	S		P			P							Louisiana Mud
LAMCOLIG	Lignite	X	X		X	X	X	X							S			P					P					Louisiana Mud
LAMCO PERMA THINZ	Aluminum chrome lignosulfonate	X	X	X	X	X	X	X	X						S			S					P					Louisiana Mud
LAMCO SLX	Emulsifier & surfactant	X	X	X	X	X	X	X							S	P						S						Louisiana Mud
LAMSALGEL	Attapulgite clay		X	X																				P				Louisiana Mud
LD-8	Non-polluting defoamer	X	X	X	X	X	X	X						P														Milchem
LEATHERSEAL	Shredded leather	X	X	X	X	X	X	X	X	X										P								Baroid
LEATH-O	Shredded leather	X	X	X	X															P								Milchem
LECTRO-MIX	Water soluble salts	X	X	X			X	X													P							Oil Base
LENALK	Causticized lignite	X				X	X	X							S			P					P					ECCO
LENOX	Lignite	X				X	X	X							S			P					P					ECCO
LEO'S PLUG	Sunflower seed hulls	X	X	X	X	X	X	X												P								Wyo-Ben
LHC	Liquid hydrocarbon cement for lost circulation																			P								Western
LIGCO	Lignite	X	X			X	X	X							S			P					S					Milchem
LIGCON	Sodium salt of lignitic material	X	X		X	X	X	X							S			P					S					Milchem
LIGNATE	Processed modified lignosulfonate	X	X	X		X	X	X							S			P					P					Temite
LIGNEX	Low molecular weight ferrochrome lignosulfonate	X	X				X											S			S		P					CECA & Avebene
LIGNEX N	Sodium lignosulfonate	X	X	X	X	X	X								P			S					P					Avebene & CECA
LIGNO THIN	Lignite base thinner	X					X	X							P			P					P					Am. Colloid
LIGTEX-K	Potassium lignite derivative	X				X		X										P			P		S					Texas Brine
LIME	Hydrated lime					X		X	X		X	P	S			S					S						S	Most companies
LO LOSS	Guar gum	X	X					X										S						P				Magcobar

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Product Tradename	Description of Material	Recommended for These Systems: Water-base, Low pH: Fresh Water	Brackish Water	Sat Salt Water	Gyp Treated	Lime Treated	Water-base, High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Functioning As: Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
LOWATE	Acid soluble weight material	X	X	X	X	X	X	X	X	X																P		Magcobar
LST-5	Non-emulsion, all purpose surfactant	X	X	X							X											P						Cardinal
LST-12	Silt suspending surfactant	X	X	X																		P	P					Cardinal
LST-13	Oil, paraffin dispersant									X												P						Cardinal
LST-34	Cationic fluorosurfactant	X	X	X																		P						Cardinal
LST-36	Fluorosurfactant blend for foaming hydrocarbon frac fluids									X									P									Cardinal
LST-37	Fluorosurfactant blend for foaming mixtures of hydrocarbon and water from well bore									X									P									Cardinal
LST-35	Nonionic fluorosurfactant	X	X	X																		P						Cardinal
LUBE-KOTE	Graphite	X	X	X	X	X	X	X								P												Magcobar
LUBE-TEX	Biodegradable lubricant	X	X	X	X	X	X	X								P												Texas Brine
LUBRA-GLIDE	Solid friction reducer & "gumbo" stabilizer	X	X	X	X	X	X	X	X	X	X					P												Sun Chem
LUBRA-PHASE I	Non ionic mud surfactant, shale solids control	X	X		X	X	X	X										S			S	P						Sun Chem
LUBRA-PHASE II	Biodegradable & non-toxic lubricant	X	X		X	X	X	X								P												Sun Chem
LUBRA-SEAL	Micronized, surface modified, cellulose-base fiber	X	X	X	X	X	X	X	X	X	X				S			S		P								Sun Chem
LUBRE TORQUE	Torq reducer	X	X	X	X	X	X								S	P												UBM
LUBRICANT JJ35	Extreme pressure lubricant	X	X	X	X	X	X	X							P													CDA/HMC
LUBRICANT 458	Biodegradable and nontoxic lubricant	X	X	X	X	X	X	X								P												Lamberti
LUBRI-FILM	E.P. lubricant and corrosion inhib.	X	X	X	X	X	X	X								P											P	Milchem
LUBRI-SAL	Non-polluting lubricant	X	X	X	X	X	X	X								P												Milchem
MAGCOBAR	Barite (barytes)	X	X	X	X	X	X	X	X	X																P		Magcobar
MAGCOBRINE C.B.	Pre-blended calcium chloride/ Bromide brines for workover, completion and packers																											Magcobar
MAGCOBRINE C.C.	Pre-blended calcium chloride brine for workover, completion and packers																											Magcobar
MAGCOBRINE P.C.	Potassium chloride	X	X	X	X	X	X	X													S					P		Magcobar
MAGCOBRINE S.C.	Sodium chloride	X	X	X	X	X	X	X									S				S					P		Magcobar
MAGCO DEFOAMER A-40	Defoamer		X	X										P														Magcobar
MAGCOFOAMER 76	Foaming agent										X								P									Magcobar
MAGCO FIBER	Blended fibers	X	X	X	X	X	X	X												P								Magcobar
MAGCOGEL	Wyoming bentonite	X	X	X	X	X	X	X										S						P				Magcobar
MAGCO INHIBITOR 101	Corrosion inhibitor for packer fluids	X	X	X	X	X	X	X																			P	Magcobar
MAGCO INHIBITOR 202	Corrosion inhibitor for direct treating oil drill string	X	X	X	X	X	X	X			X																P	Magcobar
MAGCO INHIBITOR 303	Organic amine corrosion inhibitor for workover, completion and packer brines	X	X	X	X	X	X	X																			P	Magcobar
MAGCOLUBE	Biodegradable lubricant	X	X	X	X	X	X	X								P												Magcobar
MAGCONATE	Petroleum sulfonate emulsifier	X	X			X	X	X							P													Magcobar
MAGCONOL	Alcohol defoamer	X	X	X	X	X	X	X						P														Magcobar
MAGCOPHOS	Sodium tetraphosphate	X	X	X			X	X															P	P				Magcobar
MAGCO POLY DEFOAMER	Organic polyol defoamer	X	X	X	X	X	X	X					P															Magcobar
MAGCO POLY SAL	Organic polymer	X	X	X	X	X	X	X										P										Magcobar
MAGNACIDE	Bacteriostats	X	X	X	X	X	X	X					P															Aquaness
MAGNE-MAGIC	Blend of magnesium and calcium compounds		X	X			X					P						P						S				Oil Base
MAGNE-SALT	Water soluble salts	X	X	X			X	X													P							Oil Base
MAGNE-SET	Controlled solidifier		X	X			X	X												P								Oil Base
MAGNE-SET ACCELERATOR	Material for reducing set time for Magne-Set	X	X	X	X	X	X	X												P								Oil Base
MAGNE-SET RETARDER	Material for increasing set time for Magne-Set	X	X	X	X	X	X	X												P								Oil Base
MAGNESIUM CHLORIDE	Magnesium chloride			X	X																					S		Most companies
MAGNESIUM OXIDE																												ECCO
MAGNE-THIN	Low molecular wt. polymer		X	X				X													S			P				Oil Base
MARBLE	Natural calcium carbonate	X	X	X	X	X	X	X	X	X																P		Edemsarda
MARITE	4.7 specific gravity weighting agent	X	X	X	X	X	X		X	X															P	S		Messina
MC-500	Fluid loss control, high temperature stability additive								X	X								P										Mizell
MESUCO-BAR	Barite (barytes)	X	X	X	X	X	X		X	X																P		Messina
MESUCO-BEN	Bentonite	X	X	X	X	X	X	X										P						P				Messina
MESUCO-CL	Sodium salt of lignitic material	X	X			X	X	X	X						S			P					P					Messina
MESUCO-CRCL	Chrome lignitic compound	X	X	X		X	X	X										S			P		P					Messina
MESUCO FIBER	Shredded plant fibers	X	X	X	X	X	X	X												P								Messina
MESUCO FLAKE	Sized and crimped cellophane flakes	X	X	X	X	X	X	X	X	X										P								Messina

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		Recommended for These Systems										Functioning As																
		Water-base							Oil-base																			
		Low pH				High pH																						
Product Tradename	Description of Material	Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Lime Treated	Fresh Water	Low Solids	Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
MESUCO-FOAM	Versatile foaming agent for fresh to salt saturated muds										X								P									Messina
MESUCO-GEL	Wyoming bentonite (API spec.)	X	X	X	X	X	X	X										P						P				Messina
MESUCO-GEL	Wyoming bentonite	X	X	X	X	X	X	X										P						P				Messina
MESUCO-HEC	Hydroxyethylcellulose	X	X	X	X	X	X	X			X							P						P				Messina
MESUCO-KL	Potassium lignitic compound	X	X			X	X	X							S			S			P		S					Messina
MESUCO-LIG	Lignitic material	X	X			X	X	X							S			P					S					Messina
MESUCO MUD DETERGENT	Concentrated mud detergent	X	X	X	X	X	X	X							S							P						Messina
MESUCO-PLUG	High strength ground nut shells	X	X	X	X	X	X	X	X	X						S				P								Messina
MESUCO SALT CLAY	Attapulgite clay		X	X	X	X	X	X																P				Messina
MESUCO-SEAL	Scientific blend of loss circulation materials	X	X	X	X	X	X	X												P								Messina
MESUCO-SORB	H_2S scavenger	X	X	X	X	X	X	X																			P	Messina
MESUCO SUPER GEL	Extra high yield bentonite	X	X	X			X	X										S						P				Messina
MESUCO WORKOVER-5	High molecular weight polymer-calcium carbonate blend	X	X	X																P								Messina
MF-1	Polymer, selective flocculant	X	X	X			X	X									P											RDSI
MCA	Mica flakes (sev. grades avail.)	X	X	X	X	X	X	X	X	X										P								Most companies
MICATEX	Mica flakes (fine, med. and coarse)	X	X	X	X	X	X	X	X	X										P								Baroid
MIL-BAR	Barite (barytes)	X	X	X	X	X	X	X	X	X																P		Milchem
MILCHEM MD	Mud detergent	X	X	X	X	X	X	X							S							P						Milchem
MILCHEM PIPE-GARD	Zinc chromate corrosion inhibitor	X	X	X	X	X	X	X																			P	Milchem
MIL CON	Neutralized heavy metal mod lignite	X	X	X	X	X	X	X							S			P					S					Milchem
MIL-FIBER	Shredded cane fibers	X	X	X	X	X	X	X												P								Milchem
MILFLAKE	Shredded cellophane fibers	X	X	X	X	X	X	X												P								Milchem
MIL-FREE	Surfactant for mixing with diesel oil to free stuck pipe	X	X	X	X	X	X	X								P												Milchem
MIL-GARD	H_2S scavenger	X	X	X	X	X	X	X																			P	Milchem
MILGEL	Wyoming bentonite	X	X	X	X	X	X	X			X							S						P				Milchem
MIL-PLATE	Diesel oil replacement	X	X	X	X	X	X	X								P												Milchem
MIL-PLUG	Ground walnut hulls	X	X	X	X	X	X	X	X	X										P								Milchem
MIL-POLYMER 302	Biodegradable polymer viscosifier for water base mud	X	X	X			X	X										S						P				Milchem
MIL-POLYMER 303	Drilling polymer with biocide	X	X	X			X	X					S					P						P				Milchem
MIL-POLYMER 304	Drilling polymer with biocide for calcium contaminated systems	X	X	X				X					S					P						P				Milchem
MIL-POLYMER 305	Drilling polymer for moderate temperature systems	X	X	X		X	X											P						P				Milchem
MIL-POLYMER 306	Drilling polymer for moderate to high temp. systems	X	X	X		X	X											P						P				Milchem
MIL-TEMP	Stabilize flow & fluid loss of water base muds at high temp.	X	X	X	X	X	X	X										S					P					Milchem
MIXICAL	Acid soluble fluid loss additive and lost circulation material for Polybrine systems	X	X	X			X	X	X									P		P								Magcobar
MON-DET	Mud detergent	X	X	X	X	X	X	X							S							P						Montello
MONEX	Flocculant and bentonite extender	X				X	X	X									P							P				ECCO
MON EX	Co-polymer, flocculant and clay extender	X	X				X	X									P							P				Montello
MON FOAM	Foaming agent for fresh or salt water										X								P									Montello
MON HIB	Film forming amine to control drill pipe corrosion	X	X	X	X	X	X	X																			P	Montello
MONOIL CONCENTRATE	Concentrate for Oil Base invert system								X						P													Montello
MON PAC	High molecular weight, polyanionic cellulosic polymer	X	X	X	X	X	X	X			X				S	S		P			P			P				Montello
MON PAC ULTRA LO	Polyanionic cellulose ultralo viscosity	X	X	X	X	X	X	X							S	S		P			P							Montello
MOR-REX	For shale stabilization	X	X	X	X	X	X	X																				Corn
MOR-REX	Modified starch		X			X															P		P					Milchem
MR-1	Mud removal agent	X	X														S					S						Western
MUDBAN	Oil-base mud thinner, dispersant	X	X	X	X	X	X	X	X														P					Dowell
MUD-EX	Mud detergent	X	X	X	X	X	X	X														P	P					Tretolite
MUDFLUSH	Mud removal agent	X	X	X	X	X	X	X																				Halliburton
MUD FIBER	Blended cane and wood fiber	X	X	X	X	X	X	X												P								Magcobar
MUD-MUL	Non-ionic emulsifier	X	X		X		X	X							P							S						Messina
MUD-MUL (LS)	Anionic/nonionic (low solids emulsifier)	X	X	X	X		X	X							P							S						Messina
MUD-PAC	Corrosion inhibitor for solids layden Packer Fluids	X	X	X	X	X	X	X																			P	Milchem
MUD SEAL	Cellulose fibers	X	X	X	X	X	X	X	X	X										P								Telnite

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Product Tradename	Description of Material	Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Lime Treated	Fresh Water	Low Solids	Water-in-Oil (invert)	Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat.	Shale Control Inhib.	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from:
MULCON	To correct acid number in oil muds & invert muds								X	X					S			S			S			P				Drillsafe
MULDIS	Emulsifier & wetting agent for oil base & invert muds							X	X	X					P			S				P	S					Drillsafe
MULFIL	Stabilizes suspension & plastering prop. in oil m.							X		X														P				Drillsafe
MULFIX	Oil soluble liquid for use as packer fluid, for fracturing and acidizing							X	X	X								S		S	S		S	P				Drillsafe
MULFLO	Flow improver								X	X					P	S		S				P	P					Drillsafe
MULGEL	Viscosifier & gelling agent for oil base & invert muds								X	X								P			S	S		P				Drillsafe
MULOIL A	Dry or liquid basic comp. for hi temp/hi water oil base muds								X	X					S	S		P			S			S			S	Drillsafe
MULOIL B	Dry or liquid basic comp. for oil base muds									X					S	S		P			S			S			S	Drillsafe
MULSEAL	Asphaltic, oil soluble LCM for oil base & invert								X	X								S		P				S				Drillsafe
MULSTAB	Stabilizes filtrate & emulsion under hi temp. in oil base muds								X	X					P			S				S	P					Drillsafe
MULTICEL	CMC, all grades	X	X	X	X	X	X	X			X							P						S				Drillsafe
MULTICEL EHV	Super hi vis CMC	X	X	X	X	X	X	X			X							P						P				Drillsafe
MULTICOAT	Water-dispersible asphalt for filtration, inhibition & lubric. in water base m.	X	X	X	X	X	X	X	X	X						S		P			P			S				Drillsafe
MULTICRYL	Polyacrylamide, all grades	X	X	X			X	X			X							P			P			P				Drillsafe
MULTIDET	Drilling mud detergent	X	X	X	X	X	X	X							S							P						Drillsafe
MULTIDEX	Hi temperature stable polysaccharide, 200°C	X	X	X	X	X	X	X										P			S			S				Drillsafe
MULTI-DF	Liquid all purpose d-foam	X	X	X	X	X	X	X						P														Drillsafe
MULTI-DFD	Dry all purpose d-foamer	X	X	X	X	X	X	X						P														Drillsafe
MULTIFLOC	Selective, nonionic flocculant	X	X	X	X	X	X	X									P											Drillsafe
MULTIFOAM	All purpose foaming agent	X	X	X	X	X	X	X			X								P									Drillsafe
MULTIHEC	Hydroxyethylcellulose	X	X	X	X	X	X	X			X				S	S		P			S			P				Drillsafe
MULTILAX	Oil soluble surfactant to free stuck pipe	X	X	X	X	X	X	X	X							S						P						Drillsafe
MULTILIG C	Chrome lignite	X	X	X		X	X	X										S			P		P					Drillsafe
MULTILUBE	Extreme pressure lubricant	X	X	X	X	X	X	X								P						S						Drillsafe
MULTILUBE A	Non-polluting EP lubricant	X	X	X	X	X	X	X								P						S						Drillsafe
MULTIMER	Blend of hi temp. & salt resistant polymers	X	X	X	X	X	X	X			X							P			S			S				Drillsafe
MULTIMYL	Pregelatinized starch		X	X	X	X	X	X			X							P						P				Drillsafe
MULTIMYL A	Non-fermenting, temp. stable carboxymethyl-starch	X	X	X	X	X	X	X										P			S			S				Drillsafe
MULTIPLAST	Non-polluting, hi soluble low solids LCM-additive	X	X	X	X	X	X	X	X	X	X									P								Drillsafe
MULTIPOL HT	Resin/lignitic blend for filtrate & vis control at hi temperatures	X	X	X	X	X	X	X										P			S		S	S				Drillsafe
MULTISAL	Colloidal base & filtrate reducer for clayfree muds		X	X			X					P						P						S				Drillsafe
MULTISEAL	Combination of granules flakes and fibers	X	X	X	X	X	X	X												P								Eisenman
MULTITHIN	Chrome lignosulfonate	X	X	X	X	X	X	X							S			S			S		P					Drillsafe
MULTIVIS	Hi molecular weight, salt resistant polymer	X	X	X			X	X			X							S						P				Drillsafe
MULTI-XC	Hi molecular weight xanthan gum polymer	X	X	X	X	X	X	X			X				S			S						P				Drillsafe
MV-405	Liquid oil phase mud emulsifier & wetting agent								X	X						S		S				P						Milchem
MY-LO-JEL	Pregelatinized starch	X	X	X	X	X	X	X										P							S			Magcobar
MY-LO-JEL PRESERVATIVE	Starch preservatives	X	X		X		X	X					P															Magcobar
N-4886	Organic polyelectrolyte polymers								X								P											Tretolite
NAMINAGIL	Corrosion inhibitor, biocide	X	X										S														P	Rhone Poulenc
NATROSOL	Hydroxy ethyl cellulose	X					X	X										P						P				Baker Chem.
NELU PHANE	Cellophane flakes	X	X	X	X	X	X	X	X	X										P								CDA/HMC
NELU PHLAX	Shredded fibre	X	X	X	X	X	X	X	X	X										P								CDA/HMC
NELU STARCH	Pregelatinised starch		X	X	X	X	X	X										P						S				CDA/HMC
NF-1	Liquid antifoam agent	X	X	X	X	X	X	X						P														Halliburton
NFP	Powdered antifoam agent	X	X	X	X	X	X	X						P														Halliburton
N-GAUGE	Potassium lignosulfonate	X	X	X	X	X	X	X										S			P		S					Delta Mud
NOCOR 133, 166, 203	Corrosion inhibitors									X																	P	Cardinal
NOCOR 224	Corrosion inhibitors								X	X																	P	Cardinal
NOCOR 439	Corrosion inhibitors	X	X	X	X	X	X	X	X													S					P	Cardinal

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Product Tradename	Description of Material	Water-base, Low pH: Fresh Water	Water-base, Low pH: Brackish Water	Water-base, Low pH: Sat Salt Water	Water-base, Low pH: Gyp Treated	Water-base, High pH: Lime Treated	Water-base, High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil-base: Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
NOCOR 643	Surfactant and corr. inhib.	X	X	X	X	X	X	X														P					S	Cardinal
NOCOR 644	Air/Gas Drlg. foamer with inhibitor										X								P			P					P	Cardinal
NOCOR 645	Air/Gas Drlg. foamer										X								P			P						Cardinal
NOCOR 700 S	Surfactants	X	X	X	X	X	X	X														P						Cardinal
NOMOUSS D	Defoamer	X	X				X	X						P														CECA
NOMOUSS S	Defoamer		X	X										P														CECA
NORUST 720	Corrosion inhibitor		X	X							X		S														P	CECA
NORUST 995	Corrosion inhibitor for completion brines		X	X									S														P	CECA SA
NORUST 996	Corrosion inhibitor for calcium completion brines		X	X									S														P	CECA SA
NORUST ACH	Oxygen corrosion inhibitor	X	X	X			X	X			X																P	CECA
NORUST ASW	Oxygen corrosion inhibitor	X	X																								P	CECA
NORUST OC 40	Foaming agent for fresh or salt water										X								P									CECA
NORUST PA23D	H_2S and CO_2 corrosion inhibitor		X	X					X	X																	P	CECA
NORUST SC 41	Oxygen scavenger	X	X	X	X	X	X	X																			P	CECA
NO-STIK	Surface active agent	X	X	X	X	X	X	X								S		S				P						RDSI
NOVADRIL 30	Polyanionic cellulosic polymers	X	X	X													P							P				Hercules
NOVADRIL 40	Polyanionic cellulosic polymers	X	X	X					X	X							P							P				Hercules
NOXYGEN	Oxygen scavenger	X	X	X	X	X	X	X																			P	Milchem
N.P.L. 122	Environmental Protection Lubricant	X	X	X	X	X	X	X								P		P			P						P	Trinity Mud
NUT PLUG	Ground walnut shells	X	X	X	X	X	X	X	X	X										P								Magcobar
NYMCEL	Carboxy methyl cellulose in low, high and ultra high viscosities, technical and pure grades	X	X	X	X	X	X	X			X				S			P			S			P				Nyma
OA 13	Oxidizing agent	X	X	X							X		P															Completion
OB ACID PYRO	Sodium acid pyro phosphate	X	X	X			X	X															P	P				Oil Base
OB BENGEL	Wyoming bentonite	X	X	X	X	X	X	X										S						P				Oil Base
OBC 655	Blended oxygen scavenger, corrosion inhibitor, biocide	X	X	X	X	X	X	X			X		P														P	CDA/HMC
OBC 656	Blended oxygen scavenger, corrosion inhibitor, biocide	X	X	X	X			X			X		P														P	CDA/HMC
OB CLAY	Sub-bentonite	X	X	X	X	X	X	X										S						P				Oil Base
OB CLOROGEL	Attapulgite clay		X	X				X																P				Oil Base
OB DEFOAMER	Defoamer	X	X	X	X	X	X	X						P														Oil Base
OB DETERGENT	Mud detergent	X	X	X	X	X	X	X														P	P					Oil Base
OB DIVERTER	Stimulation fluid diverter	X	X	X	X	X	X	X	X	X					S			S		P								Oil Base
OB DIVERTER-HT	Stimulation diverter for hi-temp. hi-press wells	X	X	X	X	X	X	X	X	X					S			S		P								Oil Base
OB FLOC	Clay flocculant	X	X	X	X	X	X	X									P											Oil Base
OB GEL	Conc. for improving Black Magic gel; basic conc. for location mixing of Black Magic SP	X	X	X	X	X	X	X	X	X	X				S	S		P			S	P	S	S				Oil Base
OB GRAVEL PACK FLUID	Basic oil base mud conc. for gravel packing range of 7.8 to 17-ppg (mfgr. mixed)							X		X								P						S				Oil Base
OB HEVYWATE	Barite (barytes)	X	X	X	X	X	X	X	X	X																P		Oil Base
OB HEXAGLAS	Sodium hexameto phosphate	X	X	X			X	X															P	P				Oil Base
OB HI-CAL	Calcium hydroxide	X	X	X	X	X	X	X	X	X		P	S		S			S									S	Oil Base
OB LIME HYDRATE	Hydrated lime					X		X	X	X	X	P	S				S				S						S	Oil Base
OB MIX FIX	Visc. reducer for Black Magic and mixing oil adjuster							X		X													P	S				Oil Base
OB NUT SHELL	Ground pecan shell	X	X	X	X	X	X	X	X	X										P								Oil Base
OB PACKER FLUID	Basic oil base mud conc. for ...oing annulus packing ...r. mixed	X	X	X	X	X	X	X	X	X	X																P	Oil Base
OB PFA	...tropic adjuster for oil base ...acker fluids								X	X							S							P			S	Oil Base
OB PYRO	Sodium tetraphosphate	X	X	X			X	X															P	P				Oil Base
OB SAPP	Sodium acid pyro phosphate	X	X	X			X	X															P	P				Oil Base
OB STARCH PRESERVATIVE	Paraformaldehyde												P															Oil Base
OB STP	Sodium tetraphosphate	X	X	X			X	X															P	P				Oil Base
OB WATE	Calcium carbonate									X																P		Oil Base
OB WELL PAC	Basic oil base mud conc. for bell hole & casing protection (mfgr. mixed)	X	X	X	X	X	X	X	X	X	X																P	Oil Base
OB WELL WASH	Drlg. fluid dispersant; borehole cleaner	X	X	X	X	X	X	X	X	X												S	P					Oil Base
OB WOODSEAL	Wood shavings	X	X	X	X	X	X	X	X	X										P								Oil Base
OCOBAR	Barite	X	X	X	X	X	X	X	X	X																P		OCOMA
OCOBAR BULK	Bulk barite	X	X	X	X	X	X	X	X	X																P		OCOMA
OCOBAR MB	Marine bagged barite	X	X	X	X	X	X	X	X	X																P		OCOMA
OCOBAR T	Coarse barite	X	X	X	X	X	X	X	X	X																		

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Product Tradename	Description of Material	Recommended for These Systems — Water-base — Low pH — Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	High pH — Lime Treated	Fresh Water	Low Solids	Oil-base — Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Functioning As — Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat.	Shale Control Inhib.	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from:
OCOBEN	Bentonite	X	X	X	X	X	X	X																P				OCOMA
OCOBRACHO	Spray dried quebracho	X	X			X	X	X							S			S					P					OCOMA
OCO DEFOAMER	Defoaming agent	X	X	X	X	X	X	X						P														OCOMA
OCO DRILL LUBE	Torque reducer	X	X	X	X	X	X	X	X	X					S	P												OCOMA
OCO FIBER	Shredded cane fiber	X	X	X	X	X	X	X												P								OCOMA
OCO FLAKE	Shredded cellophane fibers	X	X	X	X	X	X	X												P								OCOMA
OCO FOAM	Foaming agent for fresh to salt saturated mud systems										X								P									OCOMA
OCO FREE PIPE	Surfactant to mix with diesel to free stuck pipe	X	X	X	X	X	X	X	X							P						P						OCOMA
OCOGEL	Wyoming bentonite	X	X	X	X	X	X	X										P						P				OCOMA
OCO GEO FIX	Shale & solids control agent mud surfactant for high temp.	X	X		X	X	X	X			X										S	P						OCOMA
OCO GEO GEL	High temperature stable clay	X	X	X	X	X		X										S						P				OCOMA
OCO GEO LOW	Dispersable hydrocarbon for high temp. fluid loss control	X	X	X	X	X	X	X	X	X						S		P		S	P							OCOMA
OCO GEO MUD	Resin-lignitic blend for ht/hp rheological/fluid loss control	X	X	X	X	X	X	X										P			S		S					OCOMA
OCO HEAVY WATE	Lead sulfide powder	X	X	X	X	X	X		X	X																P		OCOMA
OCOLIG	Lignitic material	X	X			X	X	X							S			P					P					OCOMA
OCOLIG C	Caustic lignitic material	X	X	X		X	X	X							S			S			P		P					OCOMA
OCOLIG CL	Chrome lignitic material	X	X	X		X	X	X							S			S			S		P					OCOMA
OCOLIG K	Caustic Potash lignitic material	X	X			X	X	X							S			S			P		S					OCOMA
OCO MUL	Additive for stable invert emulsions								X	X					P			S						S				OCOMA
OCO MUL S	Supplement emulsifier and wetting agent								X	X					P			S				S						OCOMA
OCO MULTILOW	Non fermenting starch	X	X	X	X	X	X	X										P						S				OCOMA
OCO OIL LOW	Fluid loss control agent for inverted systems								X	X					S			P										OCOMA
OCO OIL VIS	Viscosity and gelling agent								X	X														P				OCOMA
OCO PERMAFLOW	Lignosulfonate	X	X	X	X	X	X	X							S			S			S		P					OCOMA
OCOPHOS	Sodium tetraphosphate	X	X	X			X	X															P	P				OCOMA
OCO PLUG	Ground walnut hulls	X	X	X	X	X	X	X	X	X										P								OCOMA
OCO POLY LOW	High molecular weight poly-anionic cellulose	X	X	X	X	X	X	X							S			P			S		P					OCOMA
OCO SALT GEL	Attapulgite clay	X	X	X	X	X	X	X												S				P				OCOMA
OCO SEAL	Combination of granules, flakes and fibers for lost circulation control	X	X	X	X	X	X	X												P								OCOMA
OCO SK CLAY	Very high temp. clay	X	X	X	X	X		X										P						P				OCOMA
OCO SPOT FREE	Conc. for hi density spotting fluid	X	X	X	X	X	X	X	X							P						P						OCOMA
OCO SULFSORB	H_2S scavenger	X	X	X	X	X	X	X																			P	OCOMA
OCO SUPER FLOCK	Flocculants	X	X	X	X	X	X	X									P											OCOMA
OCO SUPER SLICK	Diesel oil replacement	X	X	X	X	X	X	X								P												OCOMA
OCO SUPER VIS	Extra hi yield bentonite	X	X	X			X	X										S						P				OCOMA
OCOTHIN	Chrome modified ligno-sulfonate	X	X	X	X	X	X	X							S			S			S		P					OCOMA
OCOWATE	Calcium carbonate	X	X	X																						P		OCOMA
OCOWET	Oil wetting agent								X	X					P			S				S						OCOMA
OD 110	Corrosion inhibitor (dry)	X	X	X	X	X	X	X																			P	Wyo-Ben
OD 1100	Corrosion inhibitor (liquid)	X	X	X	X	X	X	X																			P	Wyo-Ben
OD 1550T	Salt inhibitor (liquid)		X	X																								Wyo-Ben
OD 1600	Oxygen scavenger (dry)	X	X	X	X	X	X	X																			P	Wyo-Ben
O.K. LIQUID	Detergent										X								P									King
OS-1L	Oxygen scavenger	X	X	X			X	X																			P	Magcobar
O-S-S PILL	Polymeric for clay free fluids	X	X	X														P		P				P				Brinadd
OMC	Oil mud conditioner								X	X													P					Baroid
OIL BASE MUD SPACER	Cement spacer for oil base muds								X	X												P	S					Dowell
OILCOMPLETE	No-solids/non-damaging oil base completion fluid concentration	X	X	X	X	X	X	X	X	X	X					S		P			P			P				Messina
OIL CON	Supplemental emulsifier, wetting agent								X	X					P			S				S						Messina
OILFAZE	Sacked oil base mud conc.									X					P			S						S				Magcobar
OILFOS	Sodium tetraphosphate	X	X					X															P		S			Milchem
OIL MUL	Additive for stable invert emulsions								X	X					P			S						S				Messina
OIL MUL-L	Liquid additive for stable invert emulsions								X	X					P		S							S				Messina
OILMUL-P	Powder additive for stable invert emulsions								X	X					P		S							S				Messina
OILPACK	Oil base packer fluid concentrate	X	X	X	X	X	X	X	X	X	X																P	Messina
OILSPERSE	Amine								X						P						P		P				P	Brinadd
OILSPERSE-I	Mud removal agent								X	X																		Halliburton

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Product Tradename	Description of Material	Fresh Water (Water-base, Low pH)	Brackish Water (Water-base, Low pH)	Sat. Salt Water (Water-base, Low pH)	Gyp Treated (Water-base, Low pH)	Lime Treated (Water-base, High pH)	Fresh Water (Water-base, High pH)	Low Solids	Water-in-Oil (Invert) (Oil-base)	Oil Mud (Oil-base)	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
OILSPOT	Sacked conc for hi dense spotting fluid	X	X	X	X	X	X									P						S						Messina
OILTONE	Fluid loss control agent								X	X					S			P										Messina
OIL VIS	Viscosity and gelling agent								X	X														P				Messina
OILWET	Oil wetting agent								X	X					P			S				S						Messina
OMG-40	Viscosifier/weight suspension								X	X														P				Mizell
OMG-40 LIQUID B	Viscosifier/weight suspension								X	X														P				UBM
OMG-40 SOLID B	Organophilic clay								X	X														P				UBM
OS-IL	Oxygen scavenger	X	X	X			X	X																			P	Magcobar
PAC	Polyanionic cellulose	X	X		X	X	X	X			X				S	S		P			S			S				Baker Chem
PAK-R-CHEM	Biocide for drilling and packer fluids	X	X	X	X	X	X	X					P															United Mud
PAL-MIX-100-B	Organic polysacchride	X	X	X				X			X					S	S	S		P				P				P.A.L.
PAL-MIX 110-R	Complex copolymer system	X	X	X	X	X	X	X	X	X	X									P								P.A.L.
PAL-MIX 150-D	Enzyme breaker	X	X	X	X	X	X	X	X	X	X												P					P.A.L.
PAL-MIX 150-F	Enzyme breaker	X	X	X	X	X	X	X	X	X	X												P					P.A.L.
PAL-MIX 200	HCl acid	X	X	X				X	X			P																P.A.L.
PAL-MIX 210	Liquid defoamer	X	X	X	X	X	X	X			X			P								P						P.A.L.
PAL-MIX 225	Surfactant-detergent																						P					P.A.L.
PAL-MIX 235-A	Proprietary liquid X-Aldehyde Plus	X	X	X	X	X	X	X			X		P														P	P.A.L.
PAL-MIX 236	Water-soluble corrosion inhibitor/biostart																										P	P.A.L.
PAL-MIX 255	Alkaline catalyst	X	X	X	X			X				P								P								P.A.L.
PAL-MIX 305	Fine calcium carbonate for polymer, 325 mesh	X	X	X	X	X	X	X										P		P						S		P.A.L.
PAL-MIX 333	Sized calcium carbonate for polymer fluids SG gradations 12-325 mesh G gradations 12-100 mesh EC gradations 3-16 mesh																											P.A.L.
PAL-MIX 375	Hydroxyethyl cellulose	X	X	X	X	X	X	X			X				S	S		P		P	S			P				P.A.L.
PAL-MIX 380-A	Blended polymer system	X	X	X			X	X			X				S	S	S	P		S	S	S		P				P.A.L.
PAL-'IX A Z 32	Biodegradable-non fluorescing liquid copolymers	X	X	X	X	X	X	X						S		P		S			P						S	P.A.L.
PAL-MIX FLOC-AN	Anionic polymer flocculant	X	X					X									P											P.A.L.
PAL-MIX FLOC-ONIC	Nonionic polymer flocculant	X	X					X									P											P.A.L.
PAL-MIX FOAM-R	Liquid foam agent for controlled half-life drlg. or W.O	X	X			X	X	X										S	P			P		S				P.A.L
PAL-MIX RD-238	Ammonium Bisulfite	X	X	X	X	X	X	X																			P	P.A.L.
PAL-MIX RD-320	Oil-soluble fluid-loss additive for brines	X	X	X	X	X	X	X										P		S								P.A.L.
PAL-MIX SUPER-FAC	Heavy duty cleaner														S							P						P.A.L.
PAL-MIX SUPER-X	Complex copolymer drilling fluid	X	X	X	X	X	X	X								S	S	P		S	P			P				P.A.L
PAL-MIX SUPER-X-G.S.	Thixotropic drilling polymer w/gel strength	X	X				X	X								S	S	P			P			P				P.A.L.
PAL-MIX X-TENDER-B	Alkaline Phosphate plus	X	X	X								P																P.A.L.
PARAFORMALDEHYDE	Paraformaldehyde		X		X								P															Most companies
PELADOW	94-97% pore calcium chloride			X				X									S				P							Baker Chem
PELTEX	Ferrochrome lignosulfonate	X	X	X	X	X	X	X															P					King
PEPTOMAGIC	Crude oil mud emulsifier									X				S							S			P				Oil Base
PEPTOMAGIC LS	Crude oil mud emulsifier									X				S							S			P				Oil Base
PERFHEAL	Polymeric-lignosulfonate for clay free fluids	X	X	X				X										P						P				Brinadd
PERLITE	Lost circulation material	X	X	X	X	X	X		X	X										P								Halliburton
PERMA-CHECK	Lost circulation material	X	X	X	X	X	X	X	X	X										P								Western
PERMA-LOSE	Non-fermenting starch																	P						S				Milchem
PETRO 150 DRILLING CLAY	High grade attapulgite		X	X	X	X		X										S						P				American Mud
PETRO-DF	Surfactant defoamer	X	X	X	X	X	X	X						P														American Mud
PETRO-FLO	Ferrochrome lignosulfonate	X	X	X	X	X	X	X							S			S					P					American Mud
PETROGIL 37-60 B	Polymer-bentonite extender	X	X				X	X									P							P				Rhone-Poulenc
PETROGIL 1681	Emulsifier	X	X	X			X	X							P													Rhone-Poulenc
PETROGIL A 46	Wetting agent, thinner								X	X					P								S					Rhone-Poulenc
PETROGIL ARF453	Emulsifier, filtrate reducer, stabilizer								X						P			P										Rhone-Poulenc
PETROGIL ARG	Drilling detergent	X	X	X	X	X	X	X													P							Rhone-Poulenc
PETROGIL EP	Extreme pressure additive	X	X	X	X	X	X	X								P												Rhone-Poulenc
PETROGIL F54	Basic emulsifier, stabilizer								X						P													Rhone-Poulenc
PETROGIL RF3	Temperature filtrate reducer								X									P										Rhone-Poulenc
PETROGIL SIV-CONC	Viscosifier, gelling agent								X															P				Rhone-Poulenc
PETROGIL X	Invert spotting agent for freeing stuck pipe	X	X	X	X	X	X	X	X	X						P												Rhone-Poulenc
PETRO-LIG	Lignite material	X	X	X		X	X	X							S			S					P					American Mud
PETRO-LIG-K	Reacted product of lignite and potassium	X	X	X	X	X	X	X							P			P			P							American Mud

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Product Tradename	Description of Material	Water-base, Low pH: Fresh Water	Water-base, Low pH: Brackish Water	Water-base, Low pH: Sat. Salt Water	Water-base, Low pH: Gyp Treated	Water-base, High pH: Lime Treated	Water-base, High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil-base: Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from.
PETRO-LUBE	Biodegradable-nontoxic lubricant and bit balling agent	X	X	X	X	X	X	X								P						S						American Mud
PETROTONE	Organophilic clay powder for use as oil mud suspended agent								X	X														P				Baroid
PH-10	Buffers for clay free fluids	X	X	X								P																Brinadd
pH-REGULADOR	pH control and corros. inhib. liquid	X	X	X	X	X	X					P	S														P	UBM
PHENO SEAL	Flat, chip shape, thermoset resinoid material, particle graded	X	X	X	X	X	X	X	X	X										P								Montello
PIPE LAX	Surfactant mtl. to be mixed with diesel oil to free pipe	X	X	X	X	X	X	X	X																			Magcobar
PIPE-LOOSE	Surfactant mtl. to be mixed with diesel oil to free pipe	X	X	X	X	X	X	X																				Drill. Add.
PIPE-OFF	Surfactant to be mixed with diesel oil to free stuck pipe	X	X	X	X	X	X	X	X																			Dixie
PIPE OUT	Oil soluble surfactant	X	X	X	X	X	X	X														P						CDA/HMC
PLUG-GIT	Processed hardwood fiber	X	X	X	X	X	X	X												P								Baroid
PLUGMIX	Combination of grannulates fibers	X	X	X	X	X	X													P								UBM
PLUG-SAL	Sized salt with dispersant			X																P								Texas Brine
PLURADOT	Surfactants								X	X	X			P	P				P			P	P					BASF Wyandotte
PLURAFAC	Surfactants								X	X	X				P				P			P	P					BASF Wyandotte
PLURONIC	Surfactants								X	X	X			P	P				P			P	P					BASF Wyandotte
PLURONIC R	Surfactants								X	X	X			P					P			P	P					BASF Wyandotte
POLIDRIL	Polymer for clay free drilling	X	X	X	X	X	X	X											P			P			P			Brinadd
POLIHEAL	Polymeric lignosulfonate complex for clay-free fluids	X	X	X														P										Brinadd
POLVIS 10	Synthetic flocculant							X									P											CDA/HMC
POLY-AN	Hi molecular weight polyanionic cellulosic polymer	X	X	X	X	X	X	X			X				S	S		P			P		P					Drillsafe
POLY-BEN	Polymer, flocculant and bentonite extender	X	X				X	X									P							P				Messina
POLY-BRIDGE	Self complexing polymer ug	X	X	X			X													P								Milchem
POLYBRINE	Acid soluble material for viscosity and fluid loss control	X	X	X		X	X	X										S						P				Oil Base
POLYCLAY	Bentonite extender	X	X				X	X									P							P				Drillsafe
POLYDRLG	Modified HEC	X	X	X													P							P				Drlgmud
POLYFLAKE	Oil sol. plastic film	X	X	X	X	X	X	X	X	X										P								Baroid
POLYLUBE	Extreme pressure lubricant	X	X	X	X	X	X	X								P												Oil Base Ger.
POLY-MAGIC	Co-polymer		X	X				X										P			S			P				Oil Base
POLY-MAGIC 21	Co-polymer			X				X										S			P			S				Oil Base
POLY-MAGIC-100	Co-polymer			X				X										S			P			S				Oil Base
POLY-MAGIC HT	Co-polymer		X					X										S			P			S				Oil Base
POLY-MAGIC SUPER HI VIS	Co-polymer		X	X				X										S			S			P				Oil Base
POLYMER 214	Scale inhibitor	X	X	X	X	X	X	X																	P			Aquaness
POLYMER PLUG	Lost circulation plug	X	X	X	X	X	X													P								Dowell
POLY-NOX	Oxygen scavenger for polymer fluids	X	X	X		X	X																				P	Milchem
POLY S	Sodium polyacrylate liquid system	X	X	X	X	X	X	X										P			S		S					Wyo-Ben
POLY-SEC	Selective flocculant and bentonite extender	X	X			X	X	X									P							P				Am. Colloid
POLY-SEC KD	Selective flocculant and bentonite extender for non-dispersed muds	X					X	X									S							P				Am. Colloid
POLY-SEC UD	Polymer for nondispersed muds	X					X	X									S							P				Am. Colloid
POLY-SLICK	Granular high angle drilling lubricant	X	X	X	X	X	X									P				S								Messina
POLYSURF	Drilling mud surfactant	X	X	X	X	X	X	X								S		S				P						CDA/HMC
POLYTEX	Organic polymer blend	X	X	X			X											P										Texas Brine
POTASSIUM CHLORIDE	Potassium chloride	X	X	X			X	X													P							Most companies
PREMIUM GEL	Bentonite	X	X				X									P		P						P				Am. Colloid
PRESANTIL	Surfactant mixed with diesel to free stuck pipe	X	X	X	X	X	X	X	X							P						P						Lamberti
PRESERVATIVE 4AD	Paraformaldehyde	X	X	X	X			X					P															CDA/HMC
PRESERVATIVE PCP	Sodium pentachlorophenate	X	X	X	X	X	X	X					P															CDA/HMC
PRO-2	Coating for atmospheric corrosion conditions																										P	Milchem
PROCIME	Calcium-lignosulfonate	X	X	X	X	X	X								P			S					P					Avebene & CECA
PRO FIBER	Shredded excelsior material emulsions and water blocks	X	X	X	X	X	X	X	X	X										P								Wyo-Ben and ECCO
PROTECTO FOL	Water dispersable asphalt additive	X	X	X	X	X	X		X	X					S				P			P				S		UBM
PROTECTOMAGIC	Oil dis~ersed asphalt used as oil phase in emulsion muds	X	X	X	X	X	X	X	X						S	S		P			S		S					Oil Base
PROTECTOMAGIC-M	Water dispersable asphalt additive	X	X	X	X	X	X	X								S		P			P					S		Oil Base

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Product Tradename	Description of Material	Recommended for These Systems										Functioning As																Available from
		Water-base: Low pH				Water-base: High pH			Oil-base																			
		Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Lime Treated	Fresh Water	Low Solids	Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	
PROTECTOMAGIC S	Sacked asphalt conc. location mixed w/diesel for use as oil phase in emulsion muds	X	X	X	X	X	X	X	X						S	S		P			S		S					Oil Base
PROTECTOZONE J211	Fluid-loss additive for brines less than 9.6 ppg	X	X			X	X	X										P										Dowell
PROTECTOZONE J212	Fluid-loss additive for brines heavier than 9.6 ppg			X														P										Dowell
PROTECTOZONE J213	Fluid loss additive for brines, premixed package (solids)	X	X	X			X	X										S		P				P				Dowell
PROTECTOZONE J214	Bridging agent for workover brines	X	X	X																P								Dowell
PROTECTOZONE J215	Brine viscosifier			X														S						P				Dowell
PROXEL AB	Mud and starch preservative	X	X	X	X	X	X	X					P														S	ICI
PROXEL GXL	Mud and starch preservative	X	X	X	X	X	X	X					P														S	ICI
PW 20.30	Polyanionic fluid loss reducer and viscosifier	X	X	X	X	X	X	X							S			P			P			P				Novacel
PWG	Polymeric water gel	X	X	X	X	X	X	X	X	X										P								Halliburton
Q-BROXIN	Ferrochrome lignosulfonate	X	X	X	X	X	X	X							S			S			S		P					Baroid
OF-5	Cellulose gelling agent	X	X	X														P										Cardinal
OF-6	Chemically modified low residue guar	X	X	X														P										Cardinal
O-PILL	Polymeric for clay free fluids	X	X	X														P		P				P				Brinadd
O-TROL	Inhibited mud additive	X	X				X	X										S			P							Am. Colloid
QUEBRACHO	Quebracho (tannin) extract	X	X	X	X	X	X	X										P					P					Most companies
QUICK-SET	Quick setting cement for lost circulation																			P								Western
QUIK-FOAM	Biodegradable foaming agent										X									P								Baroid
QUIK-GEL	High yield bentonite	X						X																P				Baroid
QUIK-MUD	Suspension of concentrated viscosifiers	X	X					X			X					S		S						P				Baroid
QUIK-TROL	Organic polymer	X	X	X	X	X	X														P			P				Baroid
RAPIDRIL	Organic polymer; clay extender and solids flocculant	X	X	X				X									P							P				Magcobar
RAYVAN	Chrome lignosulfonate	X	X	X	X	X	X	X															P					Wyo-Ben
RD-11	Acid corrosion inhibitor	X	X	X																							P	Cardinal
RD-12	High temperature acid corrosion inhibitor	X	X	X																							P	Cardinal
REDOU-TORQUE	Extreme pressure lubricant	X	X	X	X	X	X	X								P												Oil Base Ger
RED DEVIL CLAY	High yield bentonite	X						X																P				American Mud
REDWOOD FIBER	Redwood fiber	X	X	X	X	X	X	X												P								Most companies
REGULATED FILL-UP CEMENT	Quick set cement for lost circulation																			P								Dowell
RELEASE	Surface active agent	X	X	X	X	X	X	X								S		S				P						Montello and ECCO
REMOX	Catalyzed sodium sulfite																										P	Arnold & Clarke
REMOX L	Liquid sodium bisulfite																										P	Arnold Clarke
RESINEX	Resin additive, fluid loss control agent	X	X	X	X	X	X											P			S							Magcobar
RETABOND A.P.	Selective flocculant																P	P										Schotten
REV-DUST	Inert clay		X	X				X																P				Wyo-Ben
R.F.R. 123	Resinous filtrate reducer	X	X	X	X	X	X	X										P										Trinity Mud
RHODOPOL 23	High molecular weight long chain polymer xanthon gum	X	X	X			X	X																P				Rhone-Poulenc & CECA
RHODOPOL 23-P	Xanthan gum biopolymer	X	X	X	X	X	X	X													S			P				Rhone-Poulenc
RHODORSIL	Silicone anti-foam	X	X	X	X	X	X	X						P														Rhone-Poulenc
ROCAGIL	Acrylic resin and catalysts	X	X	X	X	X	X	X	X	X	X									P								Rhone-Poulenc
ROCAGIL 1295-S	Acrylic resin and catalysts	X	X	X	X	X	X	X	X	X	X				S					P								Rhone-Poulenc
ROD LUBE	E. P. lubricant for drill rods	X	X	X	X	X	X	X								P												Magcobar
RUF-PLUG	Woody ring of corn cob	X	X	X	X	X	X	X												P								Wyo-Ben
S-61	Amine base scale inhib.	X	X	X	X	X	X	X																			P	Wyo-Ben
SALINEX	Seawater emulsifier		X												P	S		S										Magcobar
SALGITE	Attapulgite clay		X	X																				P				Arnold & Clarke
SALT	Sodium chloride		X	X	X	X		X	X								P				S					S		Most companies
SALT GEL	Attapulgite clay		X	X				X																P				Magcobar
SALT GEL HI-YIELD	Attapulgite		X	X	X	X		X																P				ECCO
SALT MUD	Attapulgite clay		X	X																				P				Wyo-Ben
SALT WATER CLAY	Attapulgite clay		X	X	X	X		X										S						P				American Mud
SALT WATER GEL	Attapulgite clay		X	X	X	X	X	X																P				Milchem
SAM 4	Spacer fluid	X	X	X	X	X	X	X	X	X																		Halliburton
SAM 5	Spacer fluid	X	X	X	X	X	X	X	X	X																		Halliburton
SANHEAL PILL	Polymeric-lignosulfonate complex for clay free fluids	X	X	X														P		P				P				Brinadd
SAPP	Sodium acid pyrophosphate	X	X	X																			P		P			Magcobar
SCALE-BAN	Scale inhibitor for drilling muds	X	X	X	X	X		X																			P	Milchem
SCALEHIBIT S-208K	Scale inhibitor	X	X	X	X	X	X	X																	P			C-E Natco
SCALEHIBIT S-401	Scale inhibitor	X	X	X	X	X	X	X																	P			C-E Natco
SCALEHIBIT S-404	Scale inhibitor	X	X	X	X	X	X	X																	P			[illegible]

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Product Tradename	Description of Material	Recommended for These Systems										Functioning As																Available from
		Water-base							Oil-base																			
		Low pH				High pH																						
		Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Lime Treated	Fresh Water	Low Solids	Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat.	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	
SCAVENGER x H_2S	Powdered inorganic H_2S scavenger	X	X	X	X	X	X	X	X		X												S			S	P	Lamberti
SCORTRON GDF-50	Detergent, scale, corrosion inhibitor	X	X	X	X	X	X	X	X		X				S							S					P	Champion
SE-11	Secondary emulsifier for oil base and invert emulsion muds								X	X					P			S				S						Magcobar
SEABAR	Barium sulfate	X	X	X	X	X	X	X	X																	P		Seamud
SEABEN	Bentonite	X	X	X	X	X	X	X										S						P				Seamud
SEA BLEND	Filtrate reducer and viscosifier	X	X	X														P						P				Seamud
SEA CARB	Lost circulation and weighting material		X	X																P						P		Seamud
SEA CLAY	Fibrous asbestos	X	X	X	X	X	X	X	X	X										S				P				Teinite
SEADRILL	High yield viscosifier	X	X	X	X			X										S						P				Champion
SEA-FLO	Quick dissolving hi-molweight polymer	X	X	X	X	X	X	X							S	S		P			P			P				Enka
SEAFLO	Aluminum complex lignosulfonate	X	X	X	X	X	X	X										S			P							Seamud
SEAFLO-C	Chrome lignosulfonate	X	X	X	X	X	X	X							S			S			S		P					Seamud
SEA-FREE	Pipe freeing compound	X	X	X	X	X	X	X	X																			Seamud
SEALIG	Lignite	X	X			X	X	X							S			P					S					Seamud
SEA MUD	Sepiolite	X	X	X				X			X							S						P				IMV
SEAMUL	Salt water emulsifier and surfactant		X	X	X			X							P			S				S	S					Baroid
SEA VIS	Viscosifier																							P				Seamud
SEPARAN	Clay flocculant							X									P											Milchem
SEPGEL	Sepiolite		X	X	X	X		X										S						P				Drillsafe
SERVO CK, UCA	Corrosion inhibitor, bactericide	X	X	X	X	X	X	X					P														P	Servo
SERVO MCA	Oxygen scavengers, flocculants	X	X	X	X	X	X	X									P										P	Servo
SHALE LIG	Potassium lignite	X						X													P							Arnold & Clarke
SHALE-TONE	Wettable asphaltic blend for shale control	X	X	X	X	X	X	X	X							S		P			P							Dixie
SHUR-GEL	Beneficiated bentonite mud conditioner	X	X																						S			Baroid
SHUR-PLUG	Dehydrated graded cellulosic bridging agent	X	X	X	X	X	X	X										P		P								Shur-Plug
SHUR-PLUG BRIDGE BOMB	Granular polymer/clay blend for sealing vugular loss zones	X	X	X	X	X	X	X	X	X	X									P								Shur-Plug
SHUR-PLUG LINK-UP	Alkaline liquid catalyst	X	X	X	X		X	X				P								P								Shur-Plug
SHUR-PLUG PRONTO-PLUG	Blend of water soluble polymers & graded cellulosic bridging agent	X	X	X	X	X	X	X	X	X	X						S	P		P				P				Shur-Plug
SL-1000	Scale inhibitor	X	X	X	X	X	X	X																			P	Magcobar
SIDERITE	Acid soluble weight material	X	X	X	X	X			X	X																P		Magcobar
SIGTEX	Synthetic polymers	X	X	X			X																	P				Texas Brine
SIMPLE SEAL	Polymeric lignosulfonate complex & sized carbonate blend	X	X	X														P		P								Brinadd
SIMULSOL P4	Emulsifier oil-water	X	X	X	X	X	X	X							P	S												CECA
SLICKCOAT	Pipe coating lubricant	X	X	X	X	X	X	X								P		S									S	Messina
SLICKPIPE	Biodegradable non-toxic mud lubricant corrosion inhibitor and diesel oil substitute	X	X	X	X	X	X	X								P		S			S						S	Messina
SLIX	Torque reducer	X	X	X	X	X	X	X								P												Montello
SLUGGIT COARSE GRANDE MAX MEDIUM MICRO	Calcium carbonate for clay free fluids (particle sized)	X	X	X																P								Brinadd
SLUGHEAL	Polymeric-lignosulfonate complex for clay free fluids	X	X	X				X										P						P				Brinadd
SODA ASH	Sodium carbonate	X	X	X	X	X	X	X				S													P			Most companies
SODIUM BICARBONATE	Sodium bicarbonate	X	X		X	X	X	X				S												S	S			Most companies
SODIUM CARBONATE	Soda ash	X	X	X	X	X	X	X				S													P			Most companies
SODIUM DICHROMATE	Sodium dichromate	X	X	X	X	X	X	X														P					S	Most companies
SODIUM HEXAMETA PHOSPHATE	Sodium hexameta phosphate	X	X	X				X															P		P			ECCO
SODIUM SULFITE	Oxygen scavenger	X	X	X	X	X	X	X																			P	Most companies
SOLKWIK	Instant dissolving viscosifier	X	X	X	X	X	X	X			X				S	S		S						P				Enka
SOLTEX	Sulfonated residuum	X	X	X	X	X	X	X	X		X				P	P		S			P							Drill Spec. and ECCO
SOLUBLE-WATE	Acid soluble weighting material for workover/completion fluids	X	X	X	X	X	X		X	X																P		Messina
SOLUBREAK	Viscosity breaker for clay free fluids	X	X	X																								Brinadd
SOLUBRIDGE FINE MEDIUM COARSE	Particle sized resin for clay free fluids	X	X	X																P								Brinadd

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Product Tradename	Description of Material	Recommended for These Systems										Functioning As																Available from
		Water-base							Oil-base																			
		Low pH				High pH																						
		Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Lime Treated	Fresh Water	Low Solids	Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	
SOLUKLEEN	Polymeric-lignosulfonate complex for clay free fluids	X	X	X				X										P						P				Brinadd
SOLVAQUIK	Emulsifier for clay free fluids								X									P						P				Brinadd
SOLVITEX C P.	Modified polymer	X	X	X				X										S						P				Scholten
SORB-OX	Oxygen scavenger	X	X	X	X	X	X	X																			P	Messina
SPACER 1000	Mud—cement spacer, fluid loss control agent	X	X	X	X	X	X	X										P		S								Dowell
SPACER 1001	Cement spacer for oil base muds								X	X								P				P	P					Dowell
SPEEDER-P	Extreme pressure lubricants and wetting agents	X	X	X	X	X	X	X	X	X					S	P						P						Telnite
SPEEDER-X	Surfactant for mixing with diesel oil to free pipe	X	X	X	X	X	X	X	X													P						Telnite
SPECIAL ADDITIVE 47	Non-viscous organic lqd. for treating water, water base mud or dry contam. of oil base muds							X		X					S			S				P	S	S				Oil Base
SPECIAL ADDITIVE 47X	Powder for treating oil base muds contaminated by water base muds									X					S								P					Oil Base
SPECIAL ADDITIVE 58	Weight suspension stabilizer and mixing adjuster for oil base muds							X		X														P		S		Oil Base
SPECIAL ADDITIVE 77	Surfactant for treatment of water contamination								X	X					S							P						Oil Base
SPECIAL ADDITIVE 81	Oil base mud stabilizer									X					P			S				S	P	S				Oil Base
SPECIAL ADDITIVE 81-A	Concentrated oil base mud stabilizer									X					P			S				S	P	S				Oil Base
SPECIAL ADDITIVE 252	Defoamer fluids	X	X	X	X	X	X	X						P														Oil Base
SPERSENE	Chrome lignosulfonate	X	X	X	X	X	X	X										S					P					Magcobar
STABIL HOLE	Sacked asphalt-added dry to system or as a mixture with oil	X	X	X	X	X	X	X	X	X					S	S			S		P			S				Magcobar
STABILITE	Organic phosphate thinner	X					X	X														S	P					Baroid
STABILOSE	Carboxymethylated polymer low viscosity	X	X				X	X			X							P						S				Scholten
STABL-PROP	Chrome-lignite	X	X	X	X	X	X	X										S			P		P					Drill Add
STABL-VIS	Chrome-lignosulfonate	X	X	X	X	X	X	X							S			S			S		P					Drill Add
STAFLO	High molecular weight polyanionic cellulosic polymer	X	X	X	X	X	X	X			X				S			P			P			P				Enka
STAFOAM 202	Biodegradable foaming agent	X	X	X							X								P			P						American Mud
STAFLO-EXLO	Polyanionic cellulose	X	X	X	X	X	X	X			X				S			P			P			S				Enka
STARCH	Pregelatinized starch	X	X	X	X	X	X	X										P			S			S				Most companies
STARFIX	Non-fermenting starch-based polymer	X	X	X	X		X	X										P			S			S				Messina
STARLOSE	Non-fermenting starch																	P						S				Milchem
STORIT	Preservative for clay-free fluids	X	X	X									P															Brinadd
STUCKBREAKER	Surfactant product for mixing with diesel oil to free stuck pipe	X	X	X	X	X	X	X								P						P						Messina
SUPER ASBESTOS	Asbestos fibre	X	X	X	X	X	X	X										S						P				CDA/HMC
SUPER COL	Mod. extra high yield bentonite	X	X	X			X	X										S						P				Milchem
SUPER DRIL	Specially treated gilsonite	X	X	X	X	X	X	X								S					P		S					Montello
SUPERDRILL	Treated gilsonite for dispersed systems															S		P			P		S					Chemo
SUPER EXTEND	Bentonite extender	X	X				X	X							P									P				CDA/HMC
SUPERGEL	Beneficiated bentonite	X						X																P				Arnold & Clarke
SUPER GEL	High yield bentonite	X	X				X									P	P							P				Am. Colloid
SUPER LIG	Lignite	X	X				X	X							S			P					P					Am. Colloid
SUPER LUBE FLOW	Pure, pulverized, high temperature gilsonite	X	X	X	X	X	X	X								P					P							Montello
SUPERMUL	Non-ionic emulsifier	X	X	X	X	X	X	X							P							S						CDA/HMC
SUPER SHALE-TROL 202	Organo-aluminum complex	X	X		X	X	X	X													P							Milchem
SUPER TREAT	Soluble lignite	X	X				X	X							S			P					P					Am. Colloid
SUPER VISBESTOS	Fiberous asbestos material	X	X	X	X	X	X	X	X															P				Magcobar
SUPER VISBESTOS (CRUSHED)	Pre-sheared, wet-refined, pelletized, crysotile asbestos	X	X	X	X	X	X	X	X	X														P				Montello
SUPER-WATE	Special high density weighting material for blowout control only																									P		Magcobar
SURF-ACT	Mud surfactant, shale and solids control agent	X	X		X	X	X	X			X										S	P						Messina
SURFAK E	Emulsifier	X	X	X	X	X	X	X							P	S		S										Magcobar
SURFAK M	Nonionic surfactant for solids control; solulizer for CMC & starch fluids	X	X	X	X	X	X	X							P							S						Magcobar
SURFATRON DP-61	Surfactant	X	X	X	X	X	X	X														P						Champion
SURFDRIL	Biodegradable, non-ionic wetting agent	X	X	X	X	X	X	X							S							P						American Mud
SURFLO-B11	Corrosion inhibitor and biocide for treating solids free packer fluids												S														P	Baroid

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Product Tradename	Description of Material	Recommended for These Systems: Water-base, Low pH: Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Water-base, High pH: Lime Treated	Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Functioning As: Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ. Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from:
SURFLO-B33	Biocide for drlg. and pkr. fluids	X	X	X	X	X	X	X					P															Baroid
SURFLO-H35	Scale inhibitor	X	X	X	X	X	X	X																			P	Baroid
SURFLO-S362	Foaming agent for fresh or salt water										X								P									Baroid
SURFLO-S375	Foaming agent for fresh or salt water										X								P									Baroid
SURFLO-S378	Foaming agent for fresh or salt water										X								P									Baroid
SURFLO-S390	Foaming agent for fresh or salt water										X								P									Baroid
SURFLO-W300	Surface active defoamer	X	X	X	X	X	X	X						P														Baroid
SURF-LUBE	Powdered surfactant lubricant	X	X	X	X	X	X	X	X						S	P		S				P	S					Dixie
TANNATHIN	Lignite	X	X	X		X	X	X							S			S					P					Magcobar
TANNEX	Quebracho extract and lignitic mtl.	X	X			X	X	X							S			S					P					Baroid
TBA	Temporary blocking agent																			P								Halliburton
TEL-BAR	Barite (barytes)	X	X	X	X	X	X	X	X	X																P		Telnite
TEL-CELLOSE-H	CMC (pure grade hi-vis)	X	X	X	X	X	X	X										S						P				Telnite
TEL-CELLOSE-L	CMC (pure grade low-vis)	X	X	X	X	X	X	X										P						S				Telnite
TEL-CELLOSE-TL	CMC (technical grade low-vis)	X	X	X	X	X	X	X										P						S				Telnite
TEL-CELLOSE-TM	CMC (technical grade regular)	X	X	X	X	X	X	X										P						S				Telnite
TEL-CLEAN	Water soluble lubricant	X	X	X	X	X	X	X							S	P						P						Telnite
TEL-D.D.	Drilling mud detergent and wetting agent	X	X	X	X	X	X	X							S	S						P						Telnite
TEL-DEXT	Organic polymer	X	X	X	X		X	X										P						S				Telnite
TEL-FIBER	Fibrous material	X	X	X	X	X	X	X	X	X										P								Telnite
TEL-FLAKE	Shredded cellophane flakes	X	X	X	X	X	X	X	X	X										P								Telnite
TEL-GEL	Bentonite	X	X	X	X	X	X											S						P				Telnite
TEL-LIG	Ferrochrome lignosulfonate	X	X	X	X	X	X	X							S			S			S		P					Telnite
TEL-LIG-K	Ferrochrome potassium lignosulfonate	X	X	X	X	X	X								S			S			S		P					Telnite
TELNITE-A	Processed lignite	X	X			X	X	X							S			P					P					Telnite
TELNITE-B	Processed sodium lignite	X	X			X	X	X							S			P					P					Telnite
TEL-PLUG	Ground walnut shells	X	X	X	X	X	X	X	X	X	X										P							Telnite
TEL-POLYMER-L	Polyanionic cellulose	X	X	X	X	X	X								S	S		P			P							Telnite
TEL-POLYMER-H	Polyanionic cellulose	X	X	X	X	X	X								S	S		P			P			P				Telnite
TEL-PHOS	Sodium tetraphosphate	X	X			X	X	X															P					Telnite
TEL-SAPP	Sodium acid pyrophosphate	X	X	X																			P					Telnite
TEL-SEAL	Vermiculite flakes	X	X	X	X	X	X	X	X	X										P								Telnite
TEL-STOP	Cotton seed hulls (coarse and fine)	X	X	X	X	X	X	X	X	X								P										Telnite
TEMBLOK	High viscosity fluid																			P								Halliburton
TEMPOSEAL	Temporary lost circulation plug					X	X													P								Western
TEMP-WATE	Coarse barite for temporary weight control	X	X	X	X	X	X		X	X																P		Messina
TETRONIC	Surfactants								X	X	X				P				P			P	P					BASF Wyandotte
TET THIN	Sodium tetraphosphate	X	X	X			X	X				S											P		P			CDA/HMC
THERMOGEL	High temperature sepiolite	X	X	X				X			X							S						P				IMV
THERMO-SEAL	Dispersable hydrocarbon for HT water loss control	X	X	X	X			X								S		P		S	P							Messina
THERMO-TROL	Resin—lignitic blend for HT/HP rheological/water loss control	X	X	X	X	X	X											P			S		S					Messina
THIX	Emulsifier for clay free fluids	X	X	X														P						P				Brinadd
THIXOLITE	Lightweight thixotropic cement for lost circulation																			P								Western
THIXOMENT	Thixotropic cement for lost circulation																			P								Western
THIXOMIX	Thixotropic cement																			P								Halliburton
THIX-PAK	Emulsifier for clay free fluids	X	X	X																				P				Brinadd
THIXSET CEMENT	Thixotropic cement	X	X	X	X	X	X	X	X	X										P								Halliburton
TIMPLEX	Lignite based thinner and fluid loss reducer for high temperature service	X	X	X	X	X	X	X										P					P					T.I.M.
TLC	Temporary loss control																			P								Halliburton
TOL-AEROMER	Oxygen corrosion inhibitor	X	X	X	X	X	X	X	X	X	X																P	Tretolite
TOL-FOAM	Foaming agent	X	X	X			X												P			S						Tretolite
TORKEASE	Drilling mud lubricant	X	X	X	X	X	X	X								P					S							DSC Inc.
TORQ TRIM II	Biodegradable and non-toxic lubricant	X	X	X	X	X	X	X								P												Baroid
TORQ-TRIM	Biodegradable, non-toxic lubricant	X		X			X	X								P												Baroid
TORQUEOUT	Biodegradable-Non toxic lubricant	X	X	X	X	X	X	X								P												Drigmud
TREAT	Polymeric for clay free fluids	X	X	X																P								Brinadd
TRETOLITE	Multipurpose products	X	X	X	X	X	X	X	X				P	P	S	P	S	P	S			P	P					Tretolite
TRILEX	Basic invert oil emulsifier									X					P													Delta Mud
TRIL-G	Oil mud asphaltic gelling agent									X														P				Delta Mud

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Product Tradename	Description of Material	Recommended for These Systems: Water-base, Low pH: Fresh Water	Water-base, Low pH: Brackish Water	Water-base, Low pH: Sat. Salt Water	Water-base, Low pH: Gyp Treated	Water-base, High pH: Lime Treated	Water-base, High pH: Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil-base: Oil Mud	Air, Gas, Mist	Functioning As: Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
TRIL-OX	Complimentary invert oil emulsifier (quick lime)									X		P			P													Delta Mud
TRIMULSO	Oil-in-water emulsifier	X	X	X	X	X	X	X							P	S						P					S	Baroid
TRIP-WATE	Granular barite	X	X	X	X	X	X	X	X	X										P						P		Baroid
TRI-S	Surfactant additive for work-over and completion fluid																					P						Halliburton
TS-301	Polymeric-lignosulfonate complex for clay free fluids	X	X	X														P					–					Brinadd
TUF-PLUG	Walnut shells (coarse, medium, and fine)	X	X	X	X	X	X	X	X	X										P								Halliburton
TUF-PLUG	Walnut shells	X	X	X	X	X	X	X	X	X										P								Western
T-Z PILL	Polymeric for clay free fluids	X	X	X														P		P				P				Brinadd
ULTRADEFOM	Defoaming agent	X	X	X	X	X	X	X	X					P														Merit
ULTRADET	Surfactant, mud detergent and emulsifier	X	X	X	X	X	X	X	X	X					S	S						P						Merit
ULTRADRYL	Engineered drilling fluid	X	X	X			X	X									P	P			P			P				Merit
ULTRAFLOK	Non-selective flocculant																P											Merit
ULTRAFLOKOR	Non-selective flocculant/anti-corrosive																P										S	Merit
ULTRAFLOK-SEL	Selective flocculant																P											Merit
ULTRAFREE	Spotting agent	X	X	X	X	X	X	X	X	X						P												Merit
ULTRAKOR	Anti-corrosive	X	X	X	X	X	X	X																			P	Merit
ULTRAPAK	Viscosifier and filtrate reduction agent	X	X	X	X	X	X	X									S	P			S			P				Merit
ULTRASAFE	Workover fluid	X	X	X			X											P			P			P				Merit
ULTRASEAL	Seepage inhibitor	X	X	X	X	X	X	X	X	X										P								Merit
ULTRASPAN	Viscosifier and filtrate reduction agent	X	X				X	X									S	P			S			P	S			Merit
ULTRAVIS	Viscosifier and hole sweeping agent (replaces asbestos fibers)	X	X	X	X	X	X	X	X	X								S		P				P				Merit
UMS FIBER SEAL	Blended lost circulation mtl.	X	X	X	X	X	X	X																				United Mud
UNI-CAL	Chrome mod. sodium lignosulfonate	X	X	X	X	X	X	X							S			S			S		P					Mitchem
UNI-DRILL	Sodium polyacrylate liquid system	X	X	X	X	X	X	X										P			S							Wyo-Ben
UNI-FREE	Surfactant to be mixed with diesel oil to free pipe	X	X	X	X	X	X	X																				United Mud
UNITED DEFOAMER	Liquid anti-foam agent	X	X	X	X	X	X	X						P														United Mud
UNITED GEL	Wyoming bentonite	X	X				X									P		P						P				United Mud
UNITED INHIBITOR	Corrosion inhibitor	X	X	X	X	X	X	X												P							P	United Mud
UNI-THIN	Causticized lignite	X	X	X		X	X	X				S			S			S					P					United Mud
VEN-BLEND	Combination of fibers, granules, and flakes	X	X	X	X	X	X	X												P								Venture
VEN-CHEM 300	Organic polymer	X	X		X	X	X	X							S			P										Venture
VEN-FYBER 201	Micronized, surface modified, cellulose-base fiber	X	X	X	X	X	X	X	X	X	X				S			S		P								Venture
VEN-GEL	High yield bentonite	X						X																P				Venture
VENTURE BURR PAK	Blend of organic fibers	X	X	X	X	X	X													P								Venture
VENTURE FIBER KANE	Cellulose-base cane fiber	X	X	X	X	X	X													P								Venture
VENTURE POLY PELLETS	Densified and expandable fiberous LCM product	X	X	X	X	X	X	X												P								Venture
VERLOW	Oil soluble surfactant								X													P	P					CDA/HMC
VERMUL	Invert emulsifier, fluid loss control agent								X						P			P										CDA/HMC
VERMUL S	Supplementary emulsifier								X	X					P			S										CDA/HMC
VERT	Polymeric for clay free fluids	X	X	X																				P				Brinadd
VERTILE	Invert emulsion								X						P			P						P				Magcobar
VERTOIL	Sacked invert emulsion mud conc.								X						P			S						S				Magcobar
VERVIS	Organo metallic powder								X	X								S						P				CDA/HMC
VG-69	Gelling agent for invert emulsions								X									S						P				Magcobar
VISBESTOS	Inorganic viscosifier emulsion mud	X	X	X	X	X	X	X	X															P				Magcobar
VISCOGEL 618	High temperature polymer	X	X	X	X	X	X	X										P			S			S				Scholten
VISFLO (REGULAR & SUPER 20)	High molecular weight poly-anionic cellulose	X	X	X	X	X	X	X							S			P			S			P				Messina
VISGUM	Modified guar gum	X	X					X										S						P				CDA/HMC
VISQUICK	Inorganic viscosifier	X	X	X	X	X	X	X																P				Magcobar
VISTEX	Synthetic polymer & sized carbonate blend	X	X	X			X											S						P				Texas Brine
VISTROL	Causticized quebracho	X	X	X	X	X	X	X										P					P					Arnold & Clarke
W-703K	Oxygen scavenger	X	X	X	X	X	X	X			X																P	C-E Natco
WALL-NUT	Ground walnut hulls	X	X	X	X	X	X	X	X	X										P								Most companies
WATESAL	Sized salt with dispersant			X																S						P		Texas Brine
WC-14	Organic polyelectrolyte polymers								X								P											Tretolite

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Product Tradename	Description of Material	Recommended for These Systems: Water-base, Low pH: Fresh Water	Brackish Water	Sat. Salt Water	Gyp Treated	Water-base, High pH: Lime Treated	Fresh Water	Low Solids	Oil-base: Water-in-Oil (Invert)	Oil Mud	Air, Gas, Mist	Functioning As: Alkalinity, pH Control Additives	Bactericides	Defoamers	Emulsifiers	Lubricants	Flocculants	Filtrate Reducers	Foaming Agents	Lost Circ Mat	Shale Control Inhib	Surface Active Agents	Thinners, Dispersants	Viscosifiers	Calcium Removers	Weighting Materials	Corrosion Inhibitors	Available from
WEIGHTEX	Calcium carbonate	X	X	X	X	X	X		X	X																P		Texas Brine
WHITE MAGIC	Emulsifier and thinner for emulsion muds	X	X	X	X	X	X	X							P		S				S		P					Oil Base
WK-1	Filtrate reducer for kill fluids	X	X	X				X									P					S						Western
WL-100	Sodium polyacrylate	X		X			X	X										P										RDSI
WMW-1	Mud removal agent	X	X					X																				Western
W.O. 20	High-yield polymeric for viscosity and filtration control	X	X	X														P						P				Milchem
W.O. 21	High yield polymer viscosifier	X	X	X																				P				Milchem
W.O. 22	Acid soluble polymeric viscosifier-low density fluids	X	X	X			X											P						P				Milchem
W.O. 23	Acid soluble polymeric viscosifier-high density fluids	X	X	X			X											P						P				Milchem
W.O. 30	Acid-soluble, graded calcium carbonate	X	X	X																P						S		Milchem
W.O. 35	Acid soluble-high specific gravity weighting material	X	X	X	X	X	X																			P		Milchem
W.O. 50	Polymer and graded calcium carbonate	X	X	X																P								Milchem
W.O. DEFOAM	Alcohol base compound													P														Milchem
WYO-BEN X	Polymer, flocculant and clay extender	X	X				X	X									P							P				Wyo-Ben
X-900A	Powdered catalysed oxygen scavenger	X	X	X	X		X	X			X																P	C-E Natco
X-900L	Oxygen scavenger	X	X	X	X		X	X			X																P	C-E Natco
X-905	Oxygen scavenger	X	X	X			X	X			X	X															P	CE-Natco
XB 23	Biopolymer	X	X	X			X	X										S						P				CECA
XC POLYMER	Xanthum gum biopolymer	X	X	X	X	X	X	X							S			S						P				Kelco & Completion
XKB-LIG	Potassium lignite	X	X	X			X	X										P			S		S					Milchem
XKB-THIN	Iron complexed lignosulfonate	X	X	X			X	X										S			S		S					Milchem
XMDL	Multi-functional drilling liquid	X	X	X	X	X	X	X								P						P					S	RDSI
XP-20	Chrome lignite	X	X	X		X	X	X										S			P		P					Magcobar
X-PEL G	Water dispersable asphaltite (Gilsonite)	X	X	X	X	X	X	X								P		S			P							RDSI
XPK-2000	Atmospheric corrosion inhibitor																										P	Magcobar
X-TEND	Powdered flocculant and clay extender	X	X				X	X									P							P				Baroid
ZEQ	Polymeric for clay free fluids	X	X	X														P						P				Brinadd
ZEOGEL	Attapulgite powder		X	X	X	X		X																P				Baroid
ZERO TORQUE	Graded granular thermo beads	X	X	X	X	X	X	X	X	X						P												Delta Mud
ZINC BROMIDE	Zinc bromide/calcium bromide (liquid blend)																									P	S	Delta Mud

APPENDIX B

DEVELOPMENT OF CONVECTION-DIFFUSION MODEL EQUATIONS[1]

For the purposes of detection-system design, the convection-diffusion equation will be used. The equation is:

$$D\nabla^2 C - V \cdot \nabla C = \partial C/\partial t \qquad \text{(B-1)}$$

where

- C = the concentration of pollutant at point x,y,z
- D = the diffusion coefficient
- V = a vector given the direction and magnitude of fluid flow
- t = time

In pollutant fate modeling, V is not constant, but varies in space across the aquifer. As V may vary, the use of equation B-1 for modeling pollutant transport in diverse areas would be inappropriate; however, as detection-monitoring stations are to be placed fairly close together, the variation in V may be neglected for detection-system design.

If we assume that a source of the pollution (o,o,t) is located at the origin, and that V is in the x direction, and that variation in the a direction may be neglected, the solution of equation B-1 is:

$$C(x,y,t) = \int_{o}^{t} C(o,o,t-t_1) \frac{dt_1}{\sqrt{(2\pi)^2 Dt_1}} e^{-[(x-Vt_1)^2 + y^2]/2Dt} \qquad \text{(B-2)}$$

where

- V = velocity in the x direction
- D = the diffusion coefficient
- t_1 = a small time interval

---

[1]For background information, see Aris, 1978.

For an initial burst that quickly damps out, the form of C may be said to be:

$$C(o,o,t) = P\,\delta\,(t) \tag{B-3}$$

P = level of the burst at time 0

(t) = the dirac delta function.

The solution to equation (B-2), then, is:

$$C(x,y,t) = \frac{P}{(2\pi)^2 Dt_1}\, e^{-\,[(x-Vt)^2 + y^2]/2Dt} \tag{B-4}$$

Let us set the minimum detection level $S\sigma = C_0$. Solving the equation

$$\frac{P}{(2\pi)^2 Dt_1}\, e^{-\,[(x-Vt)^2 + y^2]/2Dt} = C_0 \tag{B-5}$$

we find

$$[(x-Vt)^2 + y^2] = 2DT[W - 1/2 \ln t/t_1] \tag{B-6}$$

where

$W = \ln P/[2\pi C_0 (Dt_1)^{1/2}]$

$t_1 = 1$ sec

Now, as the term $\ln t/t_1$ is small compared with the other term, we may neglect it, and we get:

$$(x-Vt)^2 + y^2 = 2DtW \tag{B-7}$$

Equation 7 is the formula of an ellipse. Solving for one-half the width of the ellipse in the x and y directions, we find:

$$\Delta x = 1/2 \quad 2WDt_0 - (x-Vt_0)^2,\ \text{for } (x-Vt)^2 < WDt \tag{B-8}$$

$= 0$ elsewhere

$$\Delta y = 1/2 \quad 2WDt - y^2,\ \text{for } y^2 < WDt_0 \tag{B-9}$$

$= 0$ elsewhere

It can be seen that the maximum y spacing occurs at $x = vt_0$, and the maximum x spacing at $y = 0$, so that $(vt_0, 0)$ is an optimal place to put a station if we wish to minimize the number of stations (see Figure B-1).

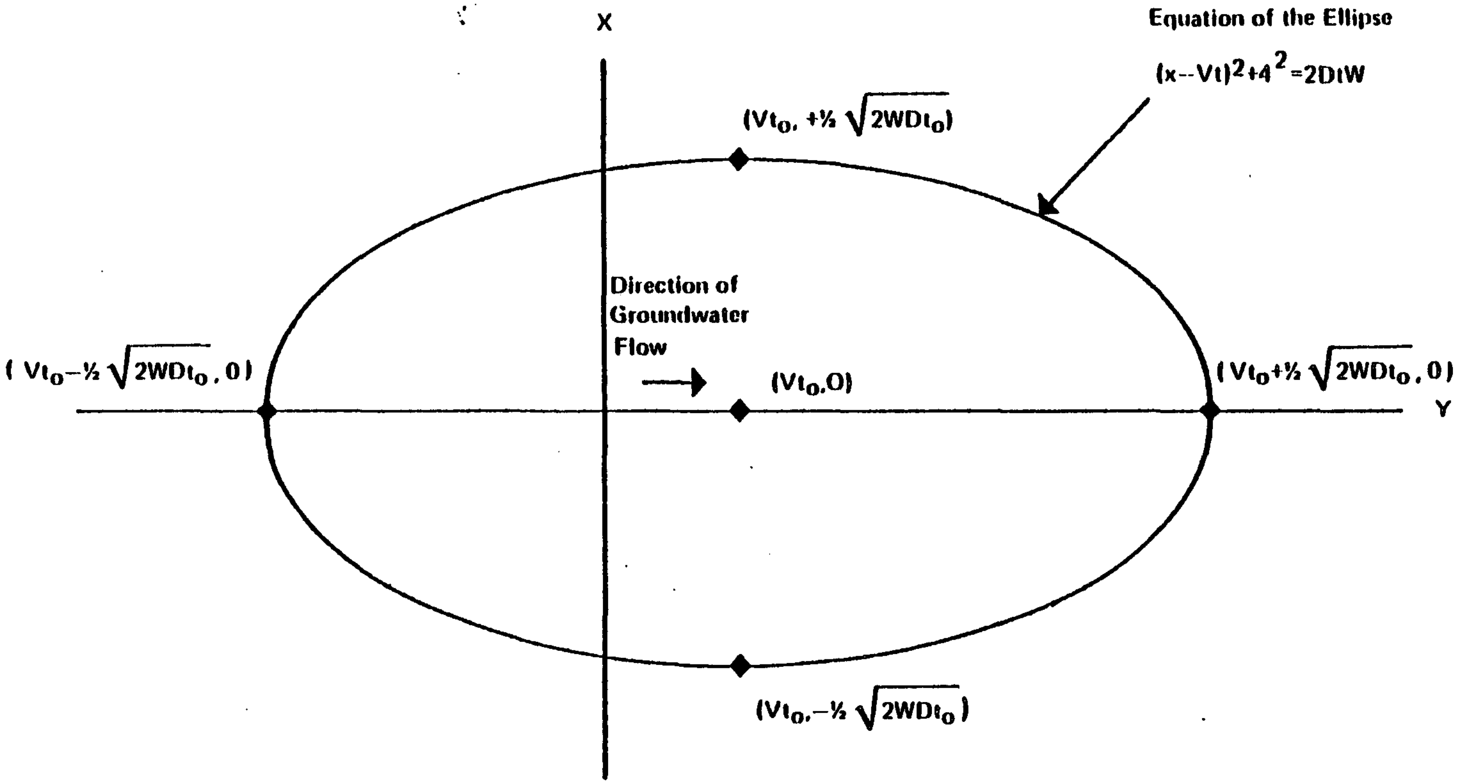

Figure B–1. Location of Recommended Monitoring Stations for a Detection Monitoring System, Based on the Solution of an Equation for an Ellipse Showing Pollutant Trace at Concentration C_o (Detection Limit) at Time t_o (an Arbitrary Time After the Spill).

The sampling frequency may be solved by finding the width of t as a function of x and y:

$$\Delta t = \frac{4W^2D^2 - 4V^2y^2 - 8xVWD}{2V^2} \qquad \text{(B-10)}$$

APPENDIX C

DEVELOPMENT OF POLLUTANT EVENT MONITORING MODEL EQUATIONS

The conservation of mass equation is of the form:

$$\nabla \cdot (\rho V) = \frac{\partial \rho}{\partial t} \qquad \text{(C-1)}$$

where ρ = the density of fluid, and V - velocity. This says that the amount of fluid entering a small volume is equal to the increase in density.

Darcy's law is expressed in the form:

$$V = -\lambda\ [\nabla P - \rho g \nabla D] \qquad \text{(C-2)}$$

where V = velocity, λ = a parameter known as <u>mobility</u>, P is pressure, ρ is density, g is the gravitational acceleration constant, and D is depth. This equation says that fluid velocity in porous rock is proportional to applied force. λ, mobility, may be a function of pollutant concentration in the fluid.

The convection-diffusion equation is:

$$D\nabla^2 C - V \cdot \nabla C = \delta C/\delta t \qquad \text{(C-3)}$$

where C = the concentration of pollutant within a fluid, D = a parameter known as the diffusion or dispersion coefficient, and V = velocity of the fluid in which the pollutant is dissolved. This equation is a relative of the heat or diffusion equation:

$$D\nabla^2 C = \delta C/\delta T \qquad \text{(C-4)}$$

When V = 0, this is a solution to equation C-3. Thus, in the frame of reference of the moving fluid, the convection-diffusion equation simplifies to a simple diffusion equation.

The mobility λ_i of a given fluid is composed of several terms:

$$\lambda_i = \frac{\kappa\kappa_{ri}}{\mu_i} \quad \text{(C-5)}$$

where κ = permeability, κ_{ri} = relative permeability of fluid, and μ_i = viscosity of fluid i.

IMMISCIBLE FLOW EQUATIONS

$$\nabla\cdot[\alpha\rho_n \frac{\kappa\kappa_{rn}^{(S_w)}}{\mu_n} (\nabla P_n - \rho_n g\nabla D)] + \alpha q_n = \alpha \frac{\partial(\phi_e \rho_n S_n)}{\partial t} \quad \text{(C-6)}$$

$$\nabla\cdot[\alpha\rho_w \frac{\kappa\kappa_{rw}^{(S_w)}}{\mu_n} (\nabla P_w - \rho wg\nabla D)] + \alpha qw = \alpha \frac{\partial(\phi_e \rho_w S_n)}{\partial t} \quad \text{(C-7)}$$

$P_c(S_w) = P_n - P_w$ (This is an empirical law, verified experimentally.) (C-8)

$S_n + S_w = 1,$ (C-9)

where a subscript n = nonwetting phase, and a w = wetting phase.

S	= saturation (varies in space)
g	= the gravitational constant
q(x,y,t)	= source or sink, volume injected per unit volume rock
D	= depth (may vary in space)
α	= h (thickness) in two dimensions (may vary in space)
	= 1 in three dimensions
ϕe	= effective porosity (may vary in space)
P	= pressure (varies in space)
ρ	= density (constant)
κ	= permeability (varies in space)
P_c	= capillary pressure (varies in space)

MISCIBLE FLOW EQUATIONS

$$\nabla\cdot[\alpha pw \frac{\kappa}{\mu_w} (\nabla P_c - \rho wg\nabla D) + \alpha qw = \alpha \frac{\partial[\phi_e \rho_w S_w]}{\partial t} \quad \text{(C-10)}$$

$P_c = P_c(S_w)$ (C-11)

$$v_w = (\nabla P_c - \rho w g \nabla D)\ \frac{\kappa}{\mu} \qquad \text{(C-12)}$$

$$\alpha\phi_e \frac{\partial}{\partial t} (S_w C) = \kappa_1 \nabla \cdot (\alpha \nabla C) - v_w \cdot \nabla(\alpha C) + \alpha q_c \qquad \text{(C-13)}$$

where

- C = concentration of pollutant in groundwater
- α = h (thickness) in two dimensions
  = 1 in three dimensions
- P_c = capillary pressure (varies in space)
- S_w = water saturation (varies in space)
- κ = permeability (constant)
- μ_w = viscosity of groundwater (constant)
- ϕ_e = effective porosity
- C = concentration of pollutant in groundwater
- κ_1 = diffusion of dispersion constant
- g = gravitational constant
- ρ_w = density of groundwater
- q = $q(x,y,z,t)$ = source of sink volume of water per volume rock
- q_w = water source term
- q_c = pollutant source term

FLUID ALTERING EQUATIONS: MODIFICATIONS FOR POLYMER AND SURFACTANT POLLUTANT EVENTS

Where the pollutant is polymer or surfactant, equations 14 and 15 must be added.

$$\kappa = \kappa(C) \qquad \text{(C-14)}$$

$$\mu_w = \mu_w(C) \qquad \text{(C-15)}$$

DETERMINING THE SOURCE TERM

The source term q in both the miscible and immiscible flow equations will vary according to the source of contamination. For contamination from a leaky well, q might be modeled as a point source:

$$q(x,y,z) = Q\delta(x-x_o)\delta(y-y_o)\delta(z-z_o) \qquad \text{(C-16)}$$

where Q is the pollutant emitted and (x_o,y_o,z_o) is the location of the leak. It is important to understand that this case is not likely to be useful because, if one knew where the leak in the well was, he would stop it and there would be no source term. For contamination via a direct communication between strata, q might take the form

$$q(x,y,z,t) = q^*C^*8x_o,y_o,z_o,t) \qquad (C-17)$$

where q^* = the fraction of reservoir fluid leaking into the aquifer from the leak at point (x_o,y_o,z_o), and C^* is the concentration of pollutants within the reservoir fluids. This is related to the progress of EOR within the reservoir.

APPENDIX D

USGS/NWDE GROUNDWATER MONITORING STATION LOCATIONS AND SAMPLING FREQUENCIES

This appendix provides examples of the nature and extent of data available for a groundwater quality baseline from the USGS data bases. Locations with high EOR potential, selected as examples, are shown in Table D-1.

TABLE D-1. SUMMARY OF EXISTING GROUNDWATER DATA FOR FOUR SAMPLE COUNTIES

Location	No. of Monitoring Wells	No. of Parameters Measured	Frequency
Stephens County, Texas	40	9	Seasonal
Wayne County, Mississippi	25	11	Annual
Osage County, Oklahoma	24	11	Annual
Kern County, California	663	14	Annual

Monitoring information for Stephens County is presented in Figure D-1 and Table D-2. Maps and sampling frequency computer printouts can be obtained from the USGS for a nominal users charge.

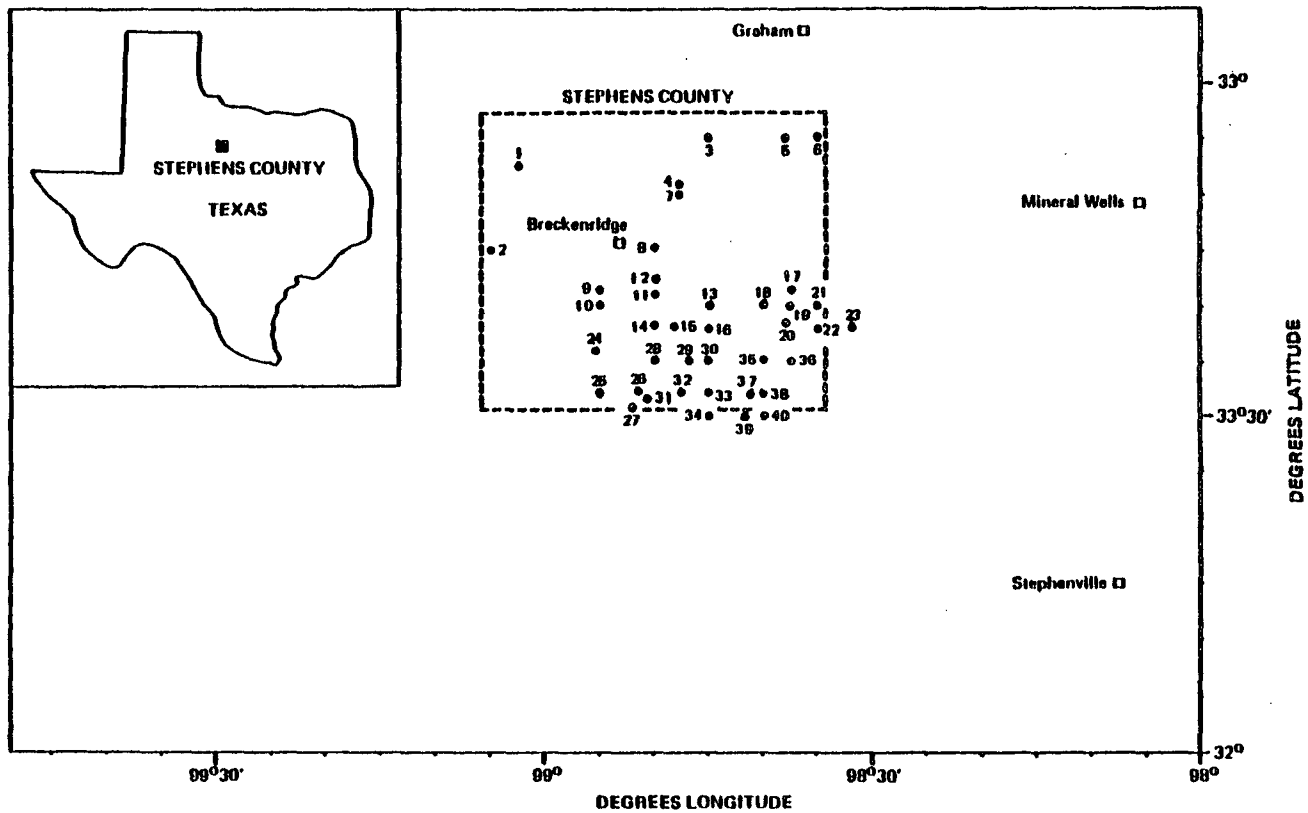

Figure D–1. Area map for Stephens County, Texas, showing locations of USGS groundwater quality monitoring wells.

TABLE D-2. PARAMETERS MEASURED - 40 STEPHENS COUNTY GROUNDWATER MONITORING STATIONS (See Figure D-1 for Station Locations) ALL PARAMETERS MEASURED SEASONALLY

Temperature
Specific Conductance
pH
Dissolved Solids
Major Ions
Hardness
Silica
Nitrogen Species
Minor Constituents

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-81-241	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Monitoring to Detect Groundwater Problems Resulting from Enhanced Oil Recovery		5. REPORT DATE October 1981
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Ron Beck, B. Aboba, D. Miller, and I. Kaklins		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS ERCO/Energy Resources Co., Inc. 185 Alewife Brook Parkway Cambridge, MA 02138		10. PROGRAM ELEMENT NO. INE 823
		11. CONTRACT/GRANT NO. 68-03-2648
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory - Cin., OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, OH 45268		13. TYPE OF REPORT AND PERIOD COVERED Final
		14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES

John S. Farlow, Project Officer (201-321-6631)

16. ABSTRACT

This report develops a four-stage monitoring program to detect groundwater contamination events that may potentially result from enhanced oil recovery (EOR) projects. The monitoring system design is based on a statistical analysis evolving from a series of equations that model subsurface transport of EOR spills. Results of the design include both spatial and frequency monitoring intervals that depend on properties of the local geology and dispersion characteristics of the potential contaminants. Sample results are provided for typical reservoir characteristics.

Selection of measures to be sampled is based on a review of the identity of likely contaminants, on the available sample and analysis procedures, and on the cost and time constraints on analysis. Nonspecific indicator measures are identified that can be used to flag those intervals requiring more intensive and specific monitoring.

The number of independent variables in the analysis dictate that EOR monitoring systems be designed on a site-specific basis. Sampling designs can be easily formulated to conform to the peculiarities of chosen EOR sites based on data already available from federal and state geological surveys and from oil company statistics.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Monitors Groundwater Pollution Oil Recovery Environmental Engineering	Monitoring Strategy Groundwater Pollution Environmental Problems Enhanced Oil Recovery	

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