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EL DORADO MICELLAR-POLYMER DEMONSTRATION PROJECT THIRD ANNUAL REPORT, JUNE 1976—AUGUST 1977

By

Cities Service Company
Prepared for DOE Under Contract No. EY-76-C-02-4100

Date Published—February 1978

Bartlesville Energy Research Center
Department of Energy
Bartlesville, Oklahoma

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By

G. W. Rosenwald, *Editor*
R. J. Miller, *Assistant Editor*
J. Vairogs, *Assistant Editor*

Cities Service Company
Tulsa, Oklahoma

Prepared for the Department of Energy
Under Contract No. EY-76-C-02-4100

R. J. Miller, *Project Manager*
Cities Service Company

W. D. Howell, *Technical Project Officer*
Bartlesville Energy Research Center
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UNITED STATES DEPARTMENT OF ENERGY
TECHNICAL INFORMATION CENTER

A COOPERATIVE DEMONSTRATION PROJECT

by

CITIES SERVICE COMPANY

and

THE UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

(Now the Department of Energy)

R. J. Miller
Project Manager
(June, 1977 - Present)

C. L. Coffman
Former Project Manager
(June, 1974 - June, 1977)

Cities Service Company

W. D. Howell

Technical Project Officer
Bartlesville Energy Research Center
Energy Research and Development Administration
(Now the Department of Energy)

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SUMMARY

The El Dorado Micellar-Polymer Demonstration Project is a cooperative venture between Cities Service Company and the United States Energy Research and Development Administration (now the United States Department of Energy). The project is governed by Contract Number EY-76-C-02-4100. The primary objectives of this project are to determine the economic feasibility of improved oil recovery using two micellar-polymer processes and to determine the associated benefits and problems of each process. The El Dorado Demonstration Project is designed to allow a side-by-side comparison of two distinct micellar-polymer processes in the same field so that the reservoir conditions for the two floods are as nearly alike as possible.

This report covers research and field work on the El Dorado Project during the third project year--June, 1976, through August, 1977. Project activities prior to this period were reported in the First and Second Annual Project Reports.

Selection of sulfonates and polymers for both patterns was completed. A synthetic sulfonate was selected to replace a low equivalent weight petroleum sulfonate in the original surfactant formulation for the north pattern. Abbott Xanthan broth and Nalco liquid polyacrylamide were the polymers selected for the north and south patterns, respectively.

Salinity changes in produced fluids and in observation well samples have shown that breakthrough of preflush (or preflood) has occurred at some wells in both patterns. The data also indicate that the breakthrough

occurred earlier in the southwest-northeast directions than in the southeast-northwest directions in the Chesney (north) pattern and earlier in the southeast-northwest directions than the southwest-northeast directions in the Hegberg (south) pattern.

Observation well sampling and logging data showed that preflush arrived earlier at the observation wells in the north pattern than the south pattern. These data, pressure transient tests, core analyses, and geological studies have shown that the upper zone is missing around the central injection well (MP-213) in the Hegberg (south) pattern. The south pattern observation wells were reperforated to permit fluid entry from the lower zone.

Injectivities of the micellar system designed for the south pattern and components of that system were tested in three monitoring wells. The relatively low injection rate of the micellar oil was somewhat discouraging. However, the final single well injection rates for micellar oil (14 bbl/day) and micellar water (60 bbl/day) were sufficient for the demonstration test.

Similarly, extensive injectivity testing of the surfactant and polymer slugs designed for the north pattern was conducted using two monitoring wells. This testing showed that a slug of the micellar solution containing either Abbott or Pfizer biopolymer can be injected at a reasonable rate (about 60 bbl/day).

Recommended preflush volumes for the Hegberg (south) pattern were revised to reflect corrections in reservoir data (primarily due to the lack of the upper zone at well MP-213). Oil recovery forecasts for the two patterns were updated with a revised program that accounts for the oil not mobilized by the chemical slug. The reservoir model forecasts for the south pattern contained modifications that account for the absence of the upper zone at well MP-213. Oil recovery for a proposed south pattern modification (using observation well MP-227 as an injector) was also investigated with this model.

Reservoir pressure forecasts of the superposition-of-line-sources simulator were compared with observed monitoring well pressures. The discrepancies between observed and theoretically calculated pressures led to the discovery of errors in the production data.

Injection of the chemical preflush for the south pattern began on June 20, 1976. Some loss of injectivity was experienced after chemical preflush initiation. The injectivity loss was attributed to insufficient chemical water softening, fines movement, and/or precipitation of solids. A three-staged acid treatment used on the injection wells was generally successful in improving the injection rate. The preflush injection phase was completed in March, 1977. The pattern injection was then interrupted to prepare equipment for the micellar fluid injection.

The micellar fluid injection began in the south pattern on March 22, 1977. The micellar fluid is injected in small, alternating slugs which are called micellar water and micellar oil (soluble oil). The quality control of micellar fluid composition has been rather good. However, the relatively low injection rate is inadequate. Wax formation at temperatures below approximately 70° F appears to be one of the causes of the low soluble oil injectivity in the south pattern. Several steps have been taken to increase the injectivity. The results are currently being reviewed and evaluated.

Preflood I injection in the north pattern was completed on December 20, 1976. Injection of the Preflood II phase began the next day. The injection rate for both prefloods has been good. The Preflood II phase is scheduled to be completed so that the surfactant slug injection can begin in the north pattern in November, 1977.

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CHEMICAL SELECTION AND SUPPORT

by

H. L. Chang

with

H. M. Al-Rikabi, C. S. Chiou, G. E. Kellerhals, S. A. Mobarak, J. Newcombe, E. F. Riedel, G. W. Rosenwald, and D. A. Siebert

Summary

The major effort in chemical selection and support work has been concentrated in five areas during the past year: (1) selecting a better low equivalent weight sulfonate for the Chesney (north) pattern chemical slug, (2) selecting polymers for mobility control agents in both the Hegberg (south) and Chesney patterns, (3) improving soluble oil quality, (4) monitoring the produced fluid compositions from observation and production wells, and (5) determining water quality requirements by core plugging tests.

The work on the selection of sulfonates and polymers has been completed. A synthetic sulfonate was chosen to replace a low equivalent weight petroleum sulfonate that was contaminated by salts. Abbott Xanthan broth and Nalco liquid polyacrylamide were the polymers selected for the north and south patterns, respectively.

A considerable amount of time has been spent trying to improve the quality of the soluble oil selected for the south pattern. Wax formation at temperatures below 70° F appears to be the major cause of the low injectivity. Work on improving the injectivity is continuing.

Salinity changes in produced fluids and in observation well samples have shown that breakthrough of preflush (or preflood) has occurred in both patterns. The data also indicate that the breakthrough occurred earlier in the southwest and northeast directions in the Chesney pattern and in the southeast and northwest directions in the Hegberg pattern.

Observation well sampling and logging data have shown that displacement of reservoir brine by preflush occurred earlier in the Chesney pattern than the Hegberg pattern. These data, pressure transient analysis, and geological studies have shown that the upper zone (as defined for production) between the central injector and the first observation well is missing in the Hegberg (south) pattern.

Other chemical support work performed during this reporting period primarily involved providing assistance to field operations in areas such as injectivity tests, blending of chemicals, quality control and monitoring of injected fluids, and educational programs for field operators.

The analysis of produced fluid samples is to be continued. Quality control and trouble shooting during the injection of chemical and polymer slugs will be a primary responsibility during the next project year.

Introduction

The chemical selection and support work area is concerned with the evaluation of the effectiveness of chemical formulations and design parameters, the selection of suitable chemicals for the various slugs, the assistance needed for the handling and testing of chemicals in field operations, the analysis and evaluation of fluids produced from observation and production wells, and chemical support as needed throughout the entire life of the project. Work discussed in this section covers the effort during the third year of this project.

The injection of micellar slug has been initiated in the Hegberg (south) pattern. Due to the low injectivity, a considerable amount of time has been spent on the improvement of the quality of the chemical slug. Work is continuing in this area. A polyacrylamide was selected for use in this pattern.

In the Chesney (north) pattern, the injection of preflood is continuing. Micellar slug injection is scheduled for November of this year. The required volume of the second type of preflood has been calculated, and the formulation of the surfactant slug and the selection of a polysaccharide have been finalized. In the process of finalizing the chemical slug, phase behavior was investigated, interfacial tensions were measured, and oil recovery flow tests were made.

In the monitoring program, injected fluid composition and quality have been analyzed and documented. Produced fluids have also been analyzed and evaluated.

As the project progresses, it is anticipated that chemical support work will be primarily in the areas of quality control for the chemical and polymer slugs and process evaluation.

Discussion

Improvement of Soluble Oil Quality

Due to the low injectivity of soluble oil in the Hegberg (south) pattern, extensive work has been performed both in the laboratory and field to identify the causes and to provide solutions. Possible causes of the poor injectivity include (1) the high viscosity of the fluid, (2) fines movement, (3) the presence of solids in the injected fluid, and (4) the crystallization of paraffin hydrocarbons (wax) and/or asphaltic materials in the Greenwood County crude oil (GCCO) at low temperatures. Significant reduction of chemical slug viscosity is undesirable because of the mobility control requirement. Laboratory flow tests have generally indicated that there is no fines movement during the injection of chemicals into El Dorado cores. Therefore, the removal of solids in the sulfonate slug and paraffin inhibition were the two major areas that were investigated. To date, all results appear to indicate that the crystallization of wax at temperatures below 65°F is the major cause of the injectivity problem. The following sub-sections will give some details of all the investigations that were performed.

Possibility of replacing GCCO with other types of oils. In addition to treated GCCO (Greenwood County crude oil), several other crude oils and a refined oil were evaluated as possible substitutes for the GCCO in the micellar slug. It was found that all the other crude oils that could be economically and practically obtained also contained wax. It was also found that the substitution of refined oils for GCCO would require reformulation of the chemical slug. Therefore, the replacement of GCCO with another oil was not practical.

Treatment of GCCO. Laboratory investigation of methods for treating GCCO included adding wax inhibitor, adding solvents, clay treatment, improved filtration, and some of the combinations of the above possibilities such as wax inhibitor with clay treatment, wax inhibitor with solvent, and wax inhibitor with diatomaceous earth filtration.* It was found that all these treatments improved the filterability of the GCCO. However, the combination method appeared to be the most effective. A comparison of the filterability of untreated GCCO, GCCO treated with a wax inhibitor, and GCCO treated by a combination method is shown in Figure A-1 in Appendix A.‡

Although the combination method showed better filterability, crude oil used to prepare the soluble oil during the first four months of injection was treated only with wax inhibitor due to the high operating costs and high equipment costs associated with the combination treatment. In addition, injectivity tests (see the section "Formation Injectivity Tests") performed using well MP-202 indicated that the injectivity of soluble oil prepared using crude oil that had been treated with wax inhibitor was acceptable.

The identification of the plugging agent in GCCO was pursued through the analyses of the crude oil and the residue resulting when the oil with wax inhibitor was filtered through a 1.2 μm millipore filter.

*A small (about 0.3 ft^2) diatomaceous earth (DE) unit from Johns-Manville was tested at the field for filtration of the untreated and treated (with Magna D-Wax 950) GCCO. A Johns-Manville representative was on site to assist with the tests. Both the treated and untreated GCCO were filtered using Johns-Manville Celite 545, 503, and Hyflo. The tests were performed to simulate a pressure-type filter.

‡Figures or tables denoted with the letter A are found in Appendix A.

The results are given in Table A1 in Appendix A. The data indicate that the ratio of asphaltenes to saturated hydrocarbons in the residue is considerably higher than the ratio of asphaltenes to saturated hydrocarbons in the crude oil. Only a small portion of the total asphaltenes (about 4.4 percent) in the GCCO was found in the filter residue. Furthermore, only a small part of the total saturated hydrocarbons in the oil was found in the filter residue (about 0.5 percent of the total in the oil). These results showed that filtration alone is not an effective method for removal of wax or paraffin hydrocarbons from GCCO.

Diatomaceous earth filtration test of soluble oil. In June, 1977, a 72 square foot diatomaceous earth (DE) filter was procured and installed at the field injection plant. Figure A-2 is a flow diagram of the filter installation. The work performed in the field was to start-up the filter and to determine the optimum precoat, body feed, flow rate, and temperature while maintaining a reasonable flow rate and total through-put volume without a backwash. It was found that 7.5 pounds of Celite 545 and five pounds of Celite Filtercel body feed were suitable for the filtration operation. The initial and final filtration rates were 0.29 and 0.12 gallons per minute per square foot at 140°F. The limiting pressure drop for this filtration unit was about 20 psi. Approximately 150 barrels could be filtered in five hours before backwash was required. The conditions described above were used during the field filtration operations.

The millipore filterability of DE filtered soluble oil was adequate. One liter of soluble oil could be filtered through 1.2 μm millipore filter paper at 74°F and 20 psi pressure drop without plugging. The comparison of the filterability of the DE filtered and the unfiltered soluble oil is given in Figure A-3.

The DE filtered oil showed adequate quality; most solid materials (approximately 70 percent above 1.2 μm in size) present at the filtration temperature were removed. However, the field injectivity was very disappointing. Further investigation indicated that once the filtered soluble oil was cooled down to about 60°F, the filterability of the previously filtered soluble oil became very poor. A comparison of the filterability of the DE filtered soluble oil maintained above 70°F with the same soluble oil which was cooled down to 60°F and warmed back up to 70°F is also shown in Figure A-3.

In addition, temperature profiles of wells MP-203 and MP-205 showed that the temperature drops to about 63°F at a depth of 250 feet to 350 feet below the surface. The temperature profiles are shown in Figures D-3 and D-4 of Appendix D.

In summary, the filterability test and temperature profile data clearly indicated that wax is a major cause of the poor injectivity. Currently, new methods to solve problems due to wax crystallization at lower temperatures (below 65°F) are being sought.

Soluble Oil Blending and Injection

Blending of chemicals at Petrolia. The blending of surfactants, cosolvent, and water for the Hegberg (south) pattern chemical slug was initiated in late January, 1977, at the Witco plant in Petrolia, Pennsylvania. Cities Service Company and Union Oil Company research personnel were in Petrolia to assist in testing the blended material and to recommend correction procedures if the mixture failed to meet the specifications. The first batch of the sulfonate concentrate arrived at the El Dorado Field on February 18, 1977, in a "jumbo" (approximately, 20,000 gallon) rail car. To date, ten batches of sulfonate concentrate have been received at the El Dorado Field. Quality control tests were performed by Witco personnel at Petrolia before each shipment. Samples of blended sulfonates were also sent to both the Cities Service Company Tulsa Laboratory and the Union Oil Company Laboratory for confirmation tests.

Injection of soluble oil into the south pattern. Injection of the chemical slug (recommended by Union Oil Company) was initiated on March 23, 1977. Approximately equal volumes of soluble oil (also called micellar oil) and micellar water* are being injected in alternating slugs. The final fluid compositions used in the Hegberg pattern are shown in Table I.

Before initiation of the micellar fluid injection, Region operations personnel visited the Tulsa Laboratory for special training concerning the test procedures for the soluble oil. Detailed quality control tests, chemical analyses, and corrective actions were explained and performed in the Tulsa Laboratory.

Performance tests (quality control tests for the soluble oil) and filterability tests (volume versus time for a fluid flowing through a 1.2 μm millipore filter at 20 psi pressure head) have been performed on all batches of soluble oil. The composition of each batch of micellar water has been determined, and filterabilities have been run periodically. Every batch of micellar oil and micellar water has passed the performance tests.

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*"Micellar water" is the term used to refer to the adjusted salinity water injected in alternating slugs with the soluble oil. The corresponding term "micellar oil" is used to refer to the soluble oil.

TABLE I

SOUTH (HEGBERG) PATTERN DESIGNED FLUID COMPOSITIONS AND VOLUMES

Fluid	Description	Weight Percent	Volume, bbl
Pretreatment			118,500
	Sodium chloride	2.000[a]	
	Fresh water	98.000	
Preflush			134,776[b]
	Sodium silicate*	0.281	
	Sodium hydroxide	0.482	
	Softened fresh water	99.237	
Micellar Oil (Soluble Oil)			22,626
	Four sodium alkyl aryl sulfonates (Equivalent weight 250-650; Average equivalent weight 425)	23.85[c]	
	Ethylene glycol monobutyl ether	2.63	
	Crude oil	66.78	
	Fresh water added	6.74[d]	
Micellar Water			22,626
	Sodium chloride	0.25	
	Nitrilotriacetic acid trisodium salt	0.65	
	Fresh water	99.10	
Polymer			724,050
	Polyacrylamide	0.068[e]	
	Fresh water	99.932	

*Common name for a mixture of Na_2O and SiO_2.

[a]The last 8900 bbl contained one percent NaCl. The last 2800 bbl was softened.

[b]Volume actually injected. The calculated volume was 120,675 bbl.

[c]About 52 percent sodium sulfonate.

[d]Does not include the water in the petroleum sulfonates.

[e]Average of several steps.

Evaluation of Polymers for the South Pattern

Five liquid-type polyacrylamides were evaluated for mobility control agents for the Hegberg (south) pattern. The five polyacrylamides were Nal-Flo-F 5257 and Nal-Flo-F G-6342 (Nalco Chemical Company) and Cyanatrol WF-940S, Cyanatrol WF-950S, and Cyanatrol RC-391 (American Cyanamid Company). It was found that both Nal-Flo-F G-6342 and Cyanatrol RC-391 have almost identical properties and are suitable as mobility control agents for the Hegberg pattern. Based on an economic evaluation, the Nalco product was chosen for use in the mobility control slug following the micellar slug.

The laboratory evaluation of these polymers included viscosity measurements and flow tests through both El Dorado 650-foot Sandstone and fired Berea Sandstone cores. Cyanatrol WF-950S and Nal-Flo-F 5257 were rejected for application in the El Dorado Micellar-Polymer Project because they failed the quality control criteria of achieving stabilized pressures when continuously injected into fired Berea cores. Nal-Flo-F G-6342 and Cyanatrol WF 940S showed better injectivity. However, as shown in Figure A-4, Nal-Flo-F G-6342 has higher viscosity than Cyanatrol WF 940S at the same concentration. Cyanatrol RC-391 showed higher viscosities than WF 940S; the viscosities of the RC-391 were about the same as those measured for Nal-Flo-F G-6342. Comparison of viscosities and flow behaviors of these two polymers are shown in Table A2 and Figure A-5.

Volume of Preflood II Required for the North Pattern

Injection of the Preflood II phase for the Chesney (north) pattern began on December 21, 1976. The process vendor originally recommended a preflood slug with 650-foot formation water and sodium chloride in Lake

Bluestem water. Because of the poor quality (solids, oil, etc.) of the 650-foot formation water, a synthetic brine was proposed as a substitute for the formation water. The change required that a substitute fluid be recommended by the process vendor as well as installing additional mixing facilities at the injection plant, and purchasing calcium and magnesium chlorides. Therefore, only sodium chloride (with an adjusted concentration which was approximately equivalent to the total dissolved solids in the original design) was used in the first portion of the preflood injection (Preflood I). Later, calcium and magnesium ions were added to the preflood slug which was then called Preflood II.

According to the ion exchange theory[1,2,3,‡] the ionic concentrations in Preflood II should be readjusted (differing from the original design) to account for the injection of sodium chloride during Preflood I. The calculation of the Preflood II requirement depends on the reservoir volume that was contacted by Preflood I and the ion exchange capacity of the reservoir rocks.

Figure A-6 shows the volume ratio of Preflood II to Preflood I versus the contacted reservoir volume at two different ion exchange capacities. Dispersion and crossflow were not considered in the calculations used to construct this figure. The volume of Preflood II needed after Preflood I was estimated to be a minimum of 70 percent of the volume of Preflood I. A volume equal to that of Preflood I would be more desirable. The composition and preferred volume of Preflood I and II are given in Table II. As of August 31, 1977, approximately 314,000 barrels of Preflood II had been injected.

[‡]References are given at the end of this section.

TABLE II

NORTH (CHESNEY) PATTERN DESIGNED FLUID COMPOSITIONS AND VOLUMES

Fluid	Description	Weight Percent	Volume, bbl
Preflood I			352,700[a]
	Sodium chloride	1.4	
	Fresh water	98.6	
Preflood II			353,000
	Sodium chloride	2.900	
	Calcium chloride	0.102	
	Magnesium chloride	0.097	
	Fresh water	96.901	
Micellar Solution			100,660
	Two sodium alkyl aryl sulfonates (Equivalent weight 300-550; Average equivalent weight 430)	4.69[b]	
	C_{12}-C_{15} Alcohol ethoxysulfate sodium salt (about 60% active)	1.13	
	Secondary butyl alcohol	4.13	
	Polysaccharide	0.09	
	Sodium chloride	0.70	
	Fresh water added	89.26[c]	
Polymer			587,170
	Polysaccharide	0.076[d]	
	Sodium chloride	0.075	
	Calcium chloride	0.008	
	Magnesium chloride	0.007	
	Fresh water	99.834	

[a] Volume actually injected. The calculated volume was 335,525 bbls.

[b] About 56 percent sodium sulfonate.

[c] Does not include the water in the sulfonates.

[d] Average of several steps. The polymer design may change. The first 83,880 bbl contain 2.0 percent secondary butyl alcohol.

Selection of a Sulfonate for the North Pattern Formulation

One of the sulfonates recommended for the surfactant slug for the Chesney (north) pattern contains eight to ten weight percent of an inorganic salt as an impurity. The impurity was found to be undesirable during laboratory design work and field operations. Hence, laboratory work was initiated to investigate the possibility of removing the impurity or substituting another suitable sulfonate in the formulation. Removal of the impurity was deemed to be time consuming, impractical, and expensive. Disposal of the impurity also presented a problem. Therefore, sulfonates to replace this undesirable sulfonate in the chemical slug were tested.

Seven sulfonates were independently substituted for the undesirable sulfonate in the north pattern formulation. Selection of a replacement sulfonate was based on results from laboratory study of phase behavior and oil recovery flow tests and economic factors.

Phase behavior of the seven surfactant systems resulting from the surfactant substitution was studied and compared to the original formulation by diluting with one or more of the following: Chesney crude oil, preflood, polymer drive solution, and Chesney produced brine. Generally, all seven systems containing one of the replacement sulfonates showed phase behavior similar to the original system.

Laboratory oil recovery flow tests through both Berea Sandstone cores and El Dorado 650-foot Sandstone core plugs were made using the "substituted" surfactant systems. These results showed that five of the seven chemicals were suitable as a replacement sulfonate. Based on economic considerations, one of the five, a synthetic sulfonate, was chosen as the substitute.

Results of oil recovery tests using ten-inch long by two-inch diameter stacked El Dorado cores are shown in Figures A-7 and A-8 for the original system and the modified system selected, respectively. Final residual oil saturations were 18 percent of the pore volume in both runs. Detailed descriptions of the flow test data are shown in Table A5. Final fluid compositions recommended for the north (Chesney) pattern are given in Table II.

The interfacial tension maps developed for the original system designed for the north pattern and for the modified system selected were also compared. These data are given in Tables A3 and A4, respectively. The tables show approximately equivalent interfacial tensions in the lower salinity region (less than 20,000 mg/l of NaCl), but the original system has somewhat lower interfacial tensions in the higher salinity region (more than 20,000 mg/l of NaCl).

Evaluation of Polysaccharides for the North Pattern

In addition to the field injectivity test (see the section "Formation Injectivity Tests"), three polysaccharides--Kelzan SS-4000, (Kelco, Division of Merck Company, Inc.), Abbott Xanthan Broth (Abbott Laboratories), and Pfizer Broth 1035 (Pfizer Chemical Division, Pfizer, Inc.)--were evaluated as mobility control agents. It was found that:

1. At the same concentration,* both Abbott and Pfizer polymers have slightly higher viscosities** than Kelzan SS-4000, and

*All concentrations were based on the activities quoted by the manufacturer.

**All viscosities were measured at 74°F with a Brookfield LVT viscometer with a UL adaptor.

the viscosities of Abbott and Pfizer polymers are about the same (see Figure A-9 and Table A6).

2. The millipore filterability results for Abbott and Pfizer polymers are superior to those for Kelzan SS-4000, and the filterability of Pfizer polymer is better than that of the Abbott polymer (see Figure A-10).

3. The injectivities of the three polymers through extracted El Dorado cores are comparable (see Figure A-11). Based on the field injectivity test, price, and this laboratory evaluation, Abbott biopolymer was recommended as the mobility control agent for the Chesney pattern.

A summary of viscosity data at various concentrations (400 to 1000 ppm) and shear rates (3.68 to 73.56 reciprocal seconds) is given in Table A6. Viscosity versus concentration curves at 6 rpm (a shear rate of about 7.4 sec^{-1}) for the three polymers are shown in Figure A-9. On the average, seven to ten percent less polymer is required for either Abbott or Pfizer polymer to achieve viscosities equal to those of Kelzan SS-4000.

Millipore filtration tests were conducted using 1.2 μm filters (47 mm in diameter) under 10.0 psi of differential pressure. Solutions containing 1000 ppm polymer and 1.0 weight percent NaCl were used in this series of tests. Filtration rates (in ml/sec) versus cumulative filtered fluid volumes are plotted in Figure A-10.

In the laboratory injectivity tests, all fluids were prefiltered through 1.2 μm millipore filter paper. Polymer and NaCl concentrations were 1000 ppm and 1.0 weight percent, respectively. Extracted El Dorado cores (one-inch diameter by three inches long) mounted in a Hassler cell were used in this series of tests. The injection rate was maintained constant at 100 ml/hr. The ratios of the pressure drop for polymer injection to the pressure drop during water injection versus the total volume of fluid injected are shown in Figure A-11. These results indicate that filtered biopolymer solution (1.2 μm filter) could be easily injected into El Dorado cores without any severe problems and with very small changes in water permeability after polymer injection.

Water Quality Requirements as Determined by Core Plugging Tests

A number of laboratory experiments were undertaken to better determine water quality requirements for fluids injected into the El Dorado Project wells. In each of these tests brines of known qualities (particle sizes) were injected into El Dorado cores until there was a significant reduction in the mobility (k/μ).

Unfiltered fresh water was obtained from the El Dorado Project plant upstream from the sandfilter. This water was used to make a 1.0 weight percent NaCl solution. The water was then filtered through various sized millipore filters and labeled according to the filter size. Thus, "0.45 μm brine" would be a 1.0 percent NaCl brine solution which has been filtered through a 0.45 μm millipore filter. In addition to prefiltering the brines, an in-line filter of the same size was employed at all times during the flow tests.

The permeability of the core obtained using a "0.45 μm brine" was used as the base permeability. The 0.45 μm brine was injected into the cores until a stable value of k/μ was obtained. The k/μ value was considered to be stabilized when the value had not changed by more than one percent for more than ten pore volumes. After a base value for k/μ

was obtained with the 0.45 μm filtered brine, the size of filtration used for the injected brine was increased in stages until plugging occurred. For each of the filtered brine solutions injection continued until k/μ stabilized or the test was completed.

Six tests were run in all; illustration of the three types of results obtained are shown in Figures A-12 through A-14. Four cores showed substantial plugging for fluids with particles in the range of 1.2 to 3.0 microns. One core was more difficult to plug, needing particles in the range of 5 to 10 microns to plug. Data from one test, using unfiltered water, was not conclusive.

From these data it was concluded that the injectivity will not be significantly reduced in the El Dorado 650-foot Sand if the size of the particulate matter is restricted to below 1.2 microns.

Monitoring of Injected Fluids

Monitoring of the injected fluid composition has continued over the past year. This monitoring included: (1) water filtration tests, (2) determination of the concentrations of monovalent and divalent cations in the preflood, and (3) determination of the alkalinity of the chemical preflush used in the Hegberg pattern. The concentrations along with the injected fluid volumes are available in a computer file for material balance calculations. Figure A-15 shows the measured preflood compositions for the Chesney (north) pattern Preflood I monovalent ion. Figure A-16 gives the Chesney (north) pattern Preflood II monovalent cation, divalent cations, and divalent cation to monovalent cation ratio. Figure A-17 shows the monitored alkalinity of the injected chemical preflush used in the Hegberg (south) pattern.

Analyses of Samples from the Observation and Production Wells

Fluid samples from observation and production wells are being periodically analyzed for chloride, sodium, calcium, magnesium, and pH. Iron content and other cations have also been monitored, but on a less frequent basis. Analyses for surfactants, cosolvents, and polymers are also to be made after the initiation of injection of micellar and polymer slugs.

Currently, preflood injection is continuing in the Chesney (north) pattern. The chemical slug has been injected into the Hegberg (south) pattern since March, 1977. No breakthrough of the surfactants into either production or observation wells in the Hegberg pattern had been observed as of August 31. The well locations are shown in Figure C-1 in Appendix C.

Salinity decreases have been detected in all four observation wells, MP-131, MP-132, MP-227, and MP-228. The salinity has decreased in three producing wells (MP-112, MP-122, and MP-124) in the Chesney pattern and two producing wells (MP-209 and MP-217) in the Hegberg pattern. A comparison of the most recent salinity and pH (August 16, 1977) from eight producers and four observation wells is given in Table A7. As noted in the table, the original salinities expressed as sodium chloride are based on an average of 20 analyses on different samples taken from April 19, 1976, through April 24, 1976. The original cation concentrations used are those given in Table A9 of the First Annual Project Report[4] which is reproduced here as Table A8 for the reader's convenience (and to correct some minor errors in the table). The trends of salinity changes of produced fluid from these twelve wells are plotted in Figures A-18 through A-29.

Valuable information has been obtained from the observation wells. Breakthrough of preflush slugs was detected in both the Chesney and Hegberg patterns. Vertical sweep (from logging data--see the section "Observation Well Logging") appears to be much more efficient in the Chesney (north) pattern than in the Hegberg (south) pattern as discussed in the sub-sections that follow.

Effective displacement of reservoir brine by preflood in well MP-131. Preflood I was initiated in November, 1975. Well MP-131 was drilled and completed in late March of 1976. It is the inner observation well in the Chesney (north) pattern located 90 feet from the central injector, well MP-118. Breakthrough of Preflood I had already occurred at the time sampling was begun. Salinity in this well showed continual decline throughout the second half of 1976, and reached a minimum in February, 1977. This minimum salinity was approximately equal to the salinity of Preflood I.

A sharp increase in salinity was observed in May, 1977. This salinity increase represents the breakthrough of Preflood II. It is interesting to notice that the breakthrough of Preflood II has a much sharper front (salinity change versus time) than Preflood I (note the differences in response time of chloride ion shown in Figure A-22). In addition, inspection of Figure C-2 in Appendix C shows that the vertical sweep of Preflood II is better. The most effectively swept zone is about 13 feet thick (642 feet to 655 feet).

Breakthrough of Preflood I in well MP-132. Well MP-132 is the outer observation well in the north pattern located about 187 feet from the central injection well MP-118. Wells MP-131 and MP-132 were drilled and completed in the same time period. Initial logging and initial fluid sampling data showed a slight salinity decrease in this well compared to average reservoir brine concentration. However, the magnitude of the salinity change was much less than that in well MP-131. In addition, breakthrough occurred in both upper and lower zones; this differs from the salinity changes observed in well MP-131, which occurred near the center.

Poor sweep by preflush in wells MP-227 and MP-228. These two observation wells in the Hegberg (south) pattern were drilled and completed at about the same time as wells MP-131 and MP-132. Reservoir fluid samples were collected from one-foot intervals perforated with four bullets. No salinity change was observed in fluid samples taken prior to April, 1977. However, logging data (see the section "Observation Well Logging") indicated that salinity decline had occurred in the lower zone (below 673 feet in well MP-227 and below 664 feet in well MP-228, see Figures C-4 and C-5 in Appendix C). Furthermore, data from subsequent logging showed that salinity decrease had also occurred in the upper zone of well MP-228. These data clearly indicate that the preflush was not sweeping the upper zone around well MP-227. It is evident that the originally perforated intervals in these two wells are located in regions that have not been swept by the preflush. This explains why fluid samples taken prior to April, 1977, did not show salinity changes in these wells.

The lower zone in both of these wells was perforated in April, 1977. The first fluid samples from these two wells, after the second one-foot intervals were perforated, were taken and analyzed in May. Unfortunately, it was found that there was communication behind the casing in MP-227. This communication between the upper and lower parts of the well has not been (and probably cannot be) corrected. Therefore, fluids sampled from well MP-227 since May, 1977, represent composite samples from multiple zones. These samples have shown lower salinities than samples collected before the perforation of the lower zone.

The salinity in well MP-228 increased substantially in July, 1977. This increase might be explained by irregular communication between the multiple zones.

Because the chemical preflush slug used in this pattern was an alkaline solution, some pH increase was anticipated in the samples from these wells. To date, no significant change in the pH value has been observed in either well MP-227 or well MP-228.

Salinity changes in producing wells. The salinity changes in samples from producing wells in the Chesney pattern have shown that preflood has arrived at wells MP-112, MP-122, and MP-124. The arrival times at wells MP-112 and MP-124 were two to three months ahead of the arrival time at well MP-122. This phenomenon indicates that the fluid moved faster in the northeast and southwest directions. There is no salinity change trend in samples from producing well MP-114. This delayed salinity change could be due to the poor productivity of this well.

The breakthrough of preflush in wells MP-209 and MP-217 in the Hegberg pattern indicates fluid movement was faster in the northwest-southeast direction. Well MP-207 is also a poor producer.

The unusual salinity "jump" in producing well MP-112 during the months of January, February, and March of 1977, was unexpected. Reserve samples taken during these three months are currently under analysis. No explanation for this unusual salinity change is available at this time.

Miscellaneous Chemical Support Work

Biocide testing. Two commercially available biopolymers were used for preparing solutions (approximately 1000 parts per million) containing Visco 3201 biocide or formaldehyde and/or alcalase enzyme. The appearance and viscosities of the solutions two weeks after preparation were determined.

Filterabilities (1.2 micron millipore filter with a pressure differential of 20 psi) of the fourteen solutions were determined approximately 16 days after preparation. Without biocide or enzyme treatment some of the solutions had viscosities of only two centipoise (rather than about 30 cp) two weeks after preparation.

Testing cartridge filters. Attempts to determine the effectiveness of one micron cartridge filters in improving the filterability of Greenwood County crude oil were made in the field laboratory and the Tulsa Laboratory. The filterability improvement was determined using 1.2 and 5 micron millipore filters at a constant pressure drop. The data indicated that a one micron cartridge filter would produce oil which gave a relatively good filterability through a five micron (absolute) millipore filter (with a pressure difference of 20 psi). On the other hand, the one micron cartridge filter did little to aid the filterability of the oil through a 1.2 μm (absolute) millipore filter (with a differential pressure of 20 psi).

Preweighed millipore filters (0.45, 1.2, and 5 μm absolute) were used upstream and downstream during field testing (for soluble oil filtration) of a 1.2 micron "absolute" cartridge filter. The weights of the residues collected on the filters were determined, and the milligrams of residue per liter of soluble oil filtered were calculated. Table A9 gives the results.

School for plant operators. On February 24, 1977, two, half-day schools were presented for all field operating personnel associated with the Micellar-Polymer Project; they included field engineers, engineering technicians, field foremen, gang pushers, and pumpers. The combination quality control and safety school was held at the El Dorado field office. One objective for this school was to emphasize the importance and necessity of quality control for the chemical fluids to be injected into the formation and to illustrate the possible consequences that could occur if correct procedures were not followed. Another objective was to give safety precautions for handling various types of chemicals and emergency treatment procedures.

The standard four slug design of micellar-polymer flooding was presented. This was followed by the specifics of the north and south pattern preflushes and the contrasts between waterflooding and micellar-polymer flooding in water treatment requirements. Specifics of the south pattern micellar fluids were also discussed.

Future Work

Monitoring of the injected fluid compositions and quality control will be continued. Analysis of produced fluids for surfactant will be initiated soon. Analysis for polymers will be performed later after polymer injection has begun.

Quality control procedures and testing methods for biopolymer broth, surfactant concentrate, and the complete chemical slug for the Chesney (north) pattern will be developed before the micellar slug injection in that pattern. Micellar slug injection for the Chesney pattern is scheduled for November, 1977. Research and field laboratory personnel will monitor the quality of the micellar and polymer slugs and the final drive water.

Efforts directed toward improvement of the injectivity of soluble oil in the Hegberg (south) pattern will be continued. Solvent treatment to prevent the crystallization of wax at low temperatures is one treatment method that will be tried in the field.

References

1. Hill, H. J., and L. W. Lake, "Cation Exchange--Chemical Flooding Experiments," Society of Petroleum Engineers of AIME, 52nd Annual Fall Technical Conference and Exhibition, Paper No. 6770, Denver, Colorado, October 9-12, 1977.
2. Lake. L. W., and F. G. Helfferich, "The Effect of Dispersion, Cation Exchange and Polymer/Surfactant Adsorption on Chemical Flood Environment," Society of Petroleum Engineers of AIME, 52nd Annual Fall Technical Conference and Exhibition, Paper No. 6769, Denver, Colorado, October 9-12, 1977.
3. Pope, G. A., L. W. Lake, and F. Helfferich, "Cation Exchange in Chemical Flooding--Basic Theory Without Dispersion," Society of Petroleum Enigneers of AIME, 52nd Annual Fall Technical Conference and Exhibition, Paper No. 6776, Denver, Colorado, October 9-12, 1977.
4. Rosenwald, G. W., and R. J. Miller (editors), El Dorado Micellar-Polymer Demonstration Project (First Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-75/1, October, 1975.

CORING AND CORE ANALYSES

by

W. H. Pusch

with

J. Rennison and R. W. Tillman

Summary

During the past year, core studies have been performed to explain the lack of lateral communication in the Admire Sandstone between injection well MP-213 and observation wells MP-227 and MP-228. The study included routine analyses on cores from wells MP-227 and MP-228 and a geological explanation of the lithologic and sedimentological characteristics of the cores.

Introduction

Analyzing preserved cores from the project area has continued in order to obtain an accurate description of the reservoir. Work has been concentrated on samples of the formation near wells MP-213, MP-227, and MP-228. The work was undertaken to explain the extremely limited communication between well MP-213 and observation wells MP-227 and MP-228. Well MP-213, which has a thin pay section, is the central injection well in the Hegberg (south) pattern. Routine core analyses and a detailed geological study have been performed on observation wells MP-227 and MP-228.

In addition, capillary pressure data have been measured on core samples from wells MP-106, MP-110, and MP-122.

Discussion

Core Analyses

A total of 27 cores from the project area have been analyzed. Routine core analyses were performed on cores from wells MP-227 and MP-228 during this reporting period. Results are given in Tables B1 and B2 of Appendix B. Because both cores were slabbed for geological studies, fluid saturations were not measured.

Capillary Pressures

Capillary pressure curves were measured on samples from wells MP-106, MP-110, and MP-122. The mercury injection capillary pressure technique was used after the plugs had been cleaned, dried, and subjected to routine core analysis for porosity and permeability. Results are shown in Figures B-1 through B-3.

Geology

During injection operations, a lack of lateral communication in the Admire Sandstone became apparent between injection well MP-213 and observation wells MP-227 and MP-228, located 90 feet and 187 feet southwest of MP-213, respectively. The lack of communication between well MP-213 and the perforated intervals (the original one-foot intervals) of these two observation wells was confirmed by pressure transient analysis as discussed in the section "Pressure Transient Testing."

Geological work commenced with the slabbing and polishing of the preserved and stored cores from wells MP-227 and MP-228. Core from well MP-213 had been previously analyzed and interpreted. The lithologic and sedimentological characteristics of all three cores were carefully described and correlated as precisely as possible with available wireline logs. Porosity-permeability plugs, petrographic slides, and clay mineralogy samples were prepared and analyzed. The results of the investigation revealed a vertical sequence of deltaic depositional environments in all three cores essentially identical to that found in cores from other project wells.

At well MP-213 and apparently at well MP-214, the upper producing unit is absent. The unit, as empirically defined, consists of a continuous and relatively thick, porous sandstone. The lower producing unit is defined as a vertical sequence of thin (usually less than two feet thick) porous sandstones interrupted by discontinuous thin shaly zones. Detailed study of these producing units indicated the upper unit, where present in wells MP-227, MP-228, MP-219, and MP-215, is a series of crevasse splay sandstones which resulted from local breakthrough of the natural levees of the channels to the west, south-southwest, and north of the indicated wells. This crevasse splay in wells MP-227 and MP-219 does not extend as far east as well MP-213. The crevasse splay in MP-215 apparently extends northward and does not intersect either well MP-213 or well MP-214 in the upper producing unit. Brackish marine shale was deposited in place of the upper producing unit in these two wells. The shale is laterally equivalent and probably time equivalent to the upper producing unit.

The lower producing unit extends through all of the above mentioned wells. The lower unit sandstones are mainly microsplay deposits which are interbedded with intertidal shales and siltstones.

Mobility Determination

Details of a study to determine the mobility of the oil-water bank in the El Dorado 650-foot Sandstone were reported in a paper given at the Society of Petroleum Engineers meeting last fall.[1] The following paragraphs are an abstract of that paper.

Minimum total relative mobilities of the oil-water bank in the Admire (Pennsylvanian) 650-foot Sandstone were determined by (1) steady-state curves, (2) direct measurement of stabilized oil-water banks developed by micellar-polymer displacement, and (3) field pressure transient data.

It was found that the minimum total relative mobility of the oil-water bank in this system can be as low as 0.016 reciprocal centipoise; this corresponds to an apparent viscosity of 62.5 centipoise. It was also found that there were large discrepancies in results using different methods and different core samples. Carefully examining the data from the various

[1]Chang, H. L., H. M. Al-Rikabi, and W. H. Pusch, "Determination of Oil-Water Bank Mobility in Micellar-Polymer Flooding Process," Society of Petroleum Engineers of AIME, 51 Annual Fall Technical Conference and Exhibition, Paper No. 6048, New Orleans, October 3-6, 1976.

sources and thoroughly investigating the meaning of the data are necessary for properly designing the mobility control slug in a micellar-polymer flooding process.

Future Work

During the next project year, samples of cores will be used for flow tests necessary in studying rock-fluid interaction and oil recovery.

OBSERVATION WELL LOGGING

by

H. M. Al-Rikabi

Summary

Four observation wells were drilled within the two demonstration areas to be used as both sampling and logging wells. The observation wells have provided valuable information concerning salinity changes and sweep efficiencies of the preflood. The variations in the formation resistivity, determined by differences between the base logs and subsequent induction logs, can indicate changes in the in-situ oil and water saturations and/or water salinity.

The results obtained from periodic logging of the four observation wells provided a tool for observing the vertical and inferring the areal conformance of the preflush slug and the fluid movement in the two patterns. The results of logging well MP-227 in the south (Hegberg) pattern indicated that the preflush has moved through the lower part of the formation at (or near) well MP-227. Subsequent careful evaluation of the cores and the gamma ray logs showed the upper sand zone missing in injection well MP-213. However, the vertical conformance is fairly uniform in wells MP-131 and MP-132 in the north (Chesney) pattern.

Introduction

Four observation wells were drilled within the confined area of the two patterns as shown in Figure C-1 in Appendix C. The wells were designed to be used as both sampling and logging wells. The observation wells have provided valuable information concerning salinity changes and sweep efficiencies of the preflush. The salinity changes observed in produced samples from both the observation wells and production wells are reported in the section "Chemical Selection and Support." This section discusses the logging of the observation wells. Variations in formation resistivity, determined by differences between the base logs and subsequent induction logs, are used as indicators of changes in in-situ oil and water saturations (breakthrough of the oil bank), and/or water salinity.

The chemical processes in the El Dorado Micellar-Polymer Project are being conducted in four basic stages. Each stage is critical to the efficiency and economics of oil recovery. The first stage, the preflush or preflood, was designed to condition the reservoir water so that it can be better tolerated by the chemical slug. The efficiency of the chemical slug depends on the effectiveness of the preflush. Results from periodic logging of the four observation wells have provided a good method for identifying the vertical and areal conformance of the preflush slug and the fluid movement. If water salinity can be properly defined from the water analysis of the samples from the observation wells, it may be possible to determine the oil and water saturation variations due to the formation of an oil-water bank.

Discussion

The four observation wells were completed with 90 feet of fiberglass casing positioned opposite and above the formation. (See the subsection "Observation Wells" in the section "Pattern Injection and Production" for additional details.) This type of completion permits induction logs to be run across the pay zone to monitor changes in the in-situ reservoir fluid saturations and water salinity.

A suite of logs was run in the open-hole. These logs included the dual induction-laterolog, compensated densilog, neutron log, spontaneous potential, caliper, and gamma ray log. Another set of resistivity logs (induction logs) was obtained through the fiberglass casings to define the base line for later cased-hole logs. Careful analysis of the two induction logs (open-hole and cased-hole) for each well indicated that the fiberglass casing did not cause a measurable change in the resistivity. Compared to other cased-hole logging methods, induction logs have the advantage of being able to investigate deep (about 24 inches) into the formation. This is beneficial because a larger portion of the reservoir is investigated and the data are not adversely influenced by the borehole environment.

Figures C-2 through C-5 show the resistivity versus depth for the open-hole and cased-hole logs. The differences in the resistivity indicate change in salinity since the movable oil was essentially zero as shown by the base logs (see the section "Well Logging" and Appendix C of the Second Annual Project Report[1]).

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[1]Rosenwald, G. W., R. J. Miller, and J. Vairogs (editors), El Dorado Micellar-Polymer Demonstration Project (Second Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-76/4, November, 1976.

Figure C-2 shows a significant change in salinity in well MP-131 over the entire formation. The fluid movement was mainly through the middle part of the formation, but it also swept the top and the bottom during the Preflood I injection period.* The salinity calculated from the logs taken near the end of Preflood I injection (November 1, 1976) was about 20,000 ppm, which is approximately the salinity of the injected fluid. This is shown in detail in Run #4 at the depth of 644-645 feet. Runs #5 and #6 were obtained after Preflood II started. Preflood II has a salinity approximately equivalent to 31,700 ppm of NaCl. These two runs show that the change in resistivity appears fairly uniform, and the current salinity is on the order of 25,000 ppm. This indicates the arrival of the more saline Preflood II front.

Figure C-3 shows the resistivity versus depth for the open-hole and cased-hole logs for well MP-132. As shown in the figure, in Run #4 Preflood I began to sweep well MP-132 fairly uniformly. There is a noticeable drop in salinity and a fairly uniform sweep in well MP-132.

The logging of the observation wells provided valuable information in defining the vertical and areal conformance for the central area of the Hegberg (south) pattern. Figure C-4 shows the resistivity versus depth for the open-hole and cased-hole logs for well MP-227. This figure shows a salinity change in the lower zone with no change in the upper zone where the original perforation for sampling is located.

Figure C-5 shows the resistivity versus depth for the open-hole and cased-hole logs for well MP-228. The figure shows that the salinity

*Preflood I was injected from November 22, 1975, through December 20, 1976. Preflood II injection was started December 21, 1976, and was still in progress as of August 31, 1977 (the end of this reporting period).

had dropped at the lower and upper parts of the formation by the time Runs #3 and #4 were made.

The results of the logging of the observation wells in the Hegberg pattern indicated that the preflush has moved through the lower part of the formation in wells MP-227 and MP-228. Careful re-examination of the cores and the gamma ray logs showed that the upper zone is missing in well MP-213. The lower zone was later perforated to permit sampling from both zones in wells MP-227 and MP-228.

The salinities determined from the logs for the perforated interval are compared with the salinities of the produced fluid samples in Table C1. The results shown in the table indicate that the agreement between the salinities as determined from the well logs and as determined from the analyses of produced samples are in moderately good agreement. Since well MP-227 was perforated a second time (the bottom perforations), the single produced fluid sample does not clearly correspond to either the top or the bottom perforations.

Future Work

Periodic logging of the observation wells will be used to monitor vertical and areal sweep efficiency, to attempt to detect the oil-water bank, and to help evaluate the efficiency of the micellar-polymer processes at given locations in the field.

PRESSURE TRANSIENT TESTING

by

L. P. Brown

Summary

Pressure transient testing was used to evaluate wellbore and reservoir conditions in each of the 18 injection wells plus four production wells in the project. Surface-recording bottom-hole temperature measuring instrumentation was used to run temperature logs in the 18 injection wells.

Surface-recording bottom-hole pressure measuring equipment was used to monitor reservoir pressures in 27 project monitoring wells during December, 1976, and March and April, 1977.

Two interference tests, one designed to investigate reservoir heterogeneity and the other to complete a 1975 data set, were conducted during the reporting period.

Several pressure fall-off tests were conducted in conjunction with formation injectivity tests and are reported in the section "Formation Injectivity Tests."

Introduction

Pressure transient testing and analysis is accepted as an accurate method of characterizing wells. Equipment maintained and operated by Cities Service Exploration and Production Research was used in the El Dorado Project to measure bottom-hole pressures and temperatures in order to provide data for analysis. The analyses are summarized in the discussion section.

Pressure transient tests run during the reporting period can be divided into the following categories: injection well fall-off tests for the north and south patterns, production well buildup tests, and interference tests. Injection well temperature logs and monitoring well pressures were also obtained using bottom-hole measuring equipment. These work categories are described below.

Discussion

Injection Well Fall-off Tests--North Pattern

Pressure fall-off tests were run in each of the nine injection wells in the Chesney (north) pattern during March and April, 1977. The wells were shut-in one at a time for 18 to 24 hours, and the pressures were recorded using Amerada surface-recording bottom-hole pressure gauges. The pressure fall-off data were interpreted in the conventional manner (Horner semi-log method). The results of the analyses are summarized in Table D1 where they are compared with data reported in the Second Annual Project Report.[1]

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[1]Rosenwald, G. W., R. J. Miller, and J. Vairogs (editors), El Dorado Micellar-Polymer Demonstration Project (Second Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-76/4, November, 1976.

The conclusions and observations from this testing are listed below:

1. Discrepancies exist between some values of formation flow capacity (kh) determined during this series of tests and values reported in the Second Annual Project Report.
2. Six wells (MP-106, MP-108, MP-120, MP-126, MP-128, and MP-130) showed substantial increases in formation flow capacity since the last tests.
3. Two wells (MP-116 and MP-118) showed about the same formation flow capacity as before.
4. One well (MP-110) was tested for the first time.
5. All wells, except MP-106 and MP-116, have wellbore damage.

A possible explanation for the increase in formation flow capacity noted in conclusion (2) above is decreased oil saturation around injectors resulting in increased relative permeability to water.

Injection Well Fall-off Tests--South Pattern

Pressure fall-off tests were conducted on the nine Hegberg (south) pattern injection wells in January and February, 1977. The results of the analyses are summarized in Table D2 where they are compared with data reported in the Second Annual Project Report.[1]

Important conclusions and observations made from this series of tests are:

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[1] Rosenwald, G. W., R. J. Miller, and J. Vairogs (editors), El Dorado Micellar-Polymer Demonstration Project (Second Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-76/4, November, 1976.

1. Formation flow capacity (kh) in five wells (MP-201, MP-203, MP-205, MP-213, and MP-215) had decreased since the last series of fall-off tests reported in the Second Annual Project Report. The reduction in formation flow capacity around these four wells might have been caused by interaction of the chemical preflush used in the south pattern with reservoir waters resulting in the formation of solid precipitates in the reservoir; inadequate chelating agent in the preflush could have caused similar problems.
2. Formation flow capacity in four wells (MP-211, MP-221, MP-223, and MP-225) had increased over those values reported in the Second Annual Project Report. The increases might be due to decreased oil saturation around the injectors resulting in increased relative permeability to water.
3. Four wells (MP-205, MP-215, MP-221, and MP-225) had a high value for wellbore damage factor (skin). The well tests on these wells occurred late in the testing sequence and a portion of the skin could have been attributable to the preflush if the chemical preflush (alkaline sodium silicate) were interacting with cations in the reservoir water to form solid precipitates at or near the wellbore.

Production Well Buildup Tests

Buildup tests were conducted on four production wells to determine the reason for low productivity. These tests were accomplished by installing dual pumping heads on the wells and running the bottom-hole pressure gauge down the tubing-casing annulus while pumping.

Well MP-207 showed a very high formation damage factor. Wells MP-207 and MP-114 had been recognized earlier as problem wells due to excessive barium sulfate scale problems. Buildup data from well MP-114 could not be analyzed due to distortion from an interference test being conducted concurrently with the buildup test. Wellbore damage factor was estimated to be +24 by the technique shown in Table D3.

Well MP-219 showed a high formation damage factor, and well MP-122 had an acceptable value of formation damage factor. Test results are summarized in Table D4.

Interference Tests

Two interference tests were conducted during the reporting period. Well MP-112, a production well, was shut-in and the response was measured at well MP-110. This test was conducted to complete the data set presented in Table E1 of the Second Annual Project Report.[1] This interference data had not been measured previously due to a severe wellbore damage problem in well MP-110. The results show that directional permeability, as defined in the Second Annual Project Report, is 32.4 md. This value is significantly lower than other directional permeabilities reported for the same quadrant. This is probably caused by the completion of well MP-110. The top six feet of Admire Sand are cased off in well MP-110. The data from this test are summarized in Table D5.

The second interference test was prompted by the absence of a salinity change in the samples from observation well MP-227 after logs

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[1]Rosenwald, G. W., R. J. Miller, and J. Vairogs (editors), El Dorado Micellar-Polymer Demonstration Project (Second Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-76/4, November, 1976.

showed the lower sand was being swept by preflush. The lack of salinity change in fluid samples from the original perforations in wells MP-227 and MP-228 is discussed in the section "Chemical Selection and Support." Primary logging data are presented in the section "Observation Well Logging." The results of the geological study of this area that was made after discovery of the problem are given in the section "Coring and Core Analyses." This interference test was conducted by using the injection well pair MP-213/226 as a pulsing well. Conclusions from this test are listed below.

1. The Admire Sand is made up of two separate sand bodies, an upper and a lower sand. The test showed that the vertical communication between these two sands is small to non-existent in the central area of the south pattern.
2. The test showed that well pair MP-213/226 is not in communication with the lower sand in well MP-227. Logs indicate that both sands are present in MP-227, which was completed in the upper sand only at the time of these tests. Reexamination of logs and core from well MP-213 showed that the upper sand is not developed at well MP-213.
3. Well MP-227 is in better pressure communication with other wells in the field than with the well pair MP-213/226 which is only 90 feet away.
4. Directional permeability (as defined in the Second Annual Project Report) between wells MP-213/226 and well MP-227 is 0.68 md. This value is two orders of magnitude less than "typical" El Dorado values.

Injection Well Temperature Logs

Temperature logs were run before and after each injection well fall-off test. These data were gathered to help explain any wellbore damage diagnosed from the pressure fall-off tests. "Typical" data are presented in Figures D-1 and D-2 where poor injectivity and normal injectivity are shown. All data are not included in this report due to the changeable nature of wellbore damage. This work showed that the temperature log is a valuable tool for diagnosing wellbore problems.

Temperature logs were run from total depth to the surface in wells MP-203 and MP-225 to help identify a possible cause for the low injectivity of soluble oil. Figures D-3 and D-4 show that the soluble oil cooled to approximately 63°F at a depth of 250 to 350 feet. The more detailed information discussed in the section "Chemical Selection and Support" indicates that wax in the Greenwood County crude oil (a component of the soluble oil) crystallizes below a temperature of 65°F.

Monitoring Well Pressures

Bottom-hole pressures were measured in 27 monitoring wells during December, 1976, February, 1977, and April, 1977. (Table C1 in Appendix C shows the locations of the monitoring wells.) Pressures at a datum of 800 feet above mean sea level are reported in Table D6.

Future Work

Pressure transient tests will be conducted on active production and injection wells throughout the life of the project. These tests will be scheduled as required to determine well conditions during injection of the various chemical solutions. In addition, periodic checks on the bottom-hole pressure in each of the monitoring wells will be made to determine the reservoir pressure in the general project area.

PERFORMANCE PREDICTION

by

D. F. Zetik

with

J. R. Tucker and J. Vairogs

Summary

Development and improvement of chemical flood performance predictions has continued. Improvements were made in the superposition-of-line-sources program, flood front and streamline tracking program and streamtube oil recovery program. The documentation for an updated version of the flood front and streamline tracking program was given to the U. S. Energy Research and Development Administration. A modified streamtube oil recovery program was tested with experimental core flood data. Ion exchange and dispersion predictions of two proprietary programs were checked against core flood observations. Development has continued on programs to include reservoir heterogeneity in front tracking and oil recovery calculations. Improvements and additions were made to the data base program.

A study with the flood front tracking program showed that permeability anisotropy and deviations from the recommended relative well rates could adversely affect areal sweep. Recommended preflush volumes for the

Hegberg (south) pattern were revised to reflect corrections in reservoir data. Oil recovery forecasts for the two patterns were updated with a revised program that accounts for the oil not mobilized by the chemical slug. The reservoir model used for the south pattern forecasts contains modifications that account for the absence of the upper zone at well MP-213. Oil recovery for a proposed Hegberg pattern modification was also investigated with this model.

The effects of vertically fracturing an injection well were investigated with a modified version of the front tracking simulator. Reservoir pressure forecasts of the superposition-of-line-sources program were compared with observed monitoring well pressures. The discrepancies between observed and theoretically calculated pressures led to the discovery of unsuspected errors in the production data. Observation well salinity data were analyzed to characterize reservoir-scale dispersion.

Introduction

This section describes performance forecasting and monitoring and the associated program development work. Updated performance forecasts are included. They account for residual oil after a micellar flood and thus, they show less recovery than reported earlier. Computations to account for loss of micellar fluid injectivity are discussed. Monitoring of well performance and development of a production data base are also included. Observation well data are analyzed. A description of program development to account for reservoir heterogeneity and anisotropy is included.

Discussion

Forecasting

Reservoir heterogeneity. Contour maps of net thickness, porosity, and permeability were prepared for both the upper and the lower zones of the Admire 650-foot Sand. These maps are based on the core analysis data presented in Table F2 of the Second Annual Project Report.[1] The data for well MP-213 were corrected to agree with the revised interpretation of pay zones (see the sections "Coring and Core Analyses" and "Pressure Transient Testing"). The upper zone thickness was reduced to zero and all core data were interpreted as being representative of the lower zone for this well. The corrected lower zone thickness for well MP-213 is 10.5 feet. Its corrected average permeability is 290 md, and the corrected average porosity is 26.2 percent.

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[1]Rosenwald, G. W., R. J. Miller, and J. Vairogs (editors), El Dorado Micellar-Polymer Demonstration Project (Second Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-76/4, November, 1976.

Figure E-1 is a contour map of net thickness for the upper zone. Figure E-2 is the upper zone permeability contour map, and Figure E-3 is the upper zone porosity contour map. Figures E-4, E-5, and E-6 are, respectively, the lower zone net thickness, permeability, and porosity contour maps.

These contour maps were used to prepare gridded data for a two-layered, heterogeneous model of the reservoir. The development of a computer program to track flood fronts and streamlines with gridded reservoir data was delayed by unexpected difficulties. Instead, the Intercomp Polymer Flood Simulator will be used to track flood fronts. This simulator will allow well rates to vary with time. Monthly average injection well rates for the model were obtained from daily injection volumes from the data base. The Cities Service oil and gas system was used to obtain monthly average rates for the production wells. Preliminary testing of this model has begun.

Effects of actual well rates and anisotropic permeability on areal sweep. The streamline and flood front tracking program was used to investigate the effects of actual well rates on areal sweep for the project. The calculations are based on a single-layer, homogeneous reservoir model. The average well rates used in this study were obtained from individual well cumulative injection and production volumes for the period November 18, 1975, through May 5, 1976. Some of these average rates are considerably different from the adjusted relative rates that were proposed for these wells.

Figure E-7 is a plot of the computed streamlines and flood front locations if the above actual well rates were continued until breakthrough. The flood front locations are plotted at one year intervals. This plot shows that the deviations from the adjusted relative rates may cause poor areal sweep in some portions of the project. A well treatment program was undertaken as a result of this information. The well treatments are discussed in the section "Pattern Injection and Production."

Hegberg (south) pattern areal sweep was also studied with a program that tracks flood fronts and streamlines in a homogeneous reservoir with ideally anisotropic permeability. This study was based on the actual average well rates discussed above. Figure E-8 shows the flood fronts and streamlines for a two-to-one permeability contrast with maximum permeability in the northeast-southwest direction. Figure E-9 presents the computed flood fronts and streamlines for a two-to-one permeability contrast with maximum permeability in the northwest-southeast direction. These figures indicate that areal sweep is poorer with anisotropic permeability than with isotropic permeability. Anisotropic permeability will aggravate sweep and channeling problems due to imbalanced well rates.

After this work was completed, errors were found in the production data. These errors are discussed later. The correct production rates were about 27 percent higher than the values used in this study. Higher production rates would reduce the sweep outside the patterns and improve sweep in the interiors of the patterns.

<u>Preflush and micellar fluid volume calculations</u>. New tables of adjusted relative preflush and micellar fluid volumes were computed for the Hegberg (south) and Chesney (north) pattern injection wells. Because of corrections to reservoir data, the new recommended volume for well MP-201 is greater than that previously recommended. The new preflush and micellar fluid volumes for the Hegberg pattern are presented in Table E1. The corresponding numbers for the Chesney pattern are shown in Table E2.

Investigation of south pattern modification. The streamtube reservoir simulator was used to calculate a new oil recovery schedule for the Hegberg (south) pattern. The calculations are based on a two-layer reservoir model that has the well rates adjusted to approximate the absence of the upper zone at well MP-213. The previous oil recovery forecasts in Table F9 of the Second Annual Project Report were based on a single-layer model. In that model, each well was assumed to be in communication with both zones. This assumption caused the previous forecasts to be overly optimistic. The new model forecasts lower oil recovery. However, the lack of residual oil losses in the streamtube calculations still make the revised oil recovery schedule overly optimistic.

The streamtube reservoir simulator was used to calculate an oil recovery schedule for the Hegberg pattern if well MP-227 were used as an injector to replace well MP-213. Since well MP-227 is in communication with both zones, this pattern revision should improve sweep in the upper zone. These calculations were based on the new reservoir model with two homogenous, non-communicating layers. The predicted oil recovery schedule for this revised pattern, the new two-layer forecast for the original pattern, and the old one-layer forecast from the Second Annual Project Report were compared. The calculated recovery for the revised pattern is greater than the new forecast for the original pattern but less than the old forecast for the original pattern. However, no preflush had been injected into well MP-227, and the pattern revision would have delayed the project schedule. The revision would have also made performance interpretation and scale-up more difficult. The pattern modification idea was rejected for these reasons.

Revised north and south pattern recovery schedules. The modified streamtube oil recovery program discussed in the sub-section "Simulator Development" below was used to compute revised oil recovery schedules for the two patterns. This program accounts for the oil saturation (S_{orc}) remaining after the micellar slug has passed through the area. Thus, the revised forecasts show less oil recovery than reported earlier. The value of S_{orc} used in the program must represent the average saturation of oil in the swept region after the micellar slug has passed through the area. Because of the uncertainty in estimating this value, forecasts were made for S_{orc} values of 0, 5, 10, 15, and 20 percent.

Figure E-10 shows the oil production rates forecast for the Chesney (north) pattern versus the volume of fluid injected after the end of micellar fluid. The corresponding cumulative oil recovery curves are presented in Figure E-11, and the instantaneous water-oil ratios are illustrated in Figure E-12. These performance forecasts were calculated with the total lease production rate and total lease injection rate both equal to 900 barrels per day. If these total injection and production rates were less than 900 barrels per day, the program would predict a proportionally lower oil rate for a given volume of fluid injected while the total oil recovery and water-oil ratio predictions would remain unchanged.

Each of the above figures contains curves for five values of S_{orc}. Comparison of these curves illustrates how the value of S_{orc} affects the point at which initial oil production begins, the point at which maximum oil production rate occurs, the maximum oil production rate, the point at which the water-oil ratio exceeds an upper limit of 50, and the total oil production at the limiting water-oil ratio.

The curve for zero oil saturation (S_{orc} = 0) is identical to the north pattern forecast that was reported in the Second Annual Project Report. If one half of the oil confined within the pattern boundaries is recovered, project performance will be most closely matched by the curves for S_{orc} equal to 15 percent. The revised oil recovery schedule for the north pattern with a final residual oil saturation, S_{orc}, value of 15 percent is presented in Table E3.

The oil production rates, cumulative oil recovery, and water-oil ratio forecasts for the Hegberg (south) pattern are presented in Figures E-13, E-14, and E-15, respectively. These forecasts are based on the two-layer reservoir model that approximates the absence of the upper zone at well MP-213. The forecasts were calculated with the total lease production rate and total lease injection rate both equal to 724 barrels per day. The reduction from the 800 barrel per day lease rates used in previous Hegberg forecasts is due to a reduction in the injection rate for MP-213 and a compensating reduction in the production rates. The forecast for an S_{orc} value of zero was discussed above in the sub-section "Investigation of South Pattern Modification." The revised oil recovery schedule for the south pattern with an S_{orc} value of 15 percent is presented in Table E4.

Effect of vertical fractures on reservoir sweep in the south pattern. A modified version of the flood front and streamtube tracking program was used to study the effect of vertical injection well fractures on reservoir sweep. This study indicated that Hegberg pattern injection wells could be fractured vertically without significantly affecting sweep efficiency, provided that two criteria are met. First, the total fracture length must not exceed 45 feet. Second, the fractures should not be extended after they have received significant quantities of micellar fluid. These conclusions hold only for vertical fractures. The effects of horizontal injection well fractures on reservoir sweep could not be determined with the available reservoir simulators.

The thickness of the micellar bank is the distance from the front of the polymer slug to the front of the micellar slug. At the start of polymer injection this thickness is greater at the ends of the fracture than at its center. The thickness of the bank becomes more uniform with increasing polymer injection. By the time the polymer front is several fracture lengths from the well, the micellar bank has almost constant thickness and nearly circular shape.

The effects of vertical fractures on the Hegberg (south) pattern were evaluated with the aid of micellar bank size calculations. The revised relative injection volumes and the total micellar slug size for the Hegberg pattern were used to compute a micellar slug volume for each Hegberg injection well. The individual well thicknesses and porosities were used to compute the micellar bank diameter for each well at the end of micellar injection. These calculations assumed radial flow. The computed micellar slug volumes and bank diameters are presented in Table E1. The diameters range from 86 to 102 feet and average 94 feet.

The computer study indicated good areal sweep and relatively uniform bank thickness if the total fracture length was one half or less than one half of the diameter of the surfactant slug at the end of micellar injection. Thus, if it is concluded that the wells could be fractured with vertical fractures, the vertical fracture lengths should be limited to one half the minimum bank diameter or approximately 45 feet.

The computer program cannot calculate front locations if fracture length changes with time. However, any fracture extension during micellar slug or polymer injection may interfere with the mechanisms that change the initially elongated, varying thickness bank into a uniform bank with good sweep properties. Fracture extension during polymer injection may result in uneven bank thickness, non-circular sweep, and possibly, breaks in the bank.

History match of chemical flood core tests. A modified version of the streamtube, chemical-flood oil recovery simulator includes the effects of residul oil that is not mobilized by the chemical slug. The simulator was history matched to a set of nine chemical-flooding core tests. These tests were conducted in both Berea and Admire 650-foot Sandstone cores and employed either the formulation for the north pattern or the one for the south pattern.

Several of the physical property data required by the simulator are difficult to measure directly. The values of these data were adjusted to make the calculated oil recovery curve agree with the oil recovery observed in the core tests. This procedure gave a fair-to-good fit of oil bank breakthrough times and initial oil cuts for eight of the nine tests. The simulator is not capable of forecasting the tailing of oil production in the rear of the oil bank that was observed in these eight tests. The results of the ninth test could not be matched. An analysis of this test indicates either extensive bypassing of oil (fingering) or else an error in the data. This simulator and history-matched physical properties will permit a more realistic performance prediction for the project.

Simulation of cation exchange and dispersion. The Intercomp Finite Difference Chemical Flood Simulator was used to simulate cation exchange and dispersion in a linear core flood. Connate water in the core was displaced by a two bank preflush similar to the one used in the north pattern. The results of these calculations are in good agreement with the predictions of a second proprietary simulator. This agreement increases confidence in both simulators. Because of their different capabilities, both simulators will be useful in future studies of cation exchange and dispersion in porous media. The Intercomp Simulator was used to study a number of cases that could not be simulated with the second simulator.

Monitoring

Calculated and observed reservoir pressures. Project reservoir pressures were computed and contoured using reported injection and production data. Pressures in the monitoring wells were measured in early December, 1976. The computed monitoring well pressures for December 7, 1976, were considerably higher than the observed values. Errors in production data were later discovered to be the cause of this discrepancy. Without the comparison of observed monitoring well pressures and theoretical pressure calculations, the errors in production data may have remained undetected.

This error was found by the following analysis of the data. The monitoring well pressures observed December 3-5, 1976, were corrected to a datum level of 695 feet above mean sea level. The average value of the 24 corrected observations was 205.5 psig. Figure E-16 is a contour map of these corrected pressures.

The superposition-of-line-source-solutions program for a homogeneous reservoir was used to compute reservoir pressures at the 24 monitoring wells. The model employed actual injection rates from the project data base and actual production rates from the Cities Service oil and gas system.

Figure E-17 is a contour plot of the computed pressures. The average value of the 24 computed pressures was 312.6 psig on December 7, 1976. This is over 107 psi greater than the average of the observed pressures. The computed pressure was greater than the observed pressure at every monitoring well.

Figure E-18 is a contour map of the difference between the computed and observed pressures. The difference is fairly uniform over the entire project. This seemed to indicate that the difference was not due to a localized cause.

A sensitivity study was performed to determine the effects of changes in permeability-thickness product (kh), total production rate, total injection rate, and initial reservoir pressure on the computed pressures. The average of computed pressures equaled the average of the observed pressures when all of the production rates employed in the calculation were arbitrarily increased by 24 percent and the rest of the reservoir model parameters were left unchanged. If the actual production rates were not changed, all of the injection rates had to be reduced by 19 percent to obtain an average computed pressure that was equal to the average observed pressure. By reducing the initial reservoir pressure from 200 psig (at 695 above sea level) to 93 psig, the computed average pressure became equal to the observed average pressure with no changes in rates.

The computed results were based on a permeability-thickness product (kh) of 1032 millidarcy-feet and an infinite reservoir. Either a smaller kh or presence of reservoir boundaries would increase the predicted pressures. The 1032 md-ft is the largest value consistent with well test data. The computed average pressure could not be matched to the observed average pressure with any reasonable kh value.

An investigation of production data found errors in the reported production volumes. The actual total volumes were 27 percent higher than the values originally reported. This error accounts for almost all of the differences between measured and theoretically calculated monitoring well pressures.

Sweep between wells MP-118 and MP-131. The anisotropic permeability version of the flood front and streamline tracking program was used to study the sweep between wells MP-118 and MP-131. The computed time for the front to reach MP-131 was found to be sensitive to small variations in a number of the reservoir parameters. Because of the uncertainty in these parameters, an accurate computed breakthrough time could not be forecast.

Analysis of Observation Well Data

Water salinity data for samples from the two Chesney (north) pattern observation wells (MP-131 and MP-132) were used to estimate a characteristic length for field-scale dispersion. The samples were taken from a one-foot perforated interval. The salinity data are presented and discussed in the section "Chemical Selection and Support." They reflect the changing salinity as the less saline preflood slugs displace reservoir brine.

The method of Hoopes and Harleman[1] was used in the data analysis. Their method is not strictly applicable to the Chesney pattern for two reasons: the flow is not completely radial, and samples were withdrawn only from a limited wellbore entry interval. The former limitation is not very serious since the observation wells are 90 feet and 187 feet from injection well MP-118. The dispersion front should still be nearly circular at these distances. The second limitation is more serious. However, since the logs

[1] Hoopes, John A and Donald R. F. Harleman, "Dispersion in Radial Flow From a Recharge Well," Journal of Geophysical Research, 72, No. 14, (July 15, 1967), 3595-3607.

presented in the section "Observation Well Logging" show a fairly uniform sweep of both the upper and the lower zones in the north pattern, one can expect the analysis based on the whole pay zone to give at least an order-of-magnitude accuracy. A more refined layering was not justified because the percentage of preflood entering the upper zone could not be estimated accurately.

The analysis was performed by plotting on probability paper the quantity one minus the pore volume of preflood injected in well MP-118 versus the dimensionless salinity measured for each observation well. The pore volume was based on the average of the reservoir properties measured at well MP-118 and the four producing wells around MP-118 and on the distance to each observation well. The dimensionless salinity was computed by the formulas shown on Figures E-19 and E-20. In those formulas C represents the measured salinity, 90,000 ppm the initial salinity, and 17,000 ppm the average injected fluid salinity.

The data are plotted on Figure E-19 for observation well MP-131 and on Figure E-20 for observation well MP-132. The analysis consisted of drawing a straight line through the points, determining its slope, and computing the characteristic length as shown on the figures. The results gave 6.2 ft for well MP-131 and 8.1 ft for well MP-132. These values are quite high but are in fair agreement with each other. There is scatter in the data, not all of which are shown on the figures. Consequently, the characteristic length parameters should be considered only approximately correct.

Theory requires that the straight line cross the 50 percent concentration point at one pore volume of injection. Judging by Figure E-19, the mid-point of the mixing zone arrived a little early at well MP-131. The "drooping" of the later data points indicates that the Preflood II front has reached well MP-131. Figure E-20 shows the Preflood I front has reached well MP-132. However, the arrival of the mid-point of the mixing zone appears to be obscured by early arrival of the Preflood II front as indicated by the nearly constant composition of the last few data points.

A similar analysis was not performed on the Hegberg (south) pattern observation wells because the missing upper zone in well MP-213 makes the analysis procedure inapplicable.

Loss of Injectivity in the South Pattern

One possible cause for loss of injectivity when injecting the micellar fluid is its high viscosity. The steady-state, radial Darcy equation was used to compute the effect of viscosity and wellbore radius on injection rate; the change in relative permeability due to the micellar fluid was also included in these calculations. The radial flow assumption is reasonable since the computation is limited to micellar slug injection only. The slug is rather small.

It was assumed that the small, alternating micellar oil and micellar water slugs could be represented by a single micellar fluid slug of 28 cp viscosity whereas the preflush viscosity was one cp. Three values of the ratio of relative permeability of micellar fluid to the relative permeability of preflush were used in an attempt to account for the increased transmissibility in the portion of the reservoir swept by micellar fluid. Wellbore radii of 0.333, 1.0, and 3.0 feet were used to represent the typical wellbore radius since some of the wells had been explosively stimulated. A range of values was used because the exact value was not known.

The results are presented in Figure E-21. The ratio of injection rate of micellar fluid to that of preflush is shown in the figure as a function of injected micellar fluid volume. Curves A, B, and C show the effect of the increased permeability ratio due to residual oil removal. The expected value for this increased ratio is two or greater. Curves D and E show the effect of increased wellbore radius for a relative permeability ratio of 2.0. Increased wellbore radius could account for explosive stimulation and for the partial removal of wellbore damage by surfactants.

Figure E-21 shows that one should expect a very large drop in injection rate when switching from preflush to micellar fluid injection. This is due to the increased viscosity. It also shows that the injection rate will continue to drop with continued injection and eventually may be only one half of what it was during the first day of micellar fluid injection. This continued drop in rate is also due to the higher viscosity. The current, average Hegberg (south) pattern micellar fluid injection rate to preflush injection rate ratio is about 0.25; this indicates that there may be a transmissibility increase due to oil removal and/or increase in effective wellbore radius due to damage removal by the surfactants.

Data Base

A number of modifications were made to the data base program to increase its capabilities. The data entry was expanded to accept daily volumes and wellhead pressures for Hegberg pattern micellar oil and micellar water. The data input procedures were simplified and improved. The format of the daily reports was changed to increase readability. The program and file structure were revised to allow simultaneous use by two or more users. Laboratory personnel can now use the data base while someone in the region office enters data.

The utility program was modified to increase the legibility of the injection performance plots. Program revisions reduced the time required to draw these plots.

A program was written to convert daily individual well rates from the data base to more convenient computation forms such as monthly or annual average rates. These average rates may be employed in sweep, pressure, and oil recovery calculations.

Considerable difficulty was caused by loss of data and errors in the data base program. Computer programs were developed to search for the source of these errors, to correct bad data, and to restore the lost data from the backup tapes. All of the data destroying errors are now thought to have been identified and corrected.

Simulator Development

Superposition-of-line-source-solution program. The program that computes reservoir pressures by the superposition of line source solutions was modified to produce contour maps of the calculated pressures. The maps may either be drawn by the Calcomp plotter or they may be output as printer plots. The portion of the program that produces these plots uses proprietary computer routines that were neither developed nor purchased with project funds.

Flood front and streamline tracking program. The program that tracks fluid movement in a homogeneous reservoir was modified to allow ideally anisotropic permeability. The program was documented with internal comments. A Fortran card deck, a listing of the program, a data deck for a test problem, and the print and plot output from the test problem were released to the U. S. Energy Research and Development Administration for distribution to the public.

The flood front and streamline tracking program was modified to allow simulation of fluid movement in heterogeneous reservoirs. This program obtains pressure gradients for fluid tracking from a previously computed pressure grid. A conventional, finite difference reservoir simulator is used to compute this grid. Testing showed that the flow tracking routines are very sensitive to errors in the pressure grid. The proprietary single phase reservoir simulator used to calculate the pressure grid employs a non-iterative, alternating direction solution technique. In regions where the pressure gradient is small, errors in the computed grid pressures cause large errors in streamline direction and front velocity. Substitution of an iterative, alternating direction solution technique for the pressure grid calculation yielded better results. However, further improvements in the pressure grid calculation must be made to obtain satisfactory front tracking. Modifications to obtain these improvements are planned. The modifications to the proprietary single phase simulator will not be charged to the project.

Streamtube oil recovery program. The streamtube calculation program was modified to incorporate ideally anisotropic permeability. The Davis-Jones equations that are used to calculate oil production from a streamtube were altered to incorporate a residual oil after the chemical slug has passed through the area. A report describing the revised equations and their deviation is being prepared. The value of the residual oil saturation after the chemical slug has passed through the area is presently the same for all streamtubes. This modified program was used to forecast a more realistic oil recovery schedule for the project. The program will be further modified to make the residul oil saturation behind the chemical slug a function of the quantity of chemicals passing through a streamtube.

Future Work

The following objectives have been set for next year:

1. Compute revised oil recovery schedules with the new streamtube oil recovery program. These calculations will incorporate variable residual oil saturations.
2. Use the Intercomp Polymer Flood Simulator to study the effects of reservoir heterogeneity, varying mobility ratio, and changes in well rates on areal sweep.
3. Finish development of flood front and streamtube programs to include reservoir heterogeneity in the calculations.
4. Maintain and improve the data base and the associated programs.
5. Evaluate concentration and salinity data from observation wells.
6. Evaluate pressure data from monitoring and active wells.

FORMATION INJECTIVITY TESTS

by

L. P. Brown, R. J. Miller, and D. A. Siebert

with

H. L. Chang, G. E. Kellerhals, and S. A. Mobarak

Summary

A major effort in the Field and Laboratory was directed toward understanding, improving, and controlling injectivity of micellar, micellar-polymer, and polymer solutions into the Admire 650-foot Sand.

Field tests included injection of the designed system for the Hegberg (south) pattern and injection of components of that system into three different wells while carefully monitoring rates and pressures. Small slugs of micellar fluid could be injected at a pseudo-stabilized rate. The relatively low injection rate of the micellar oil was somewhat discouraging. However, the final injection rates for micellar oil (14 bbl/day) and micellar water (60 bbl/day) were sufficient for the demonstration test.

Similarly, extensive testing of the injectivity of the chemical flooding system designed for the Chesney (north) pattern and of the components of that system was conducted using two wells. This testing showed

that a relatively small slug of the micellar solution containing either Abbott or Pfizer biopolymer can be injected without severe difficulties.

Laboratory and field quality control tests were used to monitor the injected fluids. Material handling techniques in the field were investigated. Filterability data were recorded in an effort to develop preliminary standards relating injectivity and filterability.

Introduction

Extensive field testing involving the injection of both of the micellar systems was conducted during the last reporting period. This section describes the test sequence for each injection test. The relative injectivity and mixing methods of three different biopolymers are also discussed. Filterability data were recorded in an effort to develop preliminary standards relating injectivity and filterability.

Discussion

South Pattern Injection Tests

During the summer of 1974, chemicals (or chemical mixtures) similar to the chemicals ultimately recommended by Union Oil Company for use in the Hegberg (south) pattern of the El Dorado Micellar-Polymer Demonstration Project were injected into well MP-104. This injectivity test was detailed in the First Annual Project Report.[1] This earlier injectivity test showed a loss of injectivity during the alkaline chemical preflush and an increase in injectivity during injection of soluble oil (also called "micellar oil") and "micellar water."*

Additional tests were conducted during this reporting period to more thoroughly evaluate the injectivity of the Union system. Injectivity

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[1] Rosenwald, G. W. and R. J. Miller (editors), El Dorado Micellar-Polymer Demonstration Project (First Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-75/1, October, 1975.

*"Micellar water" is the term used to refer to the adjusted salinity water injected in alternating slugs with the soluble oil. The corresponding term "micellar oil" is used to refer to the soluble oil.

tests were conducted in wells MP-225 and MP-211 during May and June, 1976. Data from these tests are summarized in Tables F1 and F2, respectively.

Results and conclusions for the injectivity tests using wells MP-225 and MP-211 included:

1. Low injectivity of micellar oil was experienced. Injection of micellar oil mixtures was attempted four times in the field, twice at well MP-225 and twice at well MP-211. The approximate injection rates for these four attempts (in chronological order) were 3.0, 9.0, 6.4, and 3.2 barrels per day. These were not necessarily stabilized rates. The approximate viscosities of these four slugs were 24, 48, 25, and 44 cp,* respectively, at the injection temperature (see Tables F1 and F2). The presence of wax or paraffin in the Greenwood County crude oil may have caused the low injectivity. See the section "Chemical Selection and Support" for discussion of wax formation.
2. The laboratory filterability of Greenwood County crude oil and crude oil-solvent mixtures decreased two-to-six fold two days after the crude oil or oil-solvent mixtures had been heated. It is conceivable that wax or paraffin could have caused this loss of filterability.
3. Test results were still inconsistent.

A test was designed for monitoring well MP-202 to further evaluate the injectivity of the Union system. Table F3 gives the summary of events for the test. The test was initiated on November 15, 1976, by injecting

*Viscosities measured with a Brookfield LVT viscometer with UL adaptor.

75 barrels of micellar water. All fluids during the test were filtered through either a one or a five micron depth-type cartridge filter. A subsequent fall-off test indicated a positive wellbore damage factor (skin) of six. The well was acidized with 500 gallons of 15 percent hydrochloric acid (HCl), 1000 gallons of hydrofluoric acid (HF), and 500 gallons of 15 percent HCl before injecting an additional 285 barrels of micellar water. A volume of 602 barrels of chemical preflush was then injected into well MP-202. Injectivity index ($Q/\Delta P$) decreased from 0.5 for micellar water to 0.18 for chemical preflush. Injecting 17 barrels of micellar water increased the injectivity index to 0.36 which indicated that the cause for loss of injectivity during the injection of the chemical preflush was in or near the wellbore and was reversible.

The next sequence of fluids involved injecting Greenwood County Crude Oil (GCCO) and micellar water. The purpose for injecting these fluids was to confirm extensive laboratory tests which had identified wax and other organics in the GCCO as the main contributor to potential plugging problems (see the section "Chemical Selection and Support"). The addition of Magna D-Wax 950 to GCCO in the laboratory increased the filterability through 1.2 micron millipore filter paper if the oil was heated to 150°F and held above 70°F. In the field test the GCCO was heated to 150°F and mixed with 500 ppm of Magna D-Wax 950. After injecting 15 barrels of GCCO, the rate decreased from 40 bbl/day to 20 bbl/day. The wellhead temperature could not be kept above 70°F because the injection line temperature (buried three feet) was 59°F and the injected fluids cooled to that temperature during injection. Subsequent injection of micellar water did not improve injectivity. Therefore, it was decided to modify the injection system and acidize well MP-202 with a HCl-HF-HCl treatment.

The test was interrupted to modify the system to maintain the fluid temperature above 70°F. During this period, a millipore filter test was run using the treated GCCO which had been allowed to cool to 30°F and stand for four days. The filtration test of the GCCO was a factor of two better than any previous test. One hypothesis put forth to explain this behavior was that the Magna D-Wax 950 acted as a flocculant to settle out wax particles. Samples from the bottom of the oil treating vessel supported this hypothesis. Additional GCCO (45 bbl) was treated with D-Wax 950 and allowed to stand for five days. Twenty-five barrels of treated GCCO was siphoned from the top of the treating vessel and injected into MP-202 at 41 bbl/day at a wellhead temperature of 59°F.

The next step was to mix treated GCCO with the sulfonates and cosolvent. A small batch of micellar oil was mixed and injected at 17 bbl/day at a wellhead temperature of 60°F.

The final step was to mix a larger batch of micellar oil and inject with alternating slugs of micellar water. The final injection rates for micellar oil and micellar water were 14 bbl/day and 60 bbl/day, respectively. The test was terminated because it appeared that these rates for micellar oil and micellar water would be sufficient for the demonstration test. During these tests, the absolute rate of micellar water remained nearly constant before and after micellar oil injection.

The conclusions which resulted from this test are as follows:

1. A small slug of micellar oil (soluble oil) can be injected at a pseudo-stabilized rate.
2. The filterability test run on a wellhead sample of the micellar oil that was injected indicated that only 60 milliliters could pass through 1.2 μm millipore paper at 20 psi differential

pressure and remain above a rate of one milliliter per second. This should be considered a minimum filterability criterion for future micellar oil slugs.

3. The relatively low micellar oil injection rate is mainly due to viscosity effect, solids (wax) precipitation, and possibly some fines movement.
4. Damage caused by injecting untreated Greenwood County crude oil can be successfully treated with acid.
5. Treating Greenwood County crude oil with Magna D-Wax 950 and allowing it to stand for a week at temperatures below 50°F gives better millipore filterability data.

North Pattern Injection Tests

An injection test was conducted using wells MP-109 and MP-121 and the system designed for the north (Chesney) pattern. The primary objective of the test was to evaluate the injectivity of the system recommended by Shell Oil Company for the Chesney pattern. The secondary objectives were to evaluate the injectivity of three different biopolymers under similar conditions and to test methods for mixing dry powder and broth type biopolymers. Tables F4 and F5 show the summary of events for the test sequence for wells MP-109 and MP-121, respectively. The test was started on August 10, 1976, in well MP-109 by injecting 850 barrels of preflood. All fluids during the test were filtered through either a one or a five micron depth-type cartridge filter. The injectivity index for preflood varied from 0.78 before to 0.58 after a fall-off test. A mixture of surfactant and Kelzan MF biopolymer was injected at a rate of less than one bbl/day before terminating the test. It was concluded that the low injection rate was caused by contaminants in the micellar fluid and/or in the equipment.

The equipment was moved to well MP-121 to repeat the test using fizer 1035 biopolymer instead of the Kelzan polymer. Unfortunately, the results were similar to the previous test. The injection rate declined to three bbl/day after injecting 1.5 barrels of the micellar solution. It was decided to stimulate MP-121, reestablish injection with preflood, and inject the polymer and surfactant separately. The Pfizer 1035 biopolymer concentration was increased in three steps from 320 ppm to 1075 ppm in order to evaluate the effect of increasing viscosity (see Table F6). In addition, four different injection rates were used at a constant polymer concentration of 740 ppm in order to obtain a relationship between bottom-hole pressure and injection rate. Results for this test are given in Table F7. Figures F-1 through F-4 illustrate the injectivity index versus injected volume for each polymer concentration. The millipore filtration tests, run through 1.2 micron paper at a differential pressure of 20 psi, are also plotted in these figures. The final polymer slug (1075 ppm) reached a pseudo-stabilized rate of 60 bbl/day ($Q/\Delta P^* = 0.22$). Preflood injection was reestablished before injecting 17 barrels of the surfactant concentrate (without polymer) at a rate of 96 bbl/day.

The next step was to combine the surfactant solution with Pfizer polymer for injection. In this case the holding tanks were cleaned with a surfactant fluid prior to mixing the micellar solution. The surfactant solution was also circulated through the injection line, downhole tubing, annulus, and to a pit to insure cleanliness. The surfactant concentrate was allowed to stand undisturbed for at least ten days to allow solids to settle.

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*$Q/\Delta P$ (bbl/day-psi) was obtained from the trend of the plots of injectivity versus injected volume for the fluid discussed (see Figures F-1 through F-9).

This procedure was used in all subsequent mixing of micellar solutions. The micellar fluid (containing Pfizer polymer) reached a pseudo-stabilized rate of 60 bbl/day ($Q/\Delta P^{*} = 0.21$) after injection of 79 barrels. Figure F-5 shows the injection and filterability test data for the micellar fluid containing Pfizer polymer.

The sequence used to test the Abbott and Kelzan SS-4000 biopolymers was:

1. Establish injection with preflood for a baseline.
2. Inject a polymer solution of about 1000 ppm.
3. Inject preflood for another baseline.
4. Inject micellar solution.

The injectivity index (defined as $Q/\Delta P$) for the Abbott polymer solution was 0.25^{*} (59 bbl/day) after 113 barrels were injected (see Figure F-6). The micellar solution containing Abbott polymer reached a pseudo-stabilized rate of 60 bbl/day ($Q/\Delta P^{*} = 0.21$) after 86 barrels were injected. Figure F-7 illustrates the injection and filterability test data.

The injectivity index ($Q/\Delta P$) of the Kelzan SS-4000 biopolymer solution was 0.13^{*} (31 bbl/day) after injecting 199 barrels. The filterability results shown in Figure F-8 indicate that the Kelzan solution has a greater tendency to plug than the Pfizer or Abbott polymer solutions. The Kelzan SS-4000 polymer was used instead of the previously tested Kelzan MF polymer because the SS-4000 polymer gave better millipore filterability results than the MF polymer. Figure F-9 shows the rate of micellar fluid containing Kelzan polymer declined to 8 bbl/day ($Q/\Delta P^{*} = 0.03$) after injecting 80

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*$Q/\Delta P$ (bbl/day-psi) was obtained from the trend of the plots of injectivity versus injected volume for the fluid discussed (see Figures F-1 through F-9).

barrels. However, the preflood baseline injectivity index had declined from 1.02 bbl/day-psi prior to Pfizer polymer injection to 0.46 bbl/day-psi before the micellar fluid injection containing Kelzan SS-4000. Therefore, the comparison illustrated in Table F8 was made by dividing the injection rate of the polymer or micellar solution by the prior preflood rate. This ratio attempts to account for any changing wellbore effects. This comparison indicates that both the Abbott and Pfizer polymer solutions had comparable ratios and the ratio for the Kelzan polymer was slightly lower.

The following conclusions resulted from this test:

1. A small slug of the micellar fluid recommended for the Chesney (north) pattern can be injected at a pseudo-stabilized rate without plugging.
2. Damage caused by injecting biopolymer solutions can be successfully treated with acid.
3. The micellar fluid should be circulated through all surface lines and downhole tubing to clean the system completely before injecting into the formation.
4. The comparison shown in Table F8 indicates that Abbott and Pfizer polymer solutions had comparable "injection ratios" and the injection ratio of the Kelzan polymer solution was slightly lower.

Polymer mixing methods. A goal of the injectivity testing was to try different methods for the handling of dry powder and broth type biopolymers. Three methods were used for mixing the biopolymer broths (Pfizer and Abbott polymers) with brine. These included continuous mixing with a Speedco dynamic mixer, circulating the fluid in a tank with a gear pump, and simply stirring the solution in the tank with a paddle stirrer. Two samples were taken during the testing of each mixing system. The viscosity and filterability of one sample were measured right away while the second sample was sheared in a Waring blender before being submitted to the same measurements. It was found that all mixing methods were adequate for broth concentrations up to three percent.

The Kelco SS-4000 polymer was mixed with a Chemix two-stage mixer followed by a three step shearing at 400 psi differential pressure through shear plates. This system, while necessarily more complicated than the broth mixing system, worked very well after start-up and could easily be scaled up to the volume required for pattern injection.

Figures F-10 through F-15 show the filtration plots of the fresh water used to make the biopolymer and micellar solutions. These data were obtained using a 0.45 μm millipore filter at 20 psi pressure differential. There seems to be some correlation between these filtration test results and the solution injectivity test results but it is far from definite. This testing will most likely continue during the pattern injection in an effort to develop a useful correlation between filtration test results and field (well) injectivity. Another approach tried was the post mortem calculation of apparent sand-face viscosity. Data developed in the laboratory along with well parameters (see Table F9) were used in the equation:*

$$\Gamma = \frac{\overline{V}}{(1/2\ \frac{K}{\phi})^{1/2}}$$

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*Jennings, R. R., J. H. Rodgers, and J. J. West, "Factors Influencing Mobility Control by Polymer Solutions," Journal of Petroleum Technology, 23, 391-401, (March, 1971).

where, Γ = Shear Rate

$\overline{V}$ = Pore Space Bulk Velocity

K = Permeability

ϕ = Porosity.

The results of these calculations are shown in Tables F6 and F7. They show a relationship similar to the apparent viscosity calculated from the field tests.

Future Work

No additional formation injectivity tests are expected. However, additional information will be gathered to see if a correlation between millipore filterability data and well injectivity exists.

PATTERN INJECTION AND PRODUCTION

by

R. J. Miller

with

D. R. Gordon

Summary

The primary field operations during the last fifteen months have been injecting preflush in both patterns, conducting a biocide testing program, installing equipment to inject the micellar solution in the south (Hegberg) pattern, and injecting micellar solution in the south pattern.

The low injection rate of the micellar solution in the Hegberg pattern has received considerable attention. In an effort to improve the injection rate, several steps to decrease the viscosity and increase the quality of the micellar fluid have been taken. These measures are currently being reviewed and evaluated.

Periodic fluid samples and well logs have been taken in the four observation wells. The observation well logging has proved very valuable in defining the sweep efficiency for the central areas of the patterns.

Introduction

This section describes the pattern injection and production history for the last reporting period. The observation well data, well stimulation, and bacteria testing program are also discussed. The chemical preflush was completed and micellar fluid injection was initiated in the south pattern during this reporting period. The preflood injection in the north pattern was nearing completion at the end of this reporting period.

Discussion

Preflush Injection

South pattern preflush. The chemical preflush injection phase for the Hegberg (south) pattern began on June 20, 1976. A description of the various liquids to be injected in the south pattern during the chemical flood and the volumes of each fluid are given in Table I in the section "Chemical Selection and Support." As illustrated in Figure G-1 in Appendix G, an injection rate decrease was experienced after chemical preflush initiation. Several possible causes for the injectivity problem were investigated. Insufficient chemical water softening, fines movement, and precipitation of solids were among the probable causes. The results of the stimulation treatments which began in July, and continued into August, 1976, can be seen by the increase in injection rate in Figure G-1. Figures G-2 through G-10 show the injection rate during the preflush phase for individual wells in the Hegberg pattern. Tables G1 through G10 give the daily injection rate, pressure, and preflush volume for the Hegberg pattern and for each injection well in the pattern.

The well stimulation procedure used was generally successful. The treatment consisted of the following staged acid treatment:

Stage One: 850 gallons of 15 percent hydrochloric acid

Stage Two: 1700 gallons of hydrofluoric acid

Stage Three: 850 gallons of 15 percent hydrochloric acid

Table G11 gives the well stimulation summary for the project wells.

Evaluation of the stimulation on an individual well basis was made difficult by meter problems experienced during the preflush phase. The closely machined clearances of the well meters, coupled with precipitation, low flow rates, and lubricity of the fluid, combined to cause meter slippage, resulting in erroneously low readings. Frequently, the meters stopped and required cleaning prior to continuing injection. However, a realistic evaluation was made using the increased rate shown by the master meter for the pattern. The meshed-gear master meters installed in the main distribution lines have provided trouble-free and accurate service. A paper presented at the 1977 Oklahoma City Regional meeting of the Society of Petroleum Engineers describes the project facilities in detail.[1]

The chemical preflush injection was completed in March, 1977. Pattern injection was interrupted for approximately two weeks to change over to the next injection phase.

North pattern preflood. Preflood I injection continued during part of this reporting period. The exact composition and volume of Preflood I fluid is given in Table II of the "Chemical Selection and Support" section.

Injection of the Preflood II phase for the north (Chesney) pattern began on December 21, 1976. Figure G-11 gives a plot of injection

[1]Miller, R. J. and C. N. Richmond, "El Dorado Micellar-Polymer Project Facilities," Society of Petroleum Engineers of AIME, Regional Meeting, Paper No. 6469, Oklahoma City, Oklahoma, February 21-22, 1977.

rate versus time for the Chesney pattern. Figures G-12 through G-20 show the preflood injection rate for the individual wells. Tables G12 through G21 list the daily injection rate, pressure, and cumulative volume for the Chesney (north) pattern and the individual injection wells during preflood. The Preflood II fluid for this pattern is an aqueous salt solution of sodium, calcium, and magnesium chlorides. The exact composition is shown in Table II of the "Chemical Selection and Support" section. The injection rate for the preflood has been adequate. Since the injection rate was higher in the Chesney pattern than the Hegberg pattern, fewer problems were encountered with the individual well meters.

Observation Wells

Well completion. The four observation wells provide points within the flood area for fluid sampling and periodic logging. They were drilled to help evaluate the design parameters and more accurately analyze the processes. The observation well locations are shown in Figure C-1 of Appendix C.

A five and one-half inch steel casing string with 90 feet of fiberglass casing on the bottom was run in the borehole and cemented to surface. The fiberglass casing was perforated with four bullets in a representative one-foot interval in order to collect reservoir fluid samples. One bullet was tagged with iridium 192 for correlation purposes. A tension packer was run on two-inch steel tubing and set in the bottom joint of steel casing. Three-quarter inch, hollow sucker rods were installed as production tubing. The hollow sucker rods were used to minimize the amount of fluid withdrawal necessary to obtain a representative bottom-hole fluid sample (see Figure G-21 for a diagram of the observation well).

Fluid samples. Periodic fluid samples were taken after pumping the well long enough (about three hours) to displace the fluid within the hollow sucker rods. Routine analyses of the fluid samples have included: (1) chloride concentration, (2) sodium concentration, (3) calcium concentration, (4) magnesium concentration, (5) total hardness, (6) water-oil ratio, and (7) pH. More detailed information concerning the analyses done on these samples is given in the section "Chemical Selection and Support."

Well logging. The observation well logging has proved very valuable in defining the sweep efficiency for the central area of the Hegberg pattern. The center injection well, MP-213, is located in an unusually thin part of the reservoir. The initial geological interpretation indicated that both the upper and lower zones had merely thinned and were still connected to the observation and production wells. Periodic samples taken from the upper (original) perforations in the nearest observation well, MP-227, did not show any decrease in salinity during a nine month period. Since an earlier front arrival was expected, an induction log was run in well MP-227. The second run shown in Figure C-4 clearly indicates a salinity change in the lower zone with no change in salinity in the upper zone.

Figure C-5 indicates a similar phenomenon for well MP-228. However, Runs #3 and #4 indicate a salinity decrease in the upper zone. After carefully examining the cores and running pressure transient tests, the initial geological interpretation was revised to indicate that the upper production zone was missing in well MP-213. Figure G-22 shows an interpretation of the missing zone from a cross section of gamma-ray neutron logs. See the sections "Coring and Core Analyses," "Observation Well Logging," and "Pressure Transient Tests" for additional information.

Several methods were considered to insure that the upper zone would be swept near well MP-213. However, since no acceptable solution was developed, it was decided to reduce the swept pore volume in future analyses by approximately ten percent to account for the missing upper zone (see also the section "Performance Prediction").

Micellar Fluid Injection in the South Pattern

Injection of the micellar fluid began in the Hegberg (south) pattern on March 22, 1977. The micellar fluid contains four sulfonates, crude oil, one cosurfactant, and an aqueous salt solution. The micellar fluid is injected in small, alternating slugs which are called micellar water and micellar oil (soluble oil).* The composition of each fluid is listed in Table II of the section "Chemical Selection and Support."

The south pattern injection was interrupted to prepare equipment for micellar fluid injection. A surfactant solution was used to clean all holding tanks, injection lines, and downhole tubing. Larger paddle stirrers and more reliable meters were installed during the changeover period. Few difficulties were experienced in plant start-up operations.

Figure G-23 shows the two week changeover period prior to micellar fluid injection and the initial rate decrease experienced during micellar fluid injection. Figures G-24 through G-32 give the micellar fluid injection rate versus time for each well. Tables G-23 through G-32 list the daily injection rate, pressure, and cumulative volume for the pattern and the individual injection wells during micellar fluid injection. Several causes for the low micellar fluid injection rate were considered likely.

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*"Micellar water" is the term used to refer to the adjusted salinity water injected in alternating slugs with the soluble oil. The corresponding term "micellar oil" is used to refer to the soluble oil.

The viscosity, fines movement, and solids or wax plugging were among the possible causes. The steps taken to increase injectivity have been to:

1. Decrease the water content in the surfactant concentrate which will decrease the viscosity of the micellar oil.
2. Increase the pressure gradient to 0.85 pounds per square inch per foot of depth. The resulting pressure is still below the formation fracture pressure.
3. Acidize several injection wells with a hydrochloric-hydrofluoric-hydrochloric treatment.
4. Test a small diatomaceous earth filter to remove solids from the micellar oil.

The results are being reviewed and evaluated.

Well Stimulation

Several well stimulation methods were discussed in the Second Annual Project Report.[1] As reported last year, the results of the staged acid treatment were more favorable than the results of surfactant treatment or explosive stimulation. Based on that analysis, the staged acid treatment was used during the past year to increase the preflush injection rate in several injection wells. Table G11 summarizes the well stimulations used for the individual wells. In a few cases, only 15 percent hydrochloric acid was used to successfully stimulate injection wells (see the results for wells MP-108 and MP-110 in Table G11). Since these wells had previously been acidized with a hydrochloric-hydrofluoric-hydrochloric treatment, it was assumed that any injection problems due to fines movement should no

[1] Rosenwald, G. W., R. J. Miller, and J. Vairogs (editors), El Dorado Micellar-Polymer Demonstration Project (Second Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-76/4, November, 1976.

longer present a problem. The single acid treatment reduced the stimulation cost considerably.

The staged acid treatment proved somewhat inadequate for stimulating the Hegberg pattern injection wells during micellar injection. As shown in Table G11, for wells MP-221 and MP-223 the initial increase was encouraging, but the rate one month later had decreased significantly. The micellar rate could be improved for a relatively short time period with acid treatments, but the wax and/or viscosity problem needed to be solved for lasting improvement (see the section "Chemical Selection and Support" for additional information on this subject).

Fluid Production

Fluid samples have been collected periodically from the eight production wells. The routine analyses have been: (1) chloride concentration, (2) calcium concentration, (3) magnesium concentration (4) total hardness, (5) sodium concentration, (6) water-oil ratio, and (7) pH. More information concerning these analyses is given in the section "Chemical Selection and Support."

The production wells in both patterns were operated in a "pumped-off" condition during the preflush injection phases. Table G33 gives the monthly production data for the eight producing wells.

Biocide Testing

A biocide testing program was conducted during this reporting period. The objective of the testing was to determine the most suitable biocide to be used in conjunction with the chlorine gas for the El Dorado Demonstration Project.

Since March 17, 1976, chlorine gas has been injected at six to eight ppm into the fresh water line at the pump station to control bacteria. However, subsequent addition of an ammonium sulfite oxygen scavenger to the fresh water holding tank neutralizes the chlorine and allows bacteria growth in the suction tanks and injection lines. It is undesirable to simply increase the chlorine concentration or to add chlorine gas downstream from the fresh water storage tank because a high chlorine concentration would degrade both polymers during the polymer drive stage. Therefore, biocides that were compatible with both polyacrylamide and biopolymer were selected and tested.

The four biocides selected for this test were (Nalco) Visco 3991, (Dow) Dowicide G-ST, and Tretolite X-cide-18 and X-cide-401. The bacteria growth was monitored by the standard American Petroleum Institute (API) method. This method involves injecting a one milliliter sample of the fluid to be tested for bacteria into a ten milliliter bottle containing a translucent medium for growing bacteria. The bottle is thoroughly mixed and a one milliliter sample is extracted for injection into another ten milliliter culture bottle. This diluting procedure continues until five bottles have been injected. The five culture bottles are allowed to stand for 72 hours at approximately 70° F. The bottles are then carefully observed for bacteria growth which is indicated by a "cloudy" solution in the bottle. If only the first bottle appears cloudy, then one to ten colonies per milliliter of bacteria were present in the sampled fluid. Accordingly, two bottles indicate that ten to 100 colonies per milliliter were present. Generally, two to three "contaminated" bottles are an acceptable bacteria level for maintaining injectivity.

The test results were obtained for samples from the suction tank used to mix the Preflood II for the north pattern. The test procedure involved batch treating the suction tank with a biocide and running the standard API bacteria test periodically. The results of the test indicated that control of bacteria can best be obtained by using (Nalco) Visco 3991 or Tretolite X-cide-18. Additional tests are planned to determine whether a batch treating method or a continuous treating method would provide better bacteria control.

Future Work

The tasks which should be accomplished during the next 15 months are completing injection of the micellar fluid in both patterns and initiating polymer injection in both patterns. Periodic well logs will also be run in the observation wells, and produced fluid samples will be analyzed.

The estimated completion date for Preflood II in the Chesney (north) pattern is October, 1977. Pattern injection will then be interrupted to clean all surface and downhole equipment. The micellar fluid injection should begin in November, 1977. The injection plant will be modified so that both micellar fluids can be injected simultaneously. The plant was originally designed to handle only one micellar fluid at a time.

APPENDIX A

CHEMICAL SELECTION AND SUPPORT

Tables and Figures

TABLE A1

AN ANALYSIS OF GREENWOOD COUNTY CRUDE OIL AND THE RESIDUE LEFT ON A MILLIPORE FILTER

	Sample Distribution,* percent		C_{15+} Composition, percent			
	$<C_{15}$	C_{15+}	Asphaltenes	Saturates	Aromatics	NSO**
1. Greenwood County crude oil (GCCO)	37.2	62.8	5.4	56.8	22.7	15.1
2. Residue on 1.2 micron filter, GCCO containing wax inhibitor	Not Analyzed	100.0	39.8	47.0	13.2	0.0

*$<C_{15}$ is portion lighter than C_{15}; C_{15+} is portion that is C_{15} or heavier.

**Nitrogen, sulfur, and oxygen containing components.

TABLE A2

VISCOSITIES AND SCREEN FACTORS OF POLYMERS

IN SYNTHETIC EL DORADO WATER‡

Viscosities, cp

Viscometer* Speed, rpm	Polymer Manufacturer and Concentration			
	Nalco		Cyanamid	
	500 ppm	600 ppm	500 ppm	600 ppm
3	27.2	40.2	29.4	40.2
6	23.2	32.6	24.1	32.4
12	18.05	25.1	19.3	25.0
30	13.58	17.5	13.66	17.7

Screen Factors

Polymer Manufacturer and Concentration			
Nalco		Cyanamid	
500 ppm	600 ppm	500 ppm	600 ppm
14.12	16.56	11.65	17.86

‡Synthetic El Dorado Water composition is:

NaCl	63 ppm
$CaCl_2$	82 ppm
$MgCl_2$	20 ppm

*Brookfield LVT viscometer with UL adaptor.

TABLE A3

INTERFACIAL TENSION MAP FOR ORIGINAL MICELLAR SYSTEM DESIGNED FOR THE NORTH PATTERN

Mg^{++} = 0 mg/l $(Na^+)/(Ca^{++})$ = 4.00 T ≅ 78° F

IFT values in dynes/cm Oil phase = Chesney crude oil

NaCl Conc, mg/l	Ca^{++} Conc, mg/l	0.016	0.037	0.051	0.075	$Na^+ + Ca^{++}$, Normality
40,015	3420	0.0561	0.0667	0.0502	0.0522	0.8555
32,012	2736	0.0851	0.0177	0.0757	0.0423	0.6844
24,009	2052	0.0633	0.0425	0.0255	0.0230	0.5133
16,006	1368	0.0510	0.0295	0.0252	0.0121	0.3422
12,004	1026	0.1591	0.0306	0.0124	0.0071	0.2567
8,003	684	0.0553	0.0333	0.0130	0.0015	0.1711

Surfactant Concentration in the Aqueous Phase, meq/ml (titrated)

TABLE A4

INTERFACIAL TENSION MAP FOR MODIFIED MICELLAR SYSTEM DESIGNED FOR THE NORTH PATTERN

Mg^{++} = 0 mg/l $(Na^{+})/(Ca^{++})$ = 4.00 T ≅ 77° F

IFT values in dynes/cm Oil phase = Chesney crude oil

NaCl Conc, mg/l	Ca^{++} Conc, mg/l	0.016	0.037	0.051	0.075	$Na^{+} + Ca^{++}$, Normality
40,015	3420	0.1630	0.1809	0.1402	0.1741	0.8555
32,012	2736	0.1508	0.1516	0.1527	0.1297	0.6844
24,009	2052	0.1212	0.1517	0.0917	0.0920	0.5133
16,006	1368	0.1179	0.0078	0.0736	0.0646	0.3422
12,004	1026	0.1496	0.0819	0.0591	0.0448	0.2567
8,003	684	0.1308	0.0856	0.0423	0.0193	0.1711

Surfactant Concentration in the Aqueous Phase, meq/ml (titrated)

TABLE A5

COMPARISON OF FLOW TEST PERFORMANCE OF

THE ORIGINAL CHEMICAL SYSTEM AND THE MODIFIED SYSTEM

Test Conditions and Core Data	Original System	Modified System
El Dorado Admire Sandstone Core		
Dimensions, cm	5.04 x 25.07	5.05 x 25.05
Porosity, pore volume fraction	0.265	0.270
K_w at S_{or}, md	96	160
K_o at S_w, md	88	134
S_{oi}, pore volume fraction	0.75	0.74
Flow Rate, ml/hr	5.00	5.00
Frontal Advance Rate, ft/day	0.745	0.728
Fluid Sequence, Volumes and Compositions		
Waterflood		
Pore volumes injected	5	5
Chesney produced water, weight percent	100	100
K_w at S_{or}, md	35	35
S_{or}, pore volume fraction	0.289	0.302
Preflood		
Pore volumes injected	0.40	0.41
NaCl, weight percent	2.900	2.900
$CaCl_2$, weight percent	0.102	0.102
$MgCl_2$, weight percent	0.097	0.097
El Dorado raw water, weight percent	96.901	96.901
Surfactant Slug		
Pore volumes injected	0.12	0.12
Surfactant concentration, milliequivalents/gm	0.075	0.075
Polymer Drive*		
Pore volumes injected	0.70	0.72
Kelzan MF, ppm	1125	1125
Chesney produced water, weight percent	1.0	1.0
El Dorado raw water, weight percent	98.8875	98.8875
Results, Performance Data		
S_{or} Final, pore volume fraction	0.18	0.18
Final Oil Recovery, fraction of oil in place after waterflood	0.365	0.404

*First 0.1 pore volume of polymer drive contained 2.0 wt percent secondary butyl alcohol.

TABLE A6

VISCOSITY VERSUS SHEAR RATE AND POLYMER CONCENTRATION

FOR VARIOUS BIOPOLYMERS IN ONE PERCENT NaCl WATER

Polymer Type	Polymer Concentration ppm	Viscosity* in cp at 74°F and the indicated shear rates				
		$73.56\ sec^{-1}$	$36.78\ sec^{-1}$	$14.71\ sec^{-1}$	$7.36\ sec^{-1}$	$3.68\ sec^{-1}$
Abbott Xanthan Broth	1000	--	14.52	21.3	28.80	34.60
	800	8.06	10.72	15.45	19.00	23.00
	600	5.63	7.18	8.95	11.00	13.80
	400	3.81	4.46	5.70	6.90	9.20
Pfizer Broth	1000	--	15.40	21.75	29.80	35.80
	800	8.73	11.24	15.60	19.40	23.20
	600	6.28	7.74	9.80	12.20	15.40
	400	3.90	4.64	5.75	6.20	9.40
Kelco Kelzan SS-4000	1000	--	13.46	19.50	24.00	27.80
	800	7.45	9.74	12.65	15.90	18.40
	600	5.36	6.80	8.25	9.90	11.20
	400	3.52	3.86	4.80	5.40	7.00

*Viscosities measured on a Brookfield LVT viscometer with a UL adaptor.

TABLE A7

SALINITIES OF EL DORADO PROJECT PRODUCED SAMPLES

Well Number	"Original"* Salinities (April 19-24, 1976)	Salinities* of Samples of August 16, 1977	"Original" pH (Dec. 9, 1975)	pH of Samples of August 16, 1977
MP-112	91,870	54,060	6.5	6.2
MP-114	90,730	82,990	6.9	6.1
MP-122	92,370	67,210	6.9	6.3
MP-124	93,600	65,160	6.4	6.6
MP-131	77,000[a]	30,390	7.5[b]	6.8
MP-132	88,630[c]	62,240	7.0[b]	6.1
MP-207	91,550	95,260	7.2[b]	6.1
MP-209	90,850	76,270	6.2	6.3
MP-217	96,140	76,850	6.7	6.3
MP-219	94,240	85,330	6.8	6.4
MP-227	95,230	63,120	7.0[b]	6.0
MP-228	87,400[c]	48,510	7.0[b]	6.6

Note: Original salinities (chlorides) are based on an average of 20 analyses on different samples taken from April 19, 1976, through April 24, 1976.

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*Calculated mg/l NaCl based on chlorides.

[a]A value of 90,100 ppm has sometimes been assumed since a large amount of preflood was injected before this well was sampled.

[b]Values measured on September 30, 1976.

[c]Sample taken June 22, 1976.

TABLE A8

RESIDENT WATER COMPOSITION

(Data in Milligrams per Liter)

Well Number	MP-112	MP-114	MP-122	MP-124
Sodium	28,900	27,200	30,500	29,500
Calcium	2,760	2,680	2,580	2,640
Magnesium	1,550	1,940	1,630	1,630
Potassium	230	110	210	210
Barium	240	10	300	300
Strontium	800	90	550	710
Chloride	52,350	51,940	55,630	54,930
Bicarbonate	NA	NA	NA	NA
Sulfate	< 5	∿1,000	< 5	< 5
Sulfide	ND	ND	ND	ND
Total dissolved solids (calculated)	86,830	84,970	91,400	89,920
Total dissolved solids (evaporation)	88,250	87,530	93,300	90,490

Well Number	MP-207	MP-209	MP-217	MP-219
Sodium	28,400	29,430	30,800	32,660
Calcium	2,300	2,540	2,520	2,660
Magnesium	1,660	1,540	1,800	1,580
Potassium	160	270	210	260
Barium	30	420	300	320
Strontium	140	420	650	420
Chloride	52,990	54,490	56,800	59,700
Bicarbonate	NA	NA	NA	NA
Sulfate	90	< 5	< 5	< 5
Sulfide	ND	ND	ND	ND
Total dissolved solids (calculated)	85,770	89,110	93,080	97,600
Total dissolved solids (evaporation)	85,810	90,720	94,230	99,620

NA = Not analyzed
ND = Not detected by odor

TABLE A9

EFFECTIVENESS OF A 1.2 MICRON "ABSOLUTE" CARTRIDGE FILTER FOR REMOVING SOLIDS FROM SOLUBLE OIL

Millipore Filter Pore Size	Residue: Upstream of the 1.2 Micron Cartridge Filter	Residue: Downstream of the 1.2 Micron Cartridge Filter
0.45 micron	8348 mg/l	6432 mg/l
1.2 micron	2576 mg/l	1598 mg/l
5 micron	1741 mg/l	1461 mg/l

FIGURE A-1

COMPARISON OF THE FILTERABILITY OF GREENWOOD COUNTY CRUDE OIL (GCCO) WITH TREATED GCCO AND TREATED, DE* FILTERED GCCO

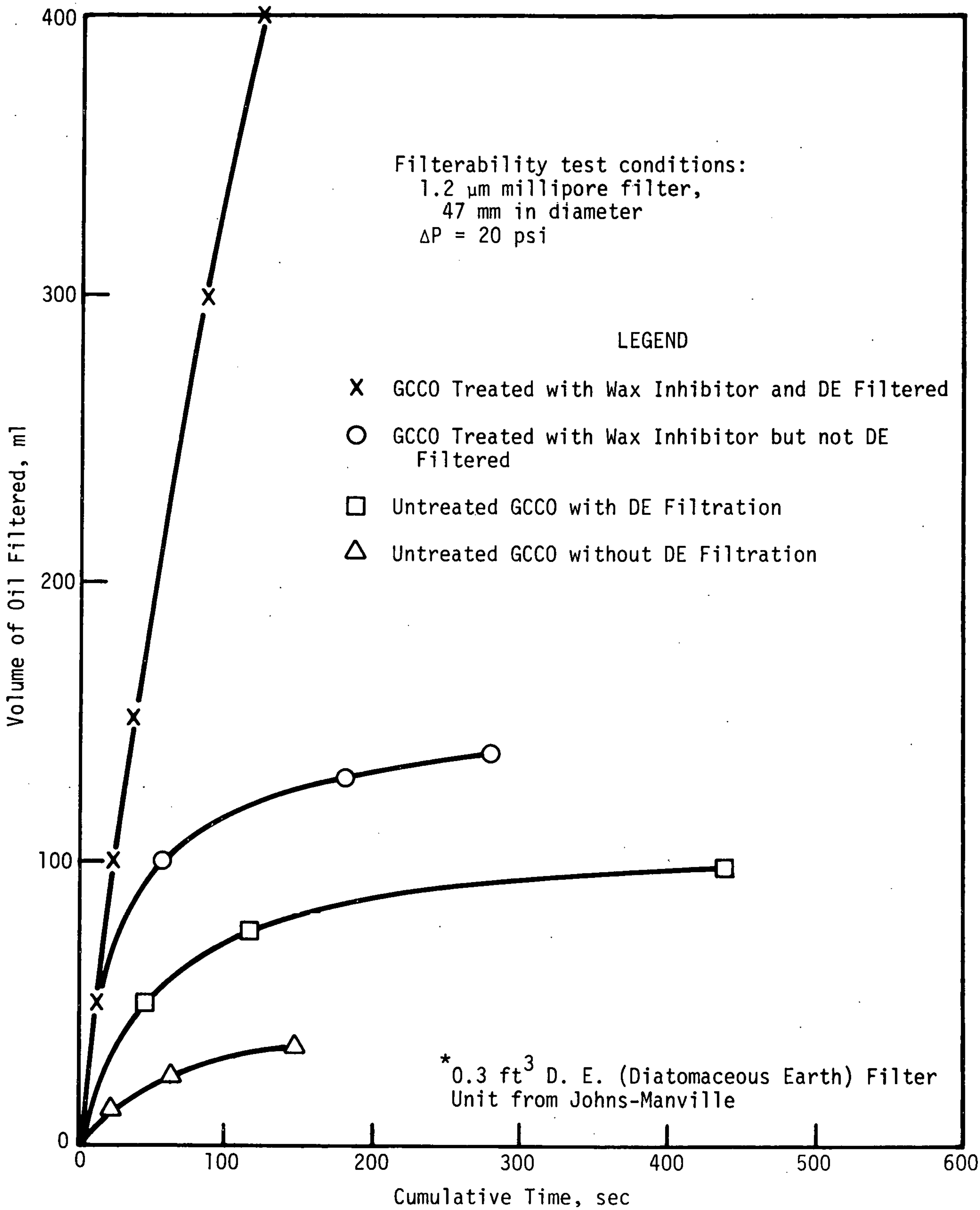


FIGURE A-2

D. E. FILTER INSTALLATION FLOW DIAGRAM

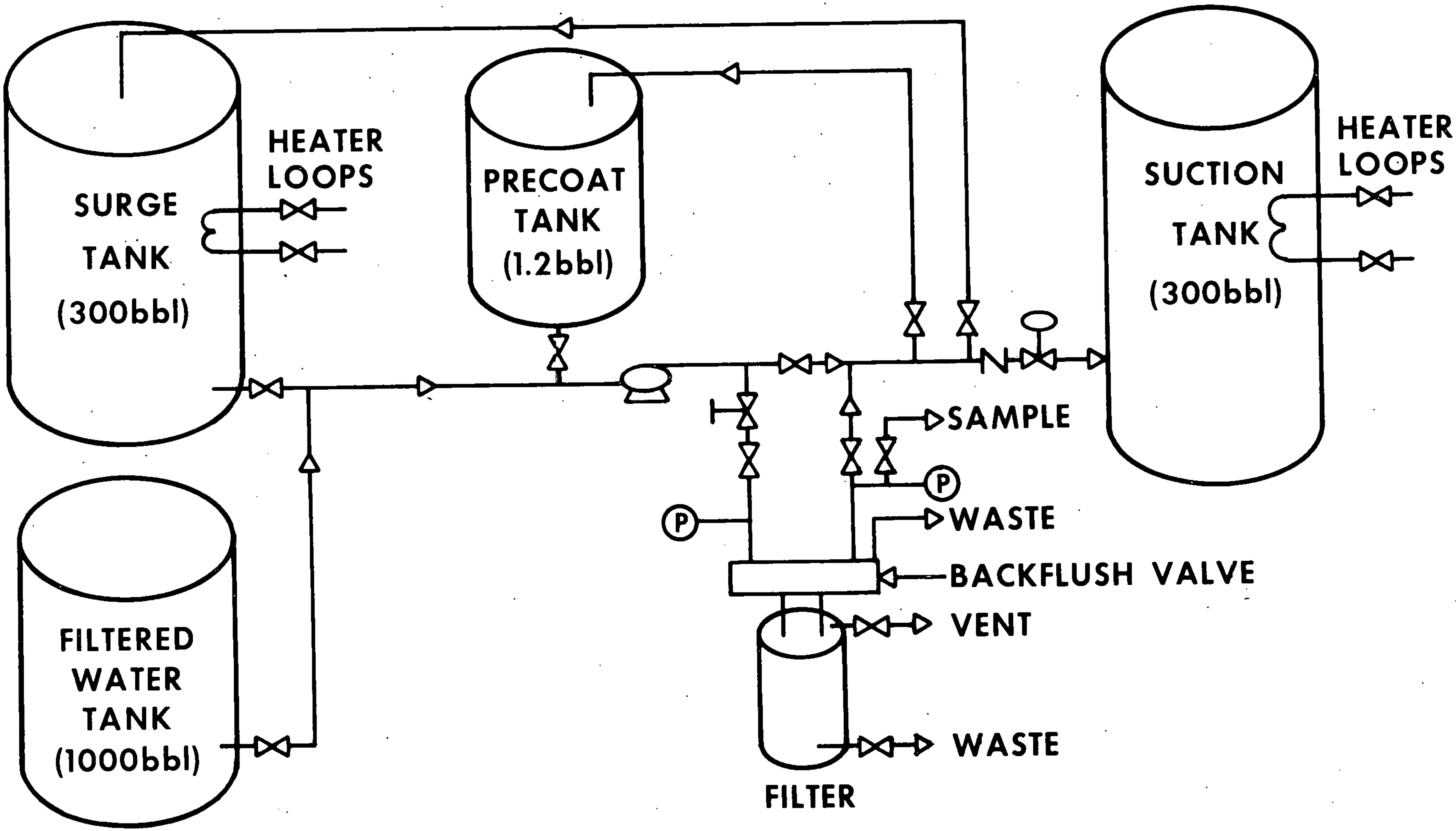


FIGURE A-3

COMPARISON OF THE FILTERABILITY OF SOLUBLE OIL AT 60° F AND 70° F
WITH AND WITHOUT DIATOMACEOUS EARTH FILTRATION

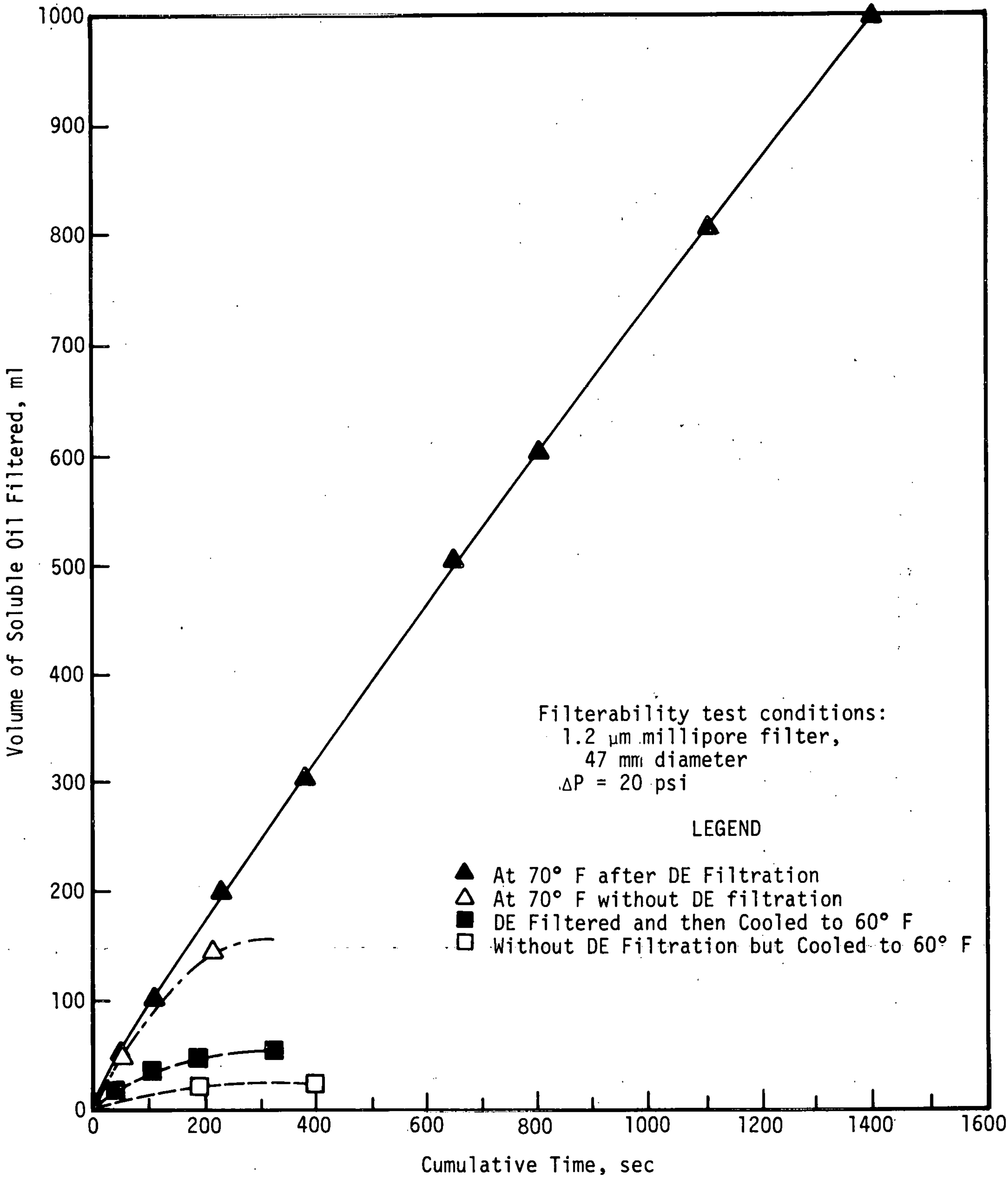


FIGURE A-4

POLYMER VISCOSITY VERSUS CONCENTRATION FOR TWO LIQUID POLYACRYLAMIDES

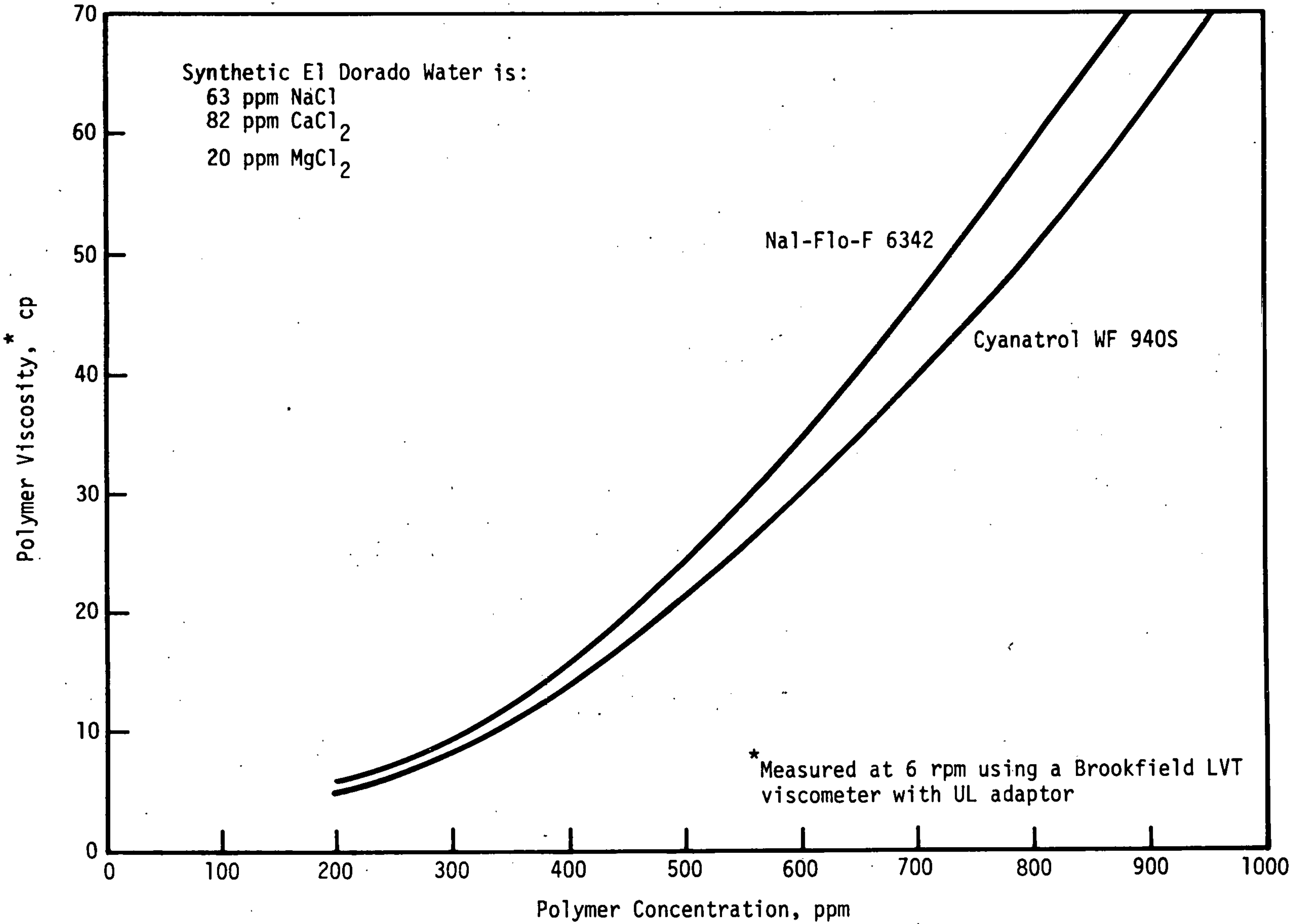


FIGURE A-5

FLOW BEHAVIOR OF POLYMER SOLUTIONS IN FIRED BEREA CORES

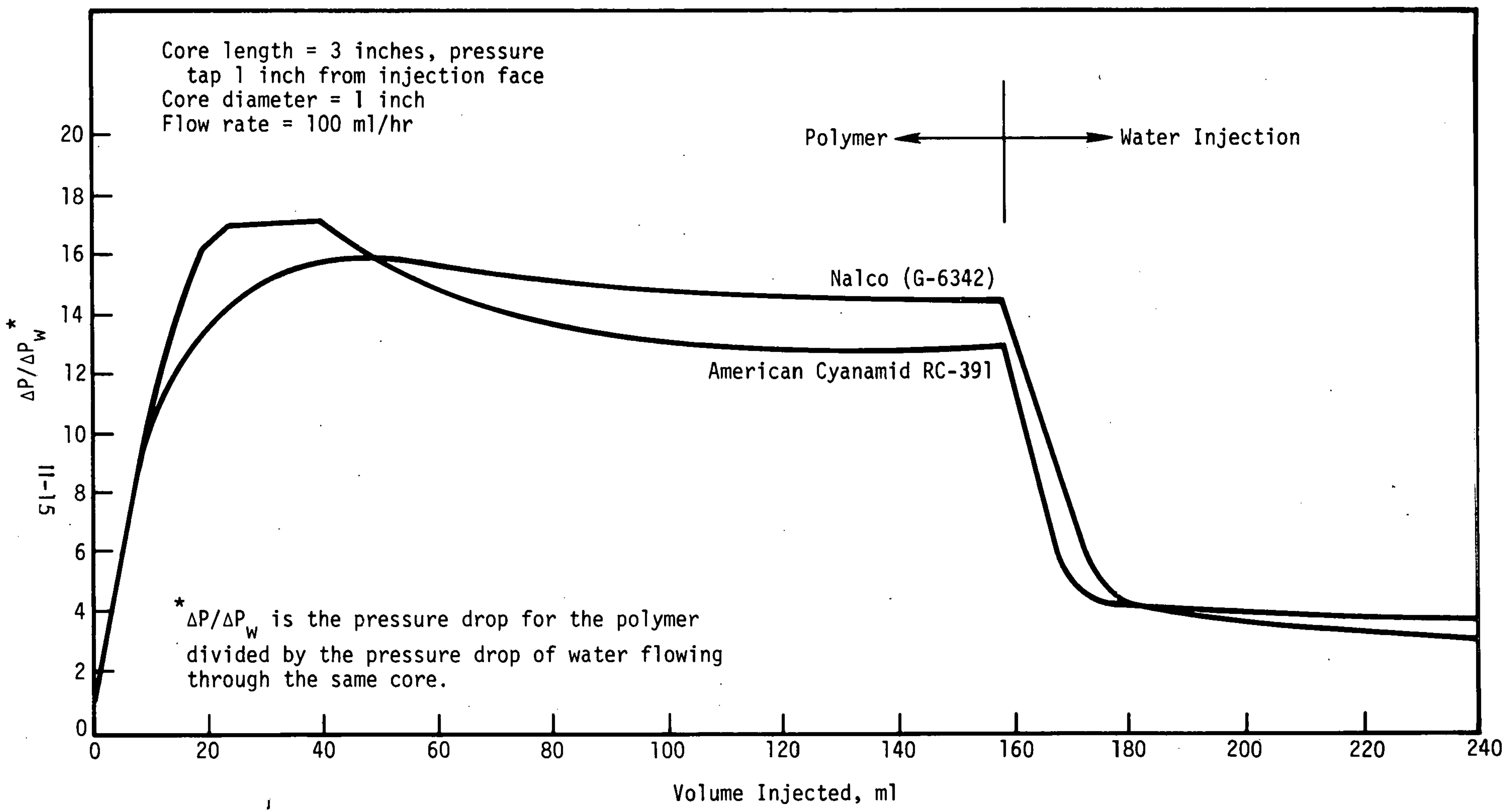


FIGURE A-6

VOLUMES OF PREFLOOD II (EXPRESSED AS FRACTION OF THE VOLUME OF PREFLOOD I) VERSUS CONTACTED RESERVOIR VOLUME AT TWO CATION-EXCHANGE CAPACITY (CEC) LEVELS

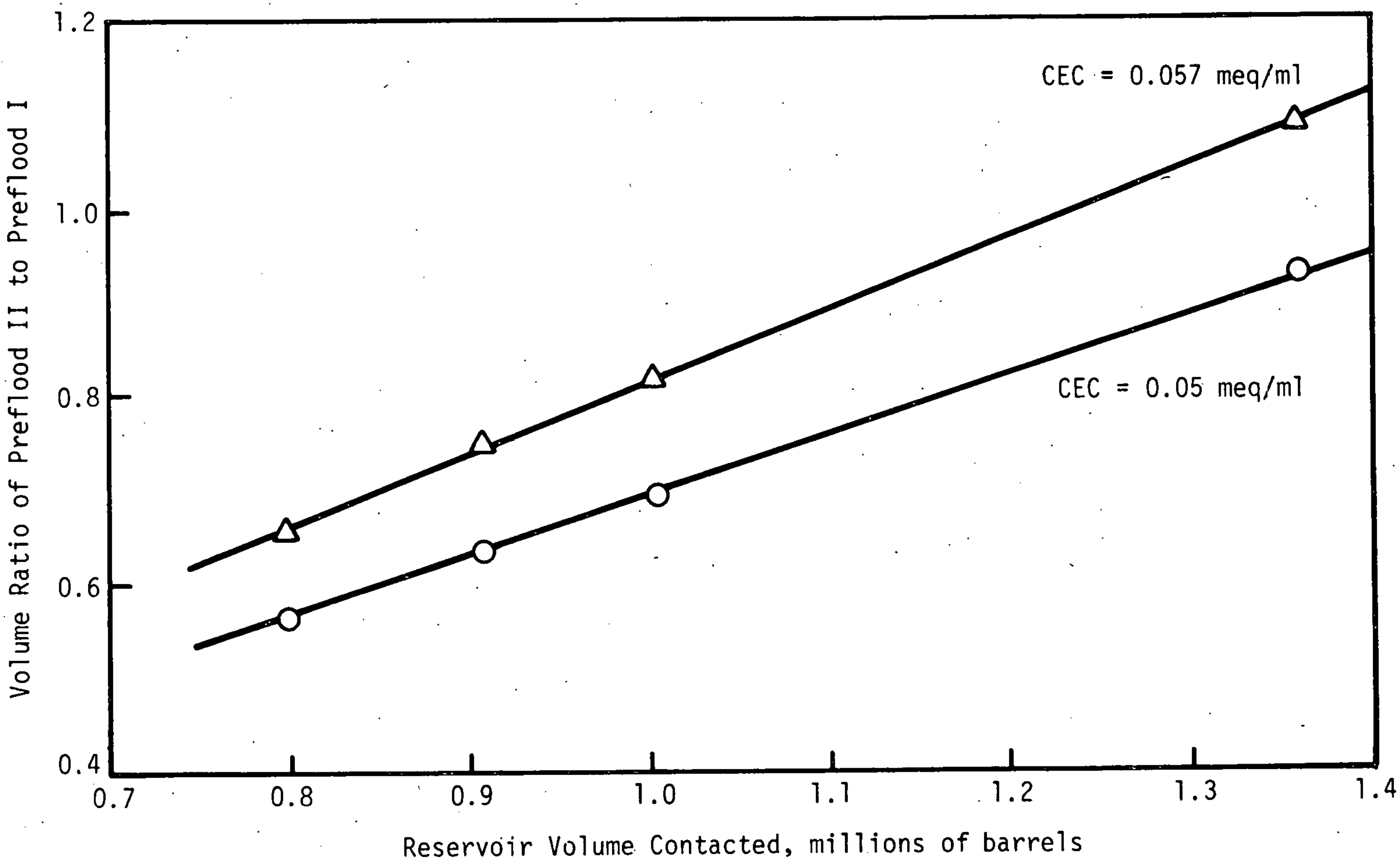


FIGURE A-7

LABORATORY FLOW TEST RESULTS FOR THE

ORIGINAL CHEMICAL SLUG DESIGNED FOR

THE NORTH PATTERN

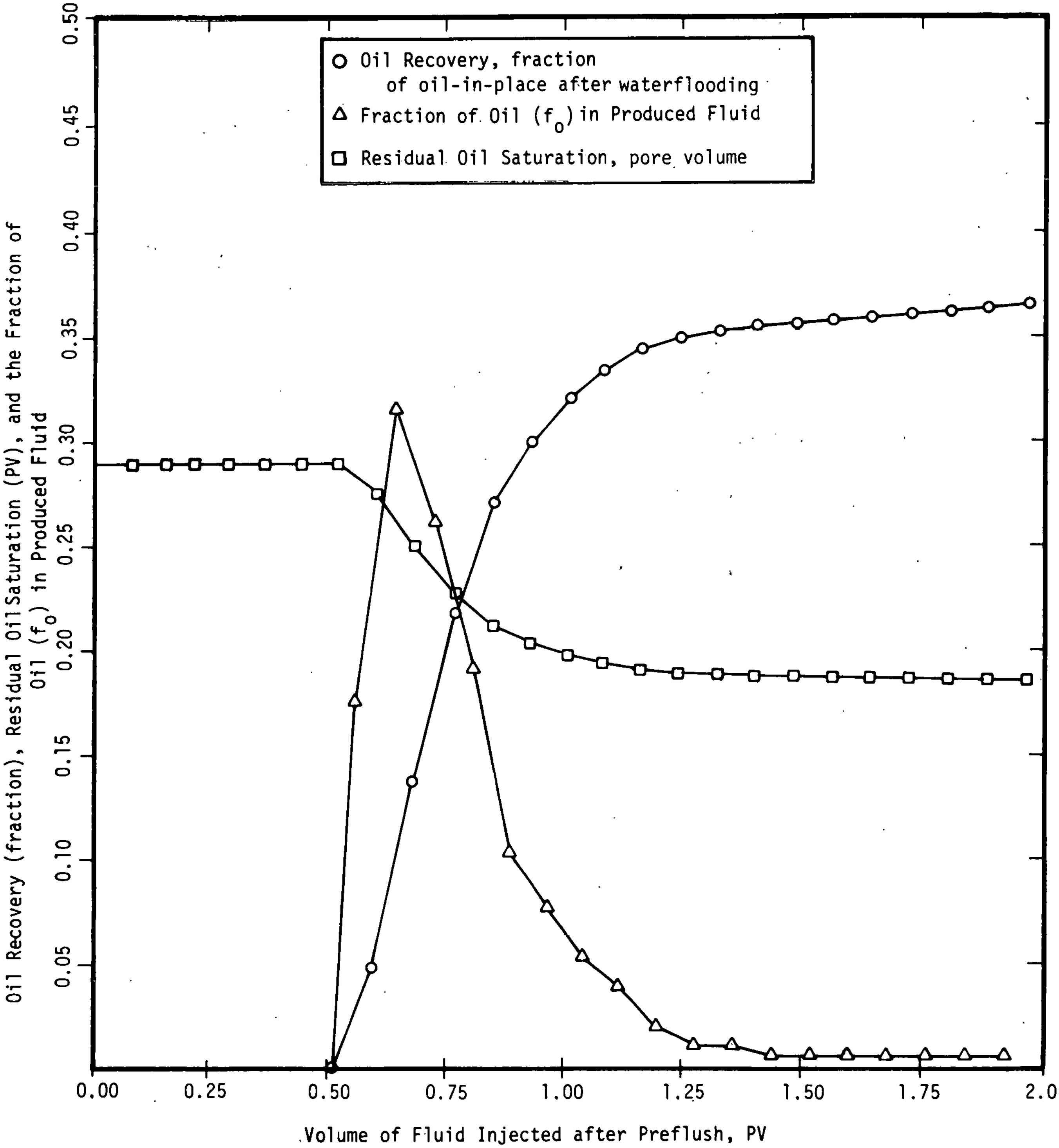


FIGURE A-8

LABORATORY FLOW TEST RESULTS FOR THE

MODIFIED CHEMICAL SLUG DESIGNED FOR

THE NORTH PATTERN

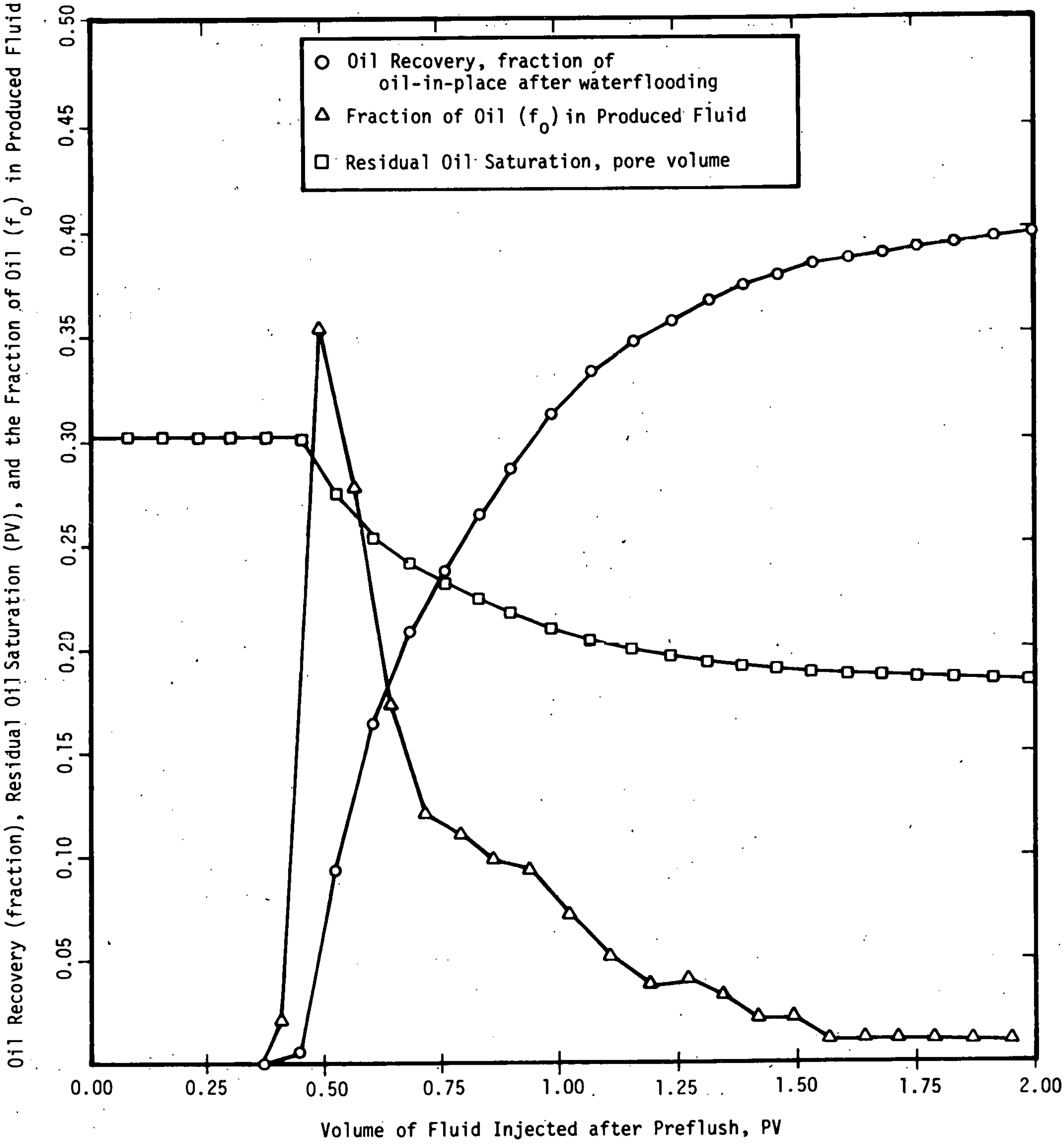


FIGURE A-9

VISCOSITY VERSUS POLYMER CONCENTRATION IN
1.0 PERCENT NaCl WATER

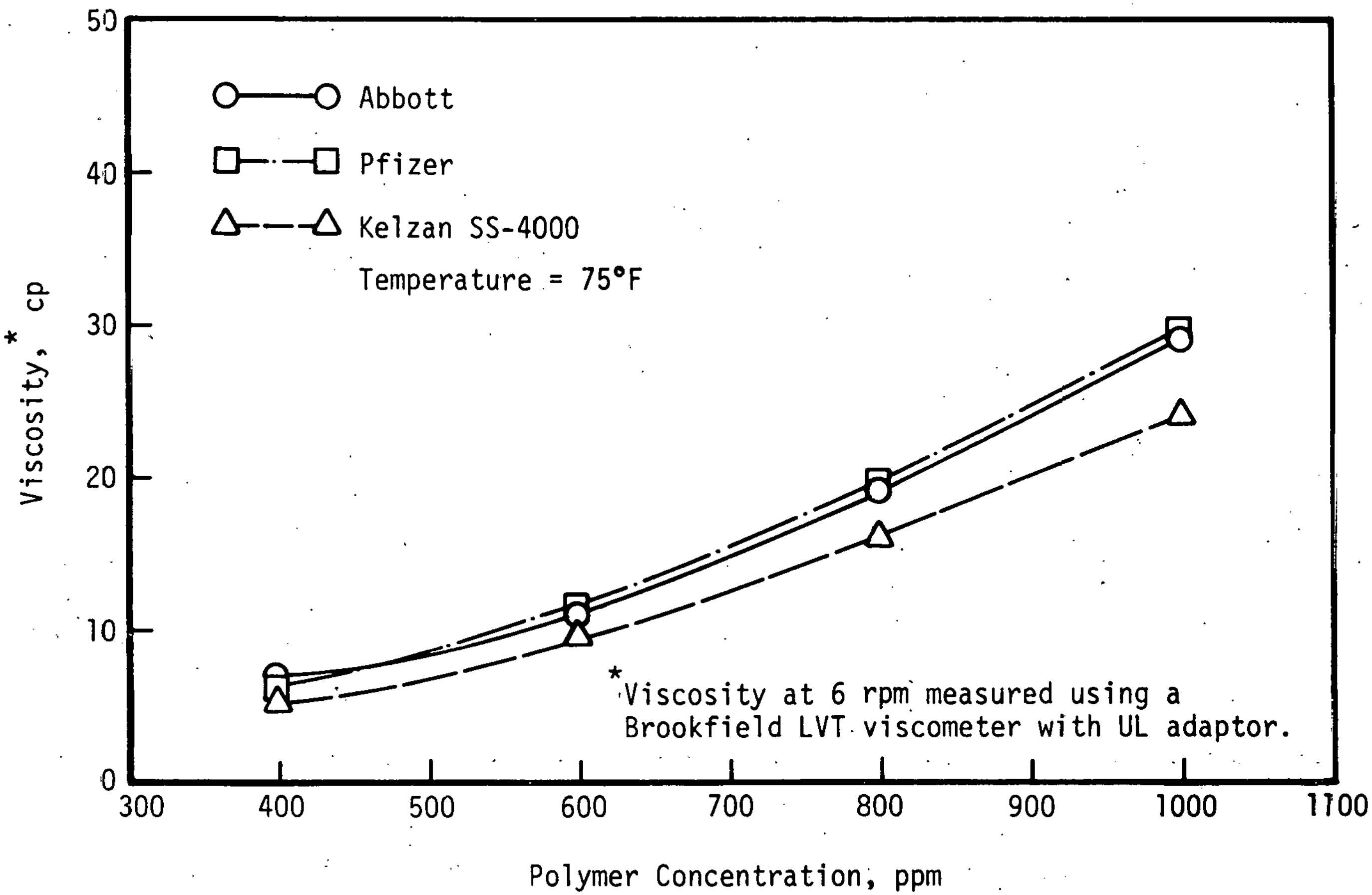


FIGURE A-10

FILTRATION BEHAVIOR OF VARIOUS BIOPOLYMER PRODUCTS

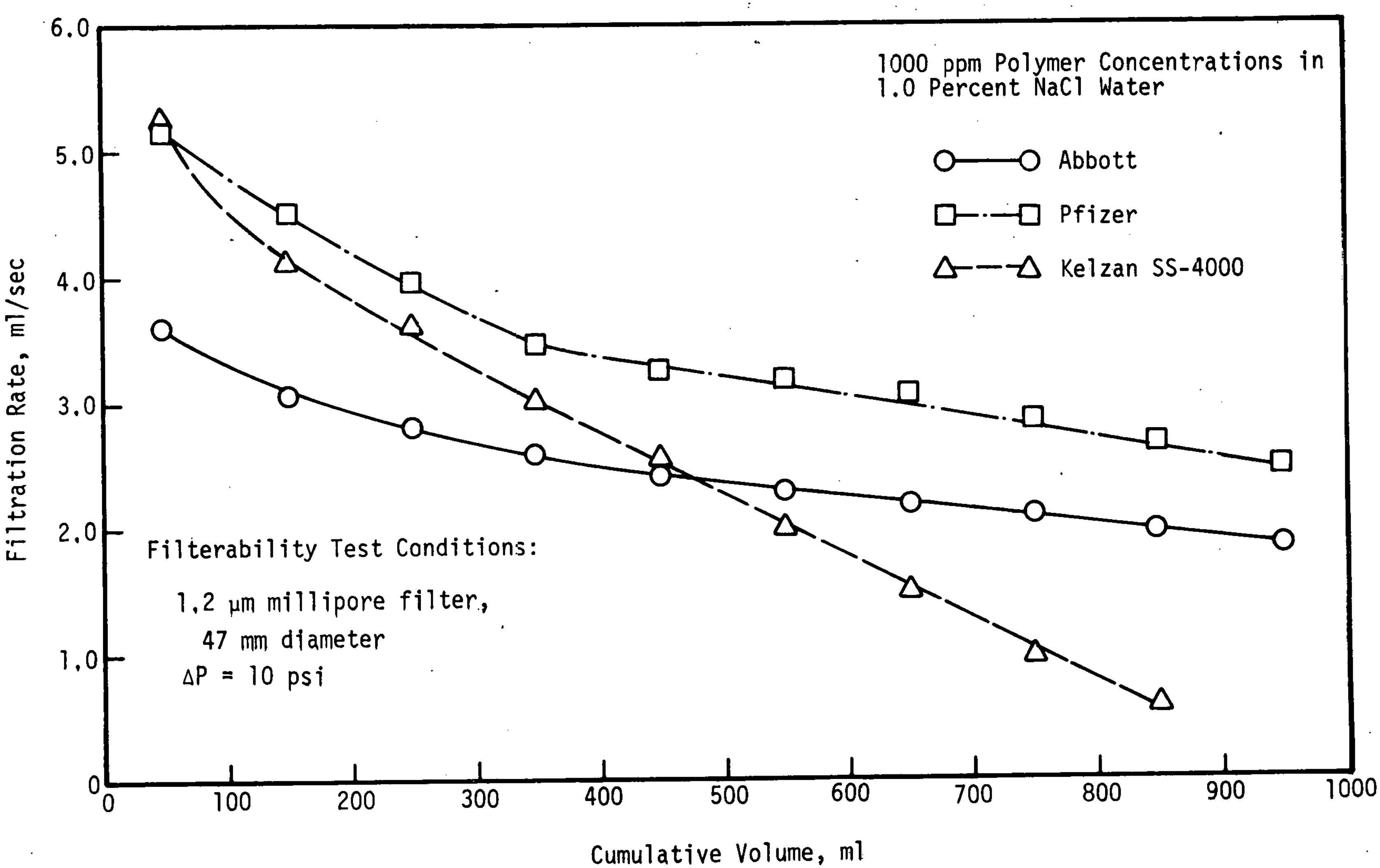


FIGURE A-11

INJECTIVITY RESULTS FOR THREE BIOPOLYMERS USING EXTRACTED EL DORADO CORE

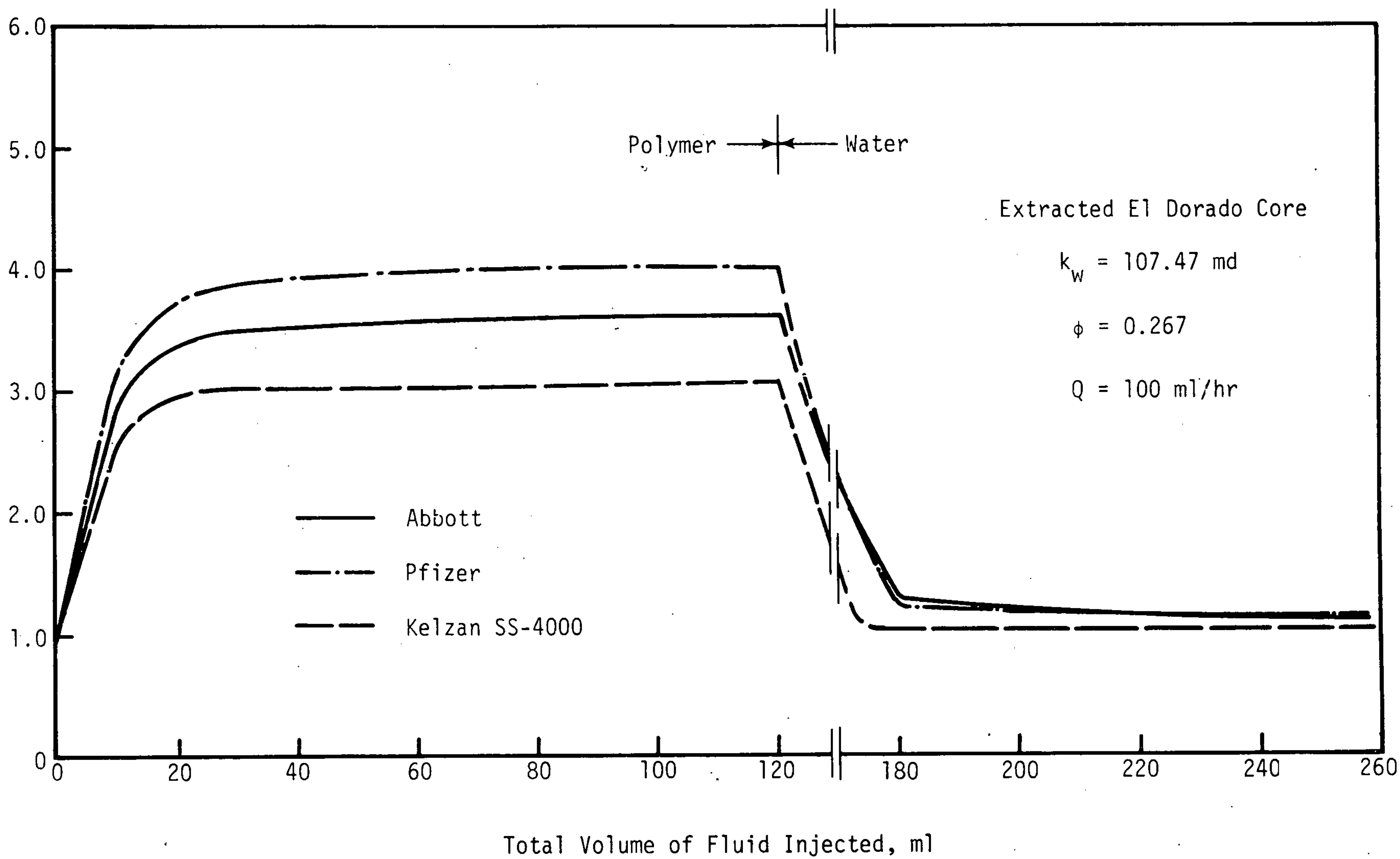


FIGURE A-12

PLUGGING TEST USING CORE FROM WELL MP-114

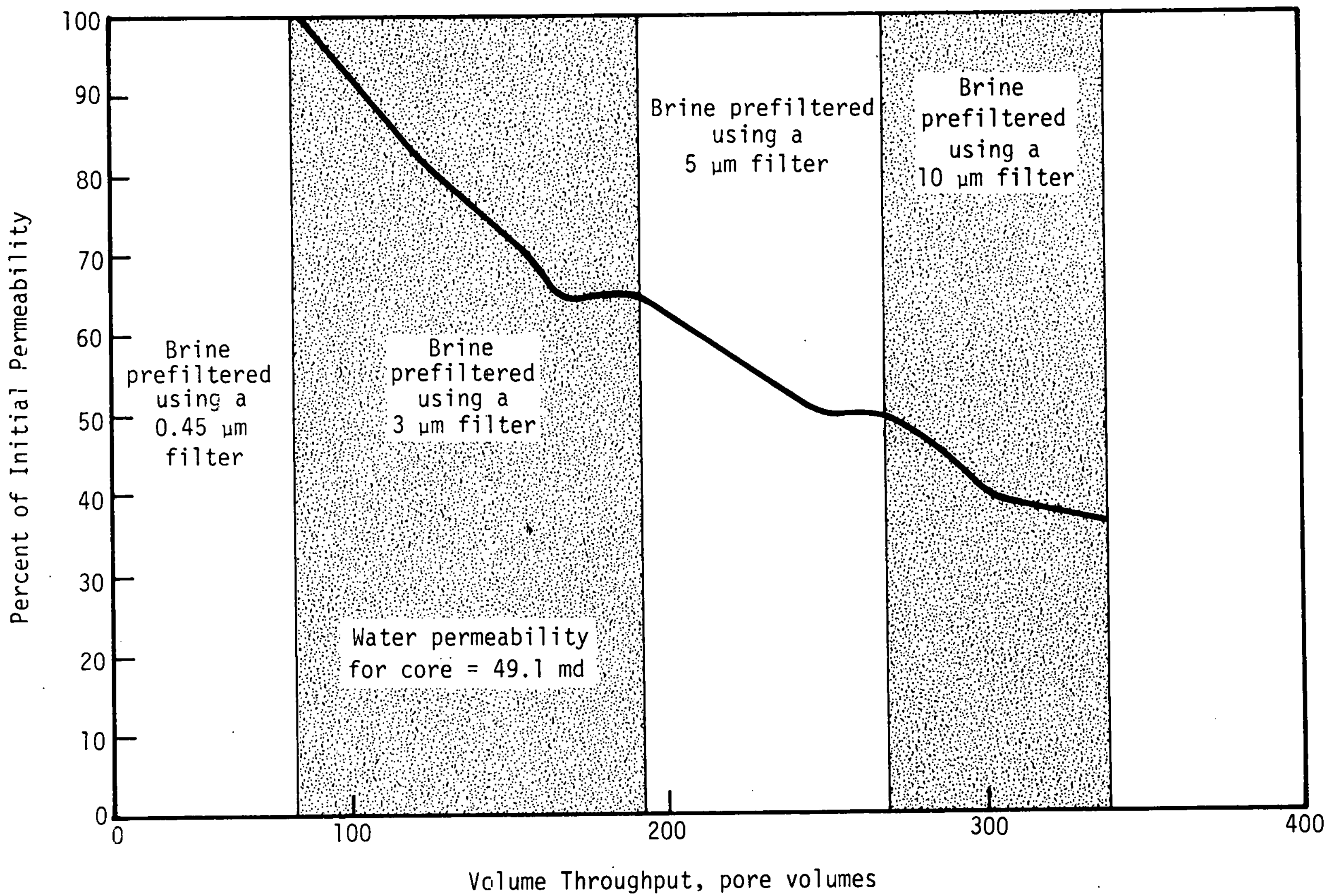


FIGURE A-13

PLUGGING TEST USING CORE FROM WELL MP-114

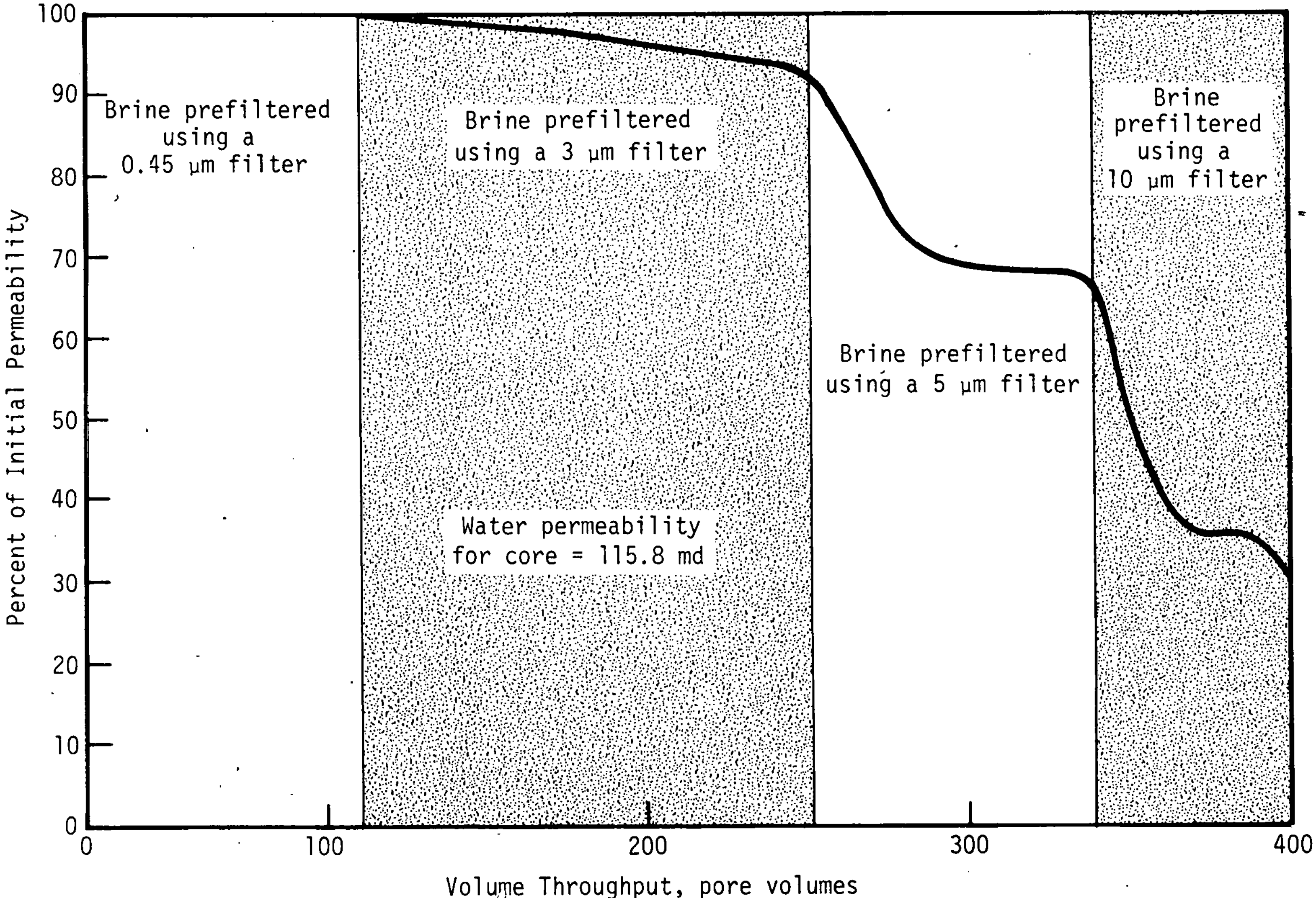


FIGURE A-14

PLUGGING TEST USING CORE FROM WELL HEGBERG 31-W

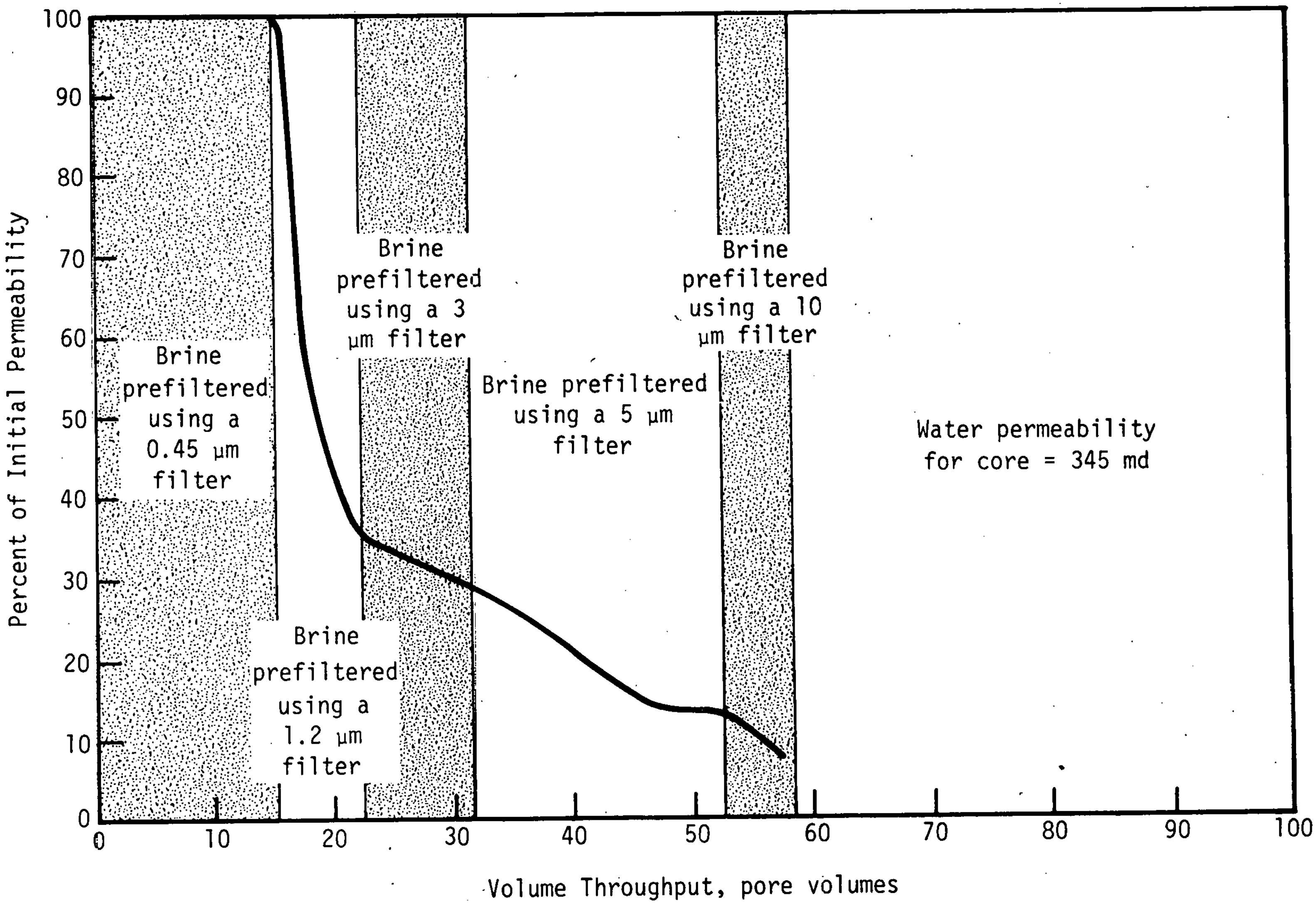


FIGURE A-15

CATION COMPOSITION OF PREFLOOD I INJECTED

VERSUS TIME

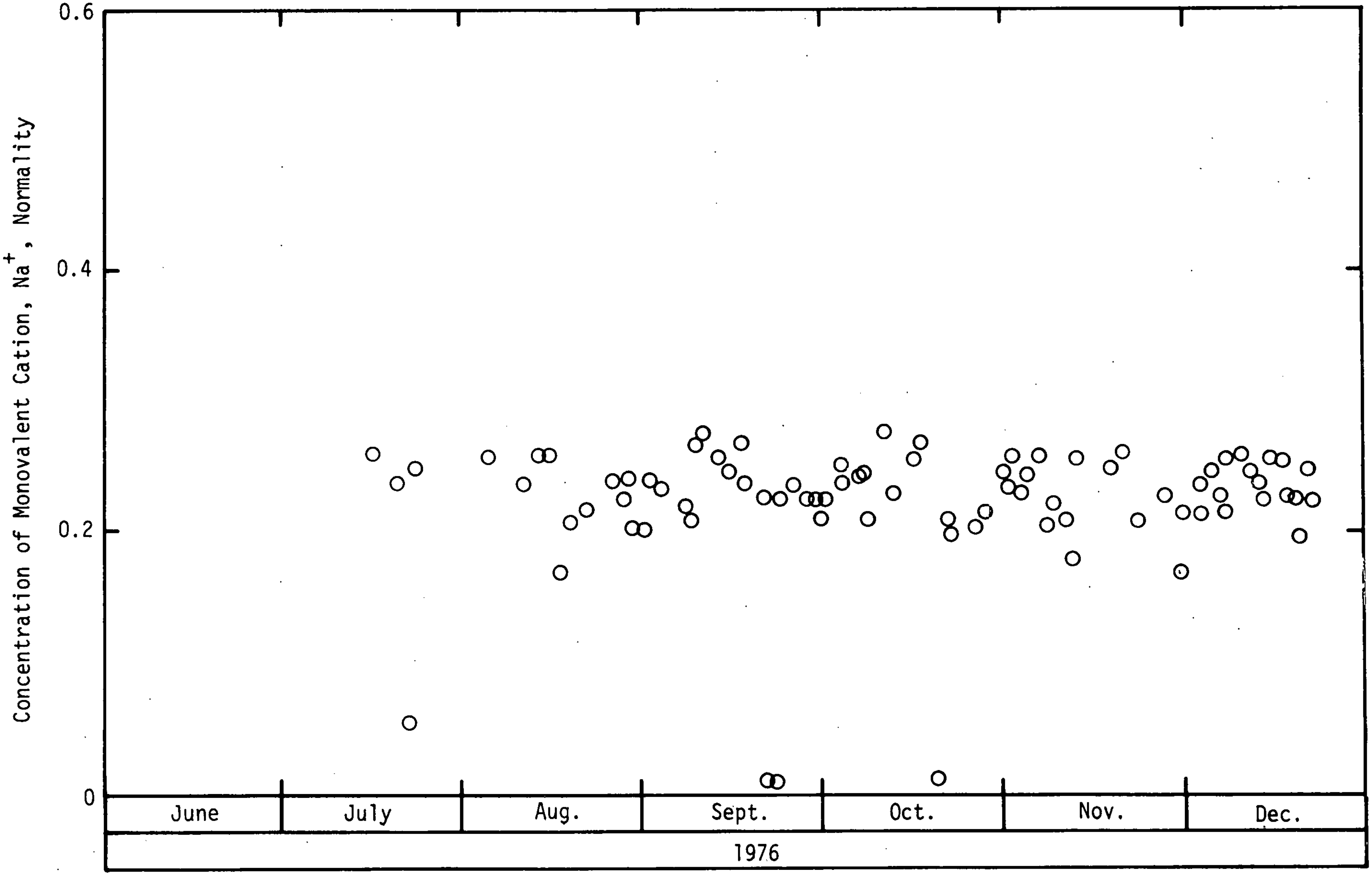


FIGURE A-16

CATION COMPOSITION OF PREFLOOD II INJECTED

VERSUS TIME

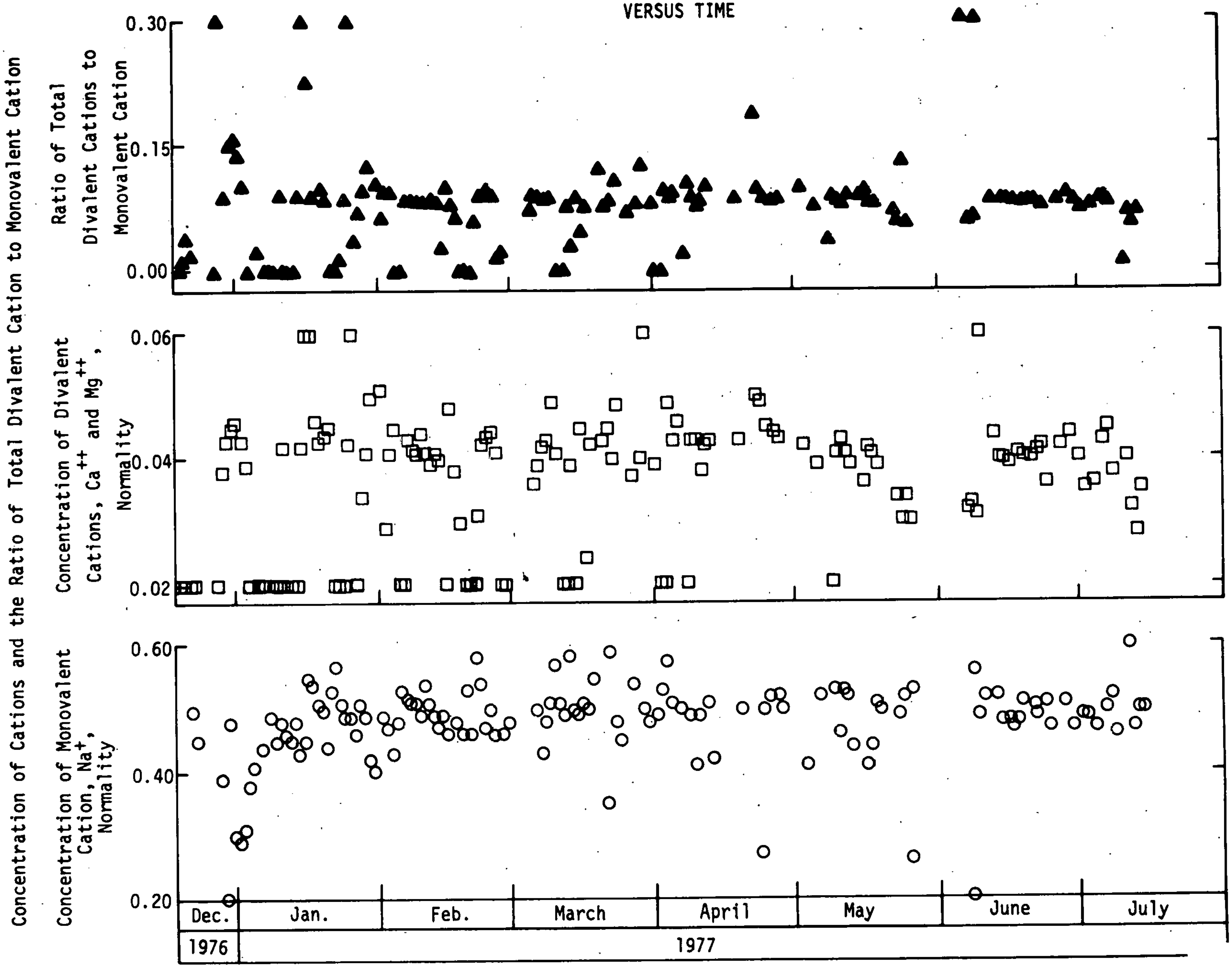


FIGURE A-17

ALKALINITY OF CHEMICAL PREFLUSH INJECTED VERSUS TIME

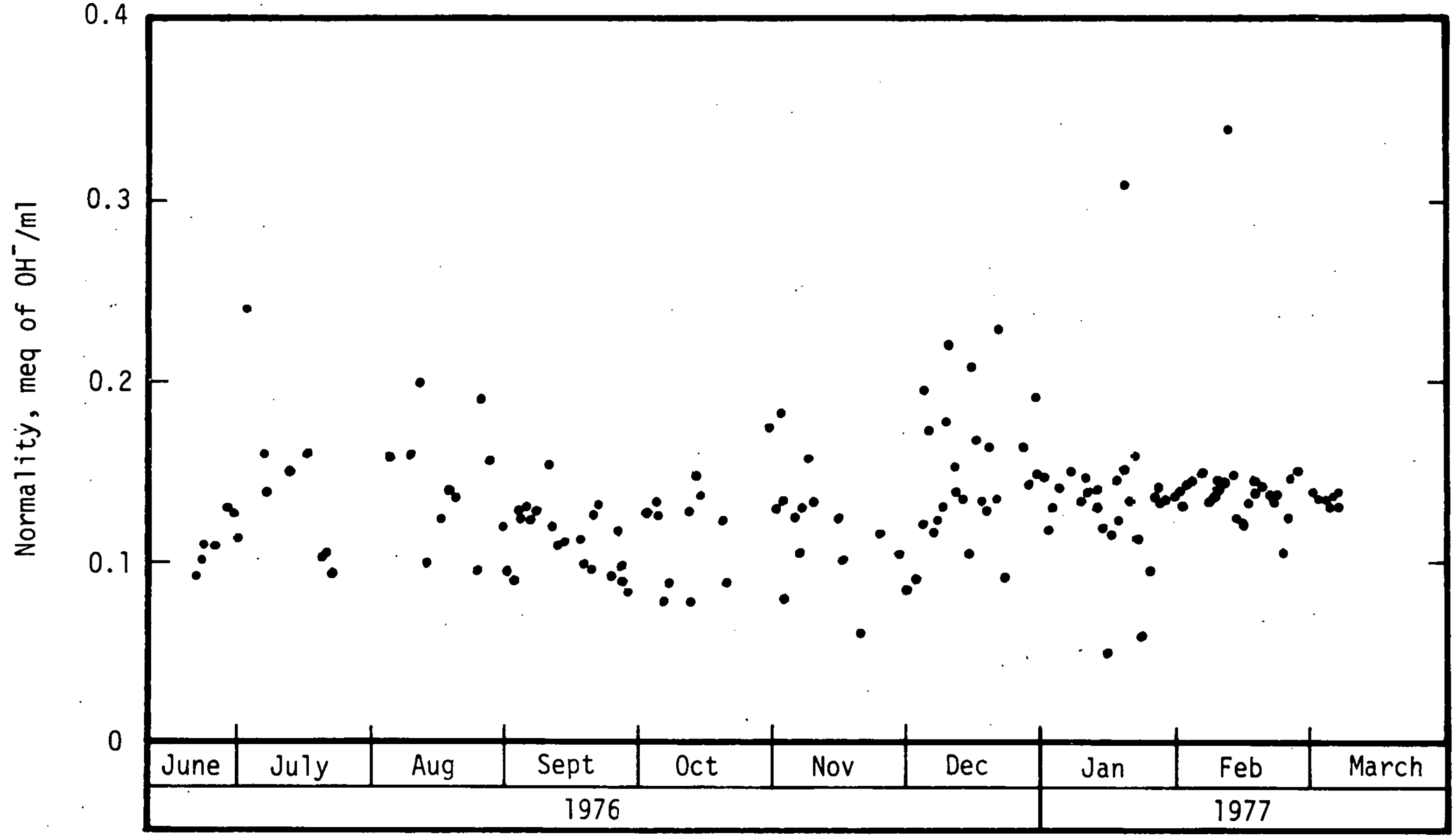


FIGURE A-18

SODIUM, CHLORIDE, CALCIUM, AND MAGNESIUM ION CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-112

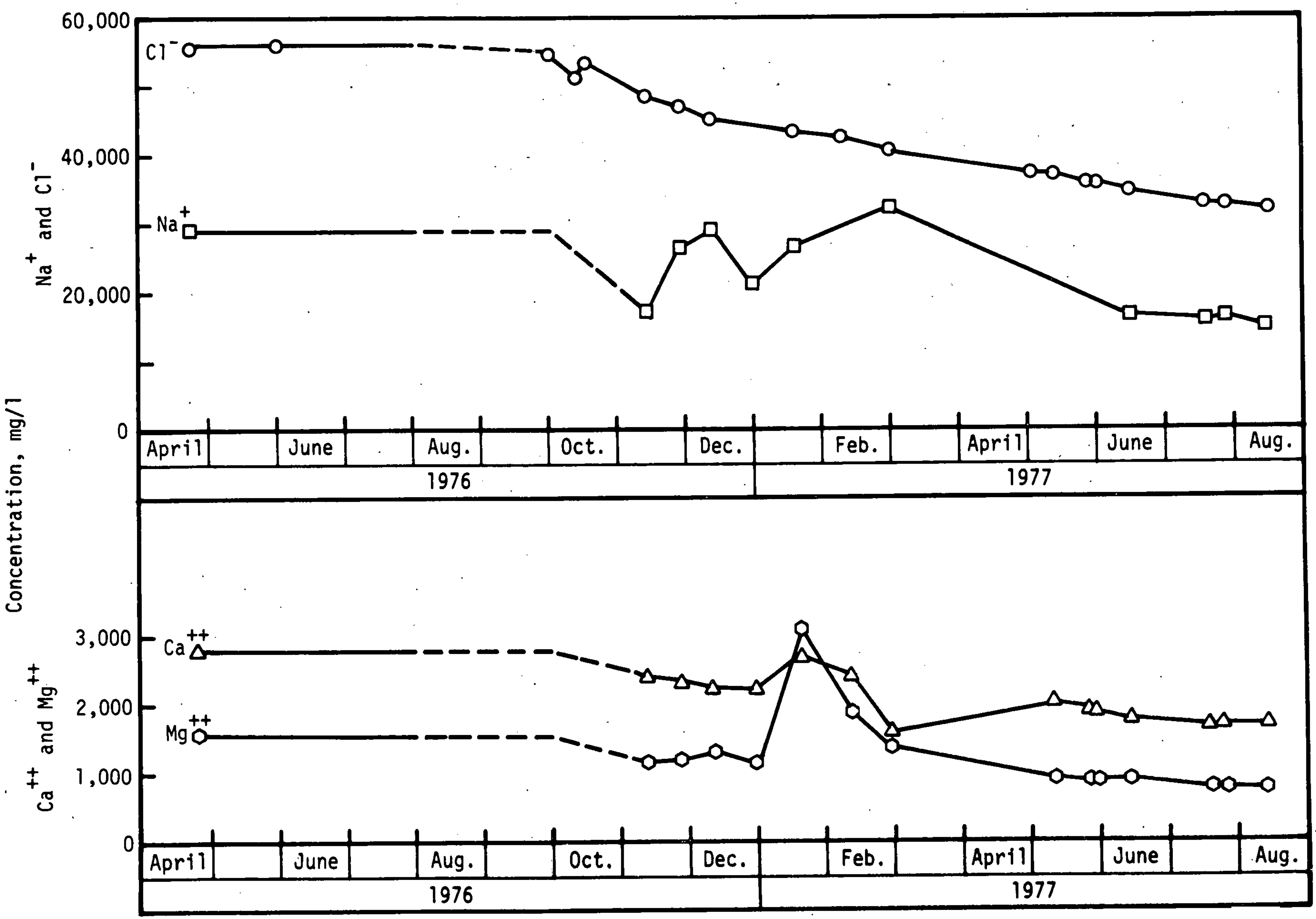


FIGURE A-19

CHLORIDE CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-114

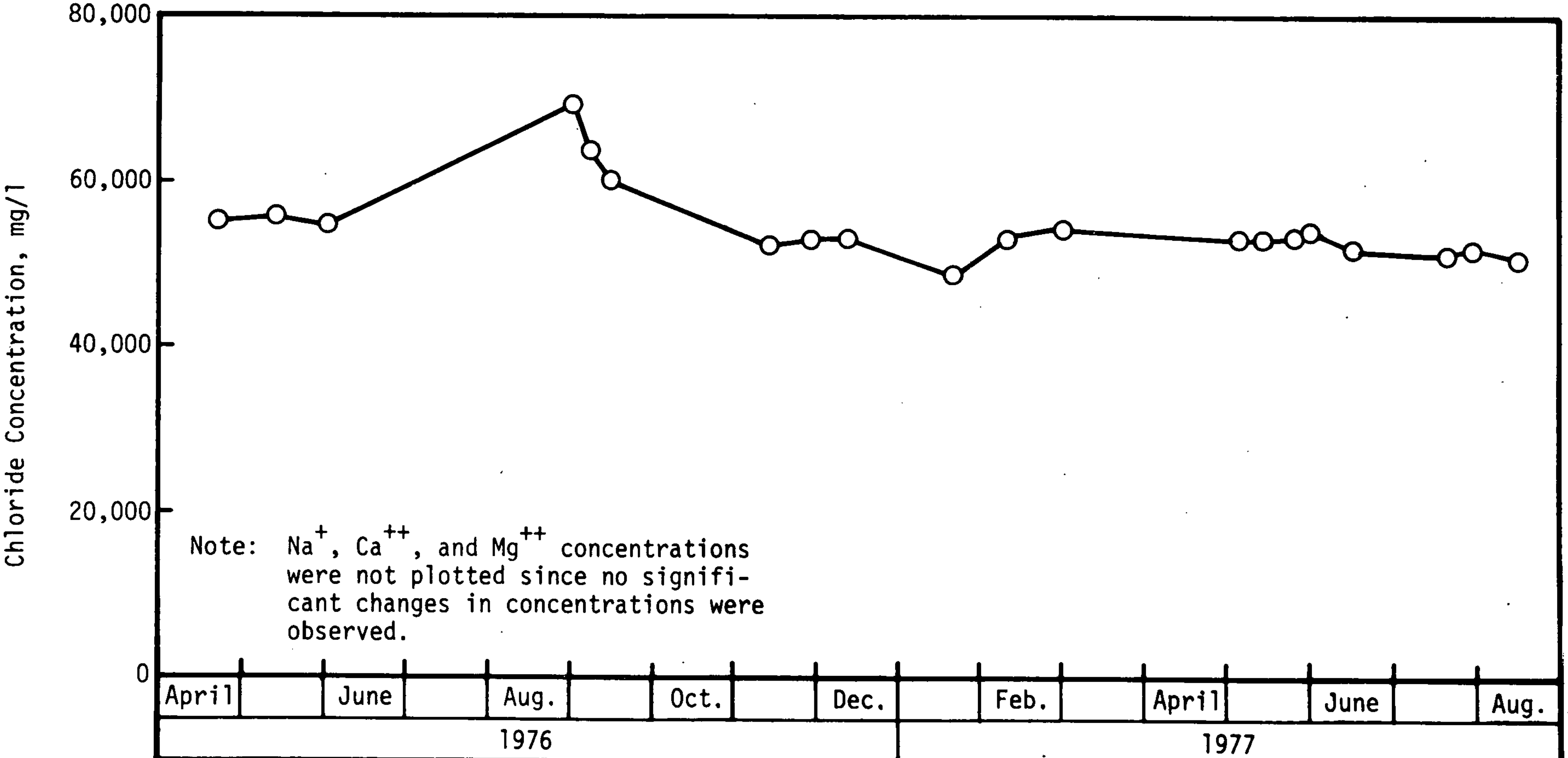


FIGURE A-20

SODIUM, CHLORIDE, CALCIUM, AND MAGNESIUM ION CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-122

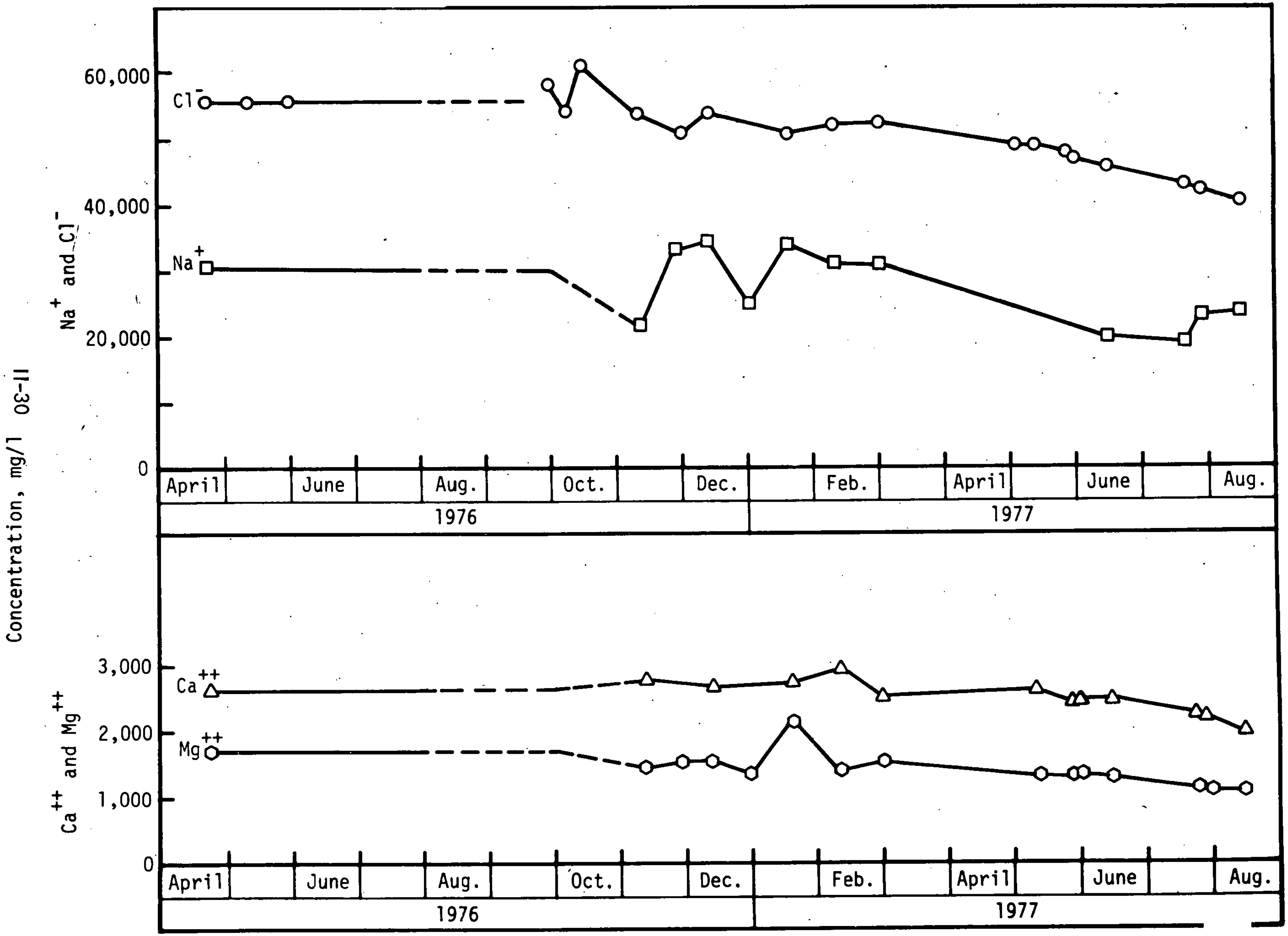


FIGURE A-21

SODIUM, CHLORIDE, CALCIUM, AND MAGNESIUM ION CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-124

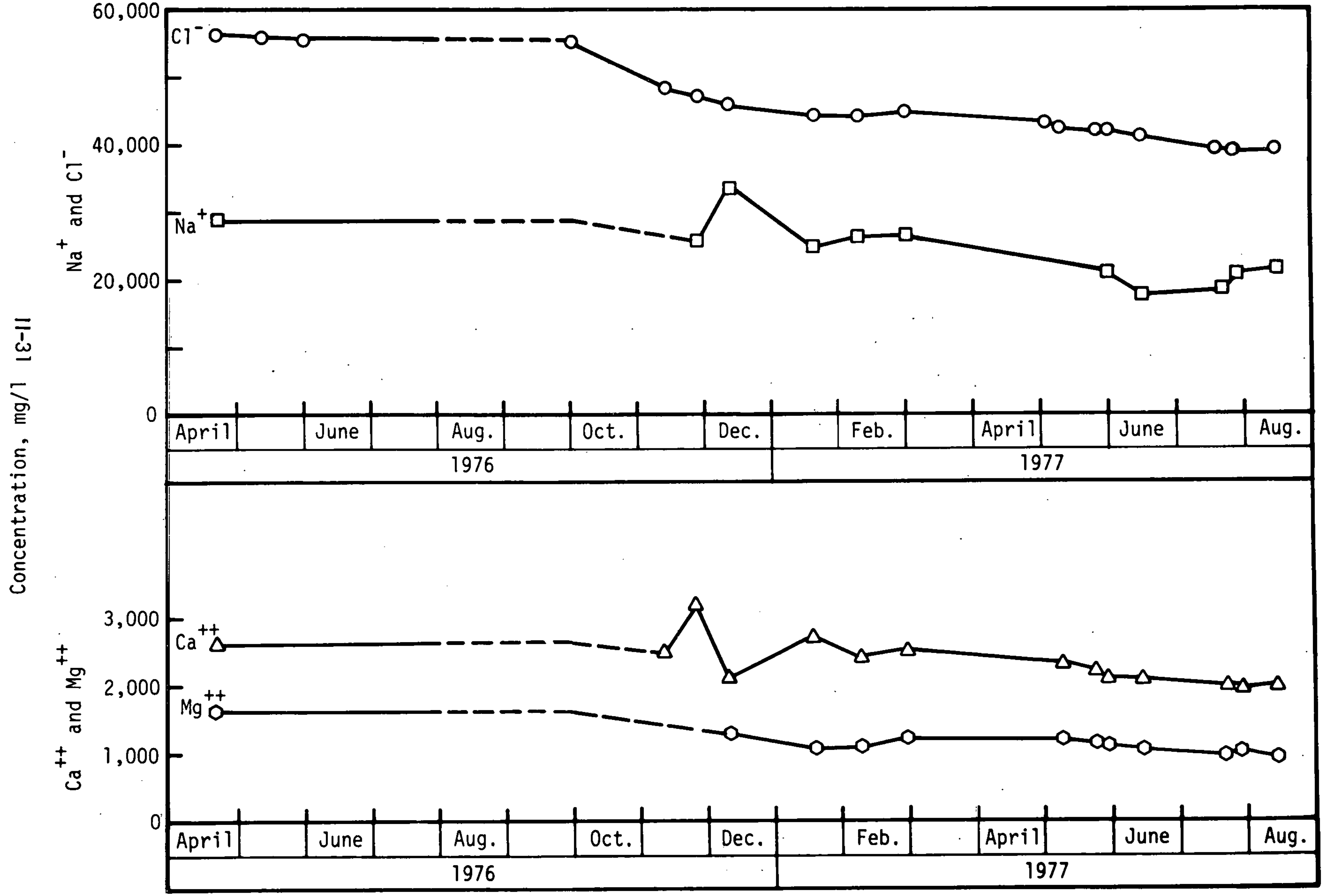


FIGURE A-22

SODIUM, CHLORIDE, CALCIUM, AND MAGNESIUM ION CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-131

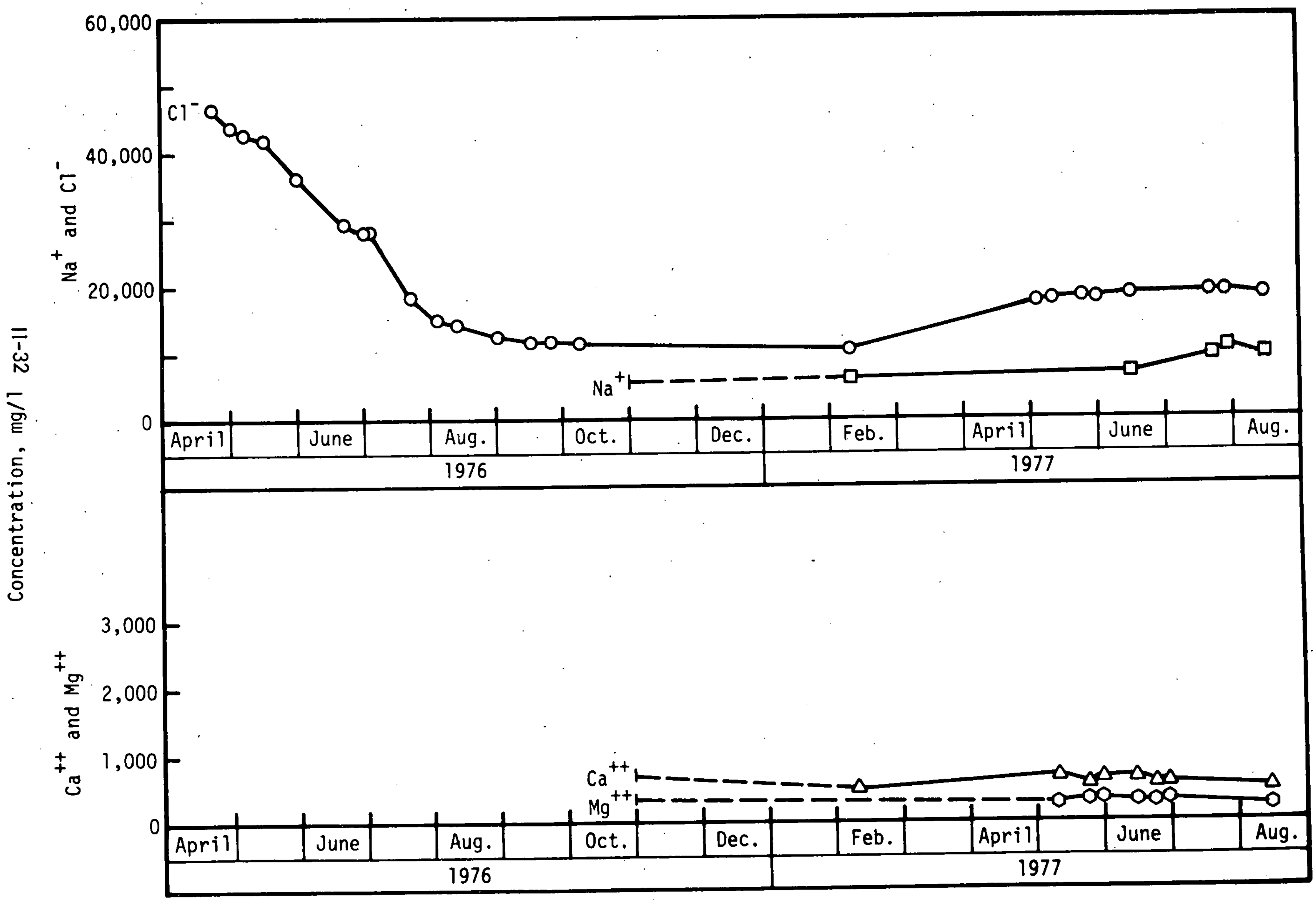


FIGURE A-23

SODIUM, CHLORIDE, CALCIUM, AND MAGNESIUM ION CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-132

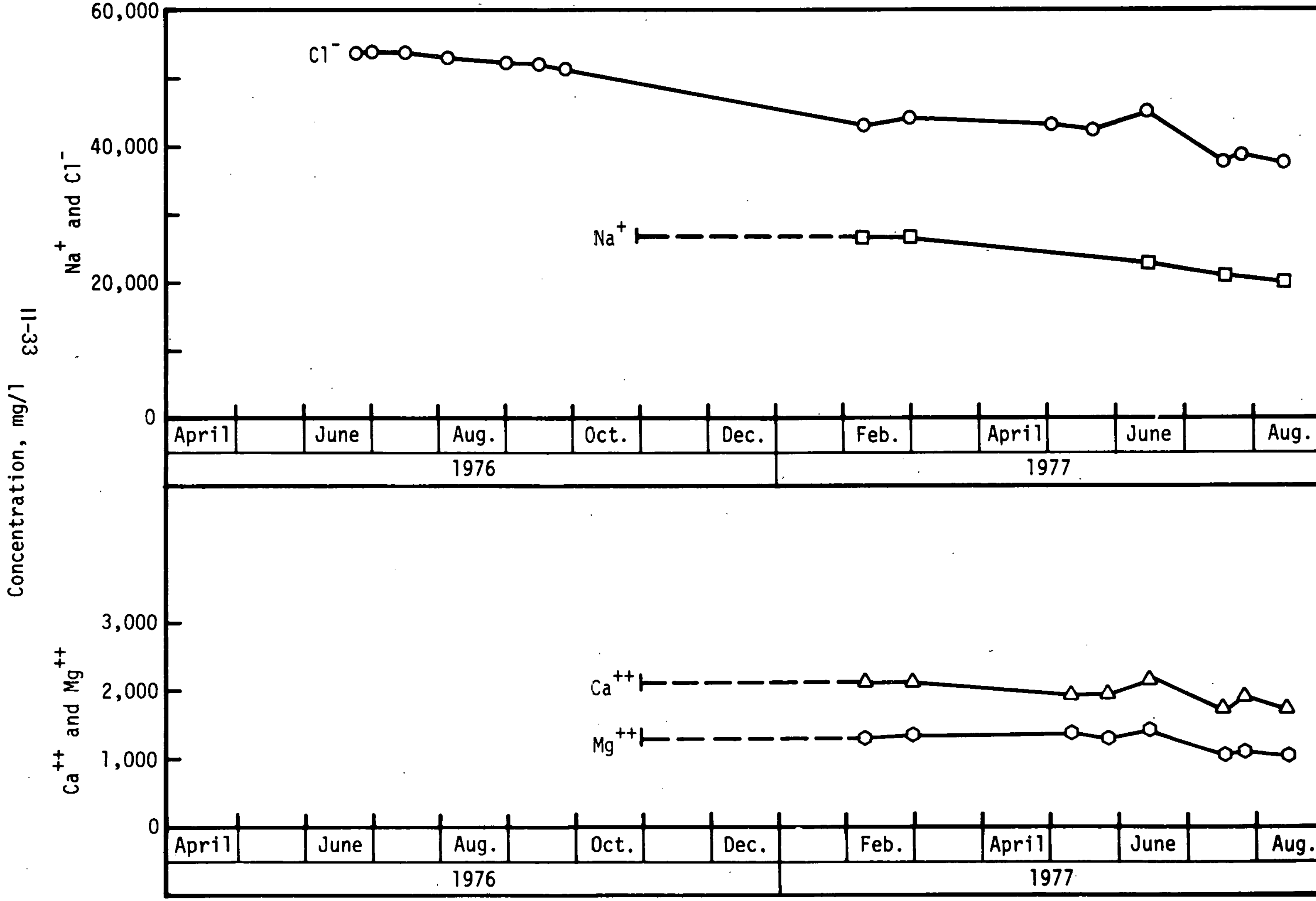


FIGURE A-24

CHLORIDE CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-207

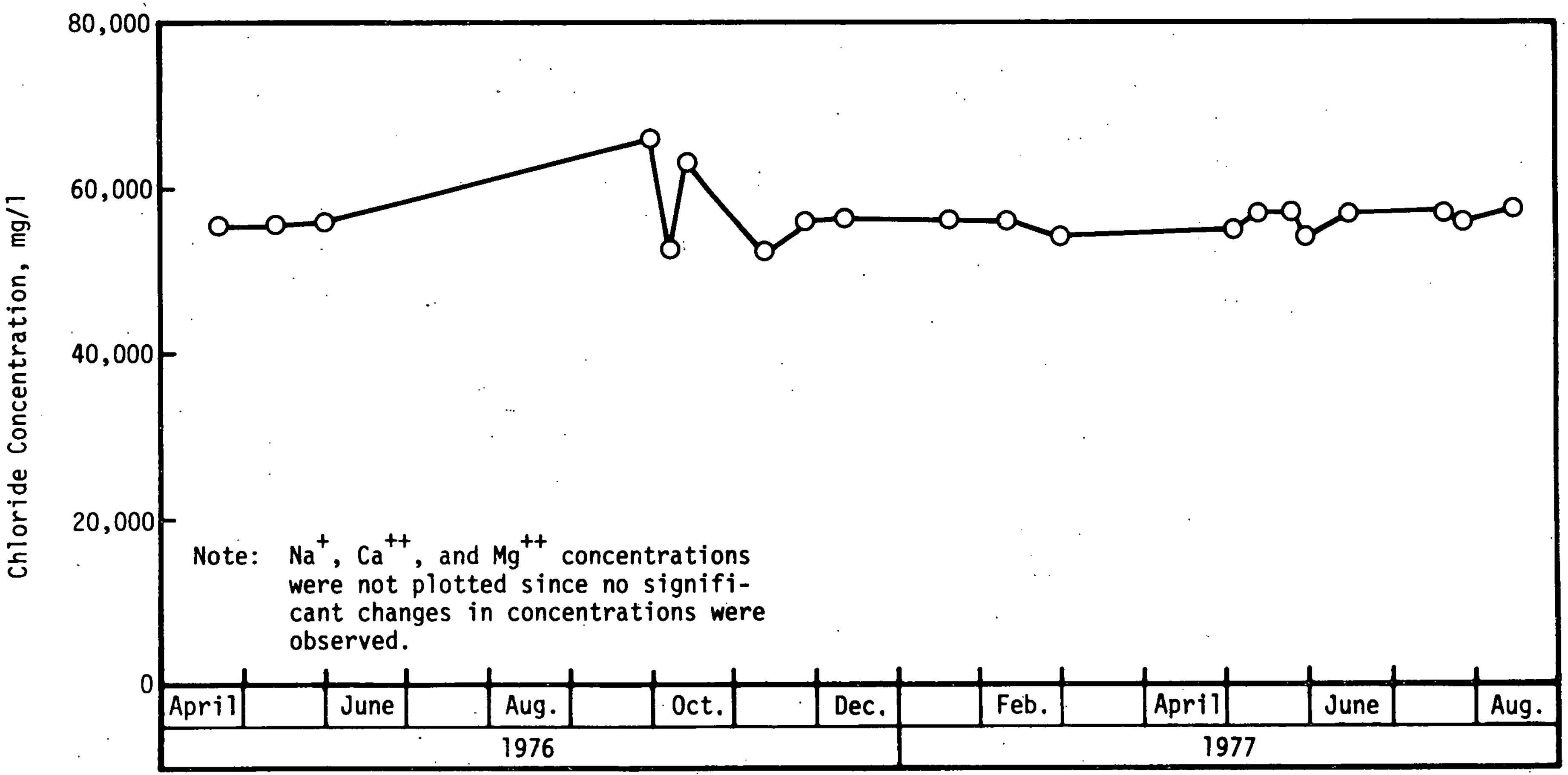


FIGURE A-25

SODIUM, CHLORIDE, CALCIUM, AND MAGNESIUM ION CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-209

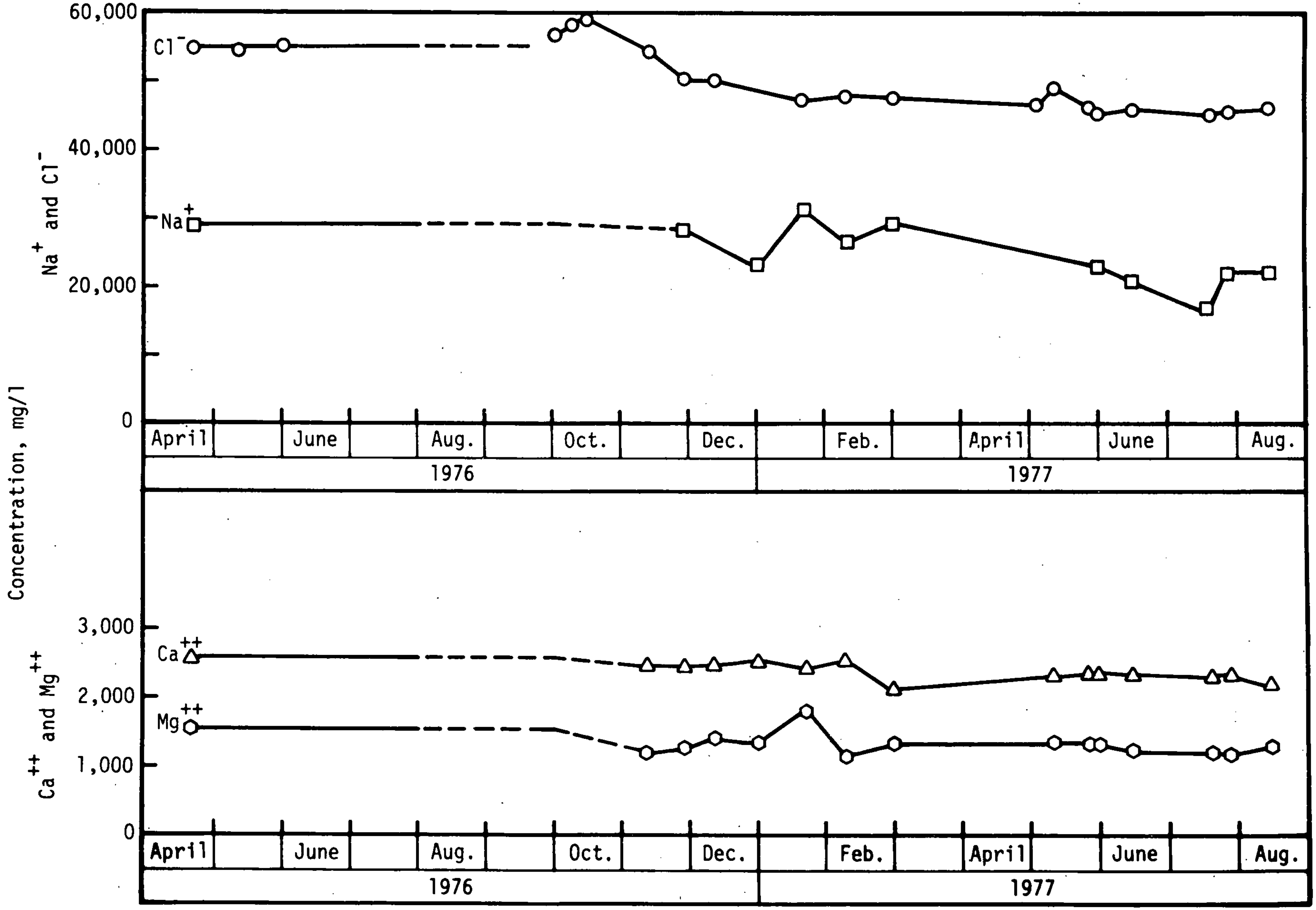


FIGURE A-26

SODIUM, CHLORIDE, CALCIUM, AND MAGNESIUM ION CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-217

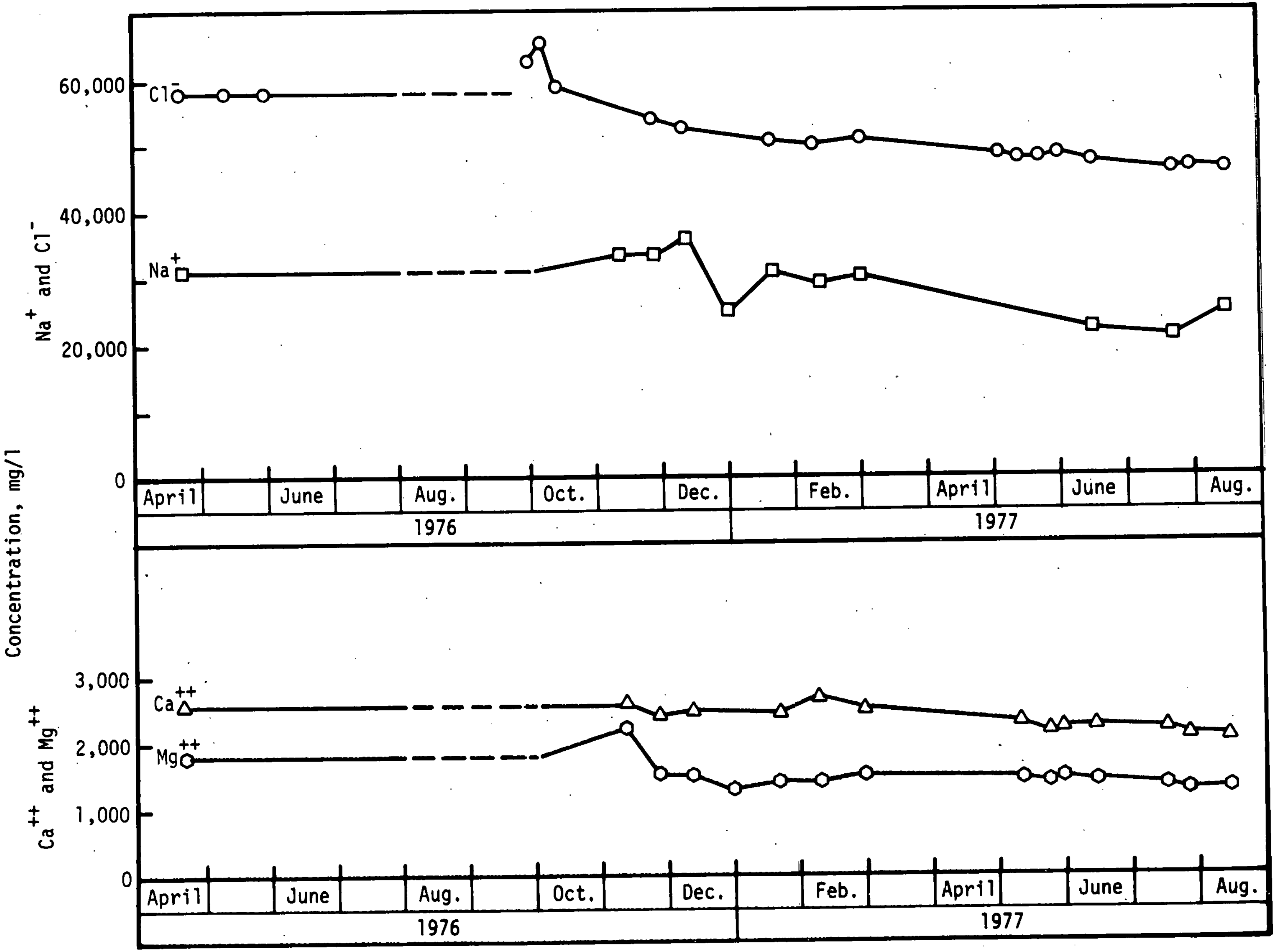


FIGURE A-27

CHLORIDE CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-219

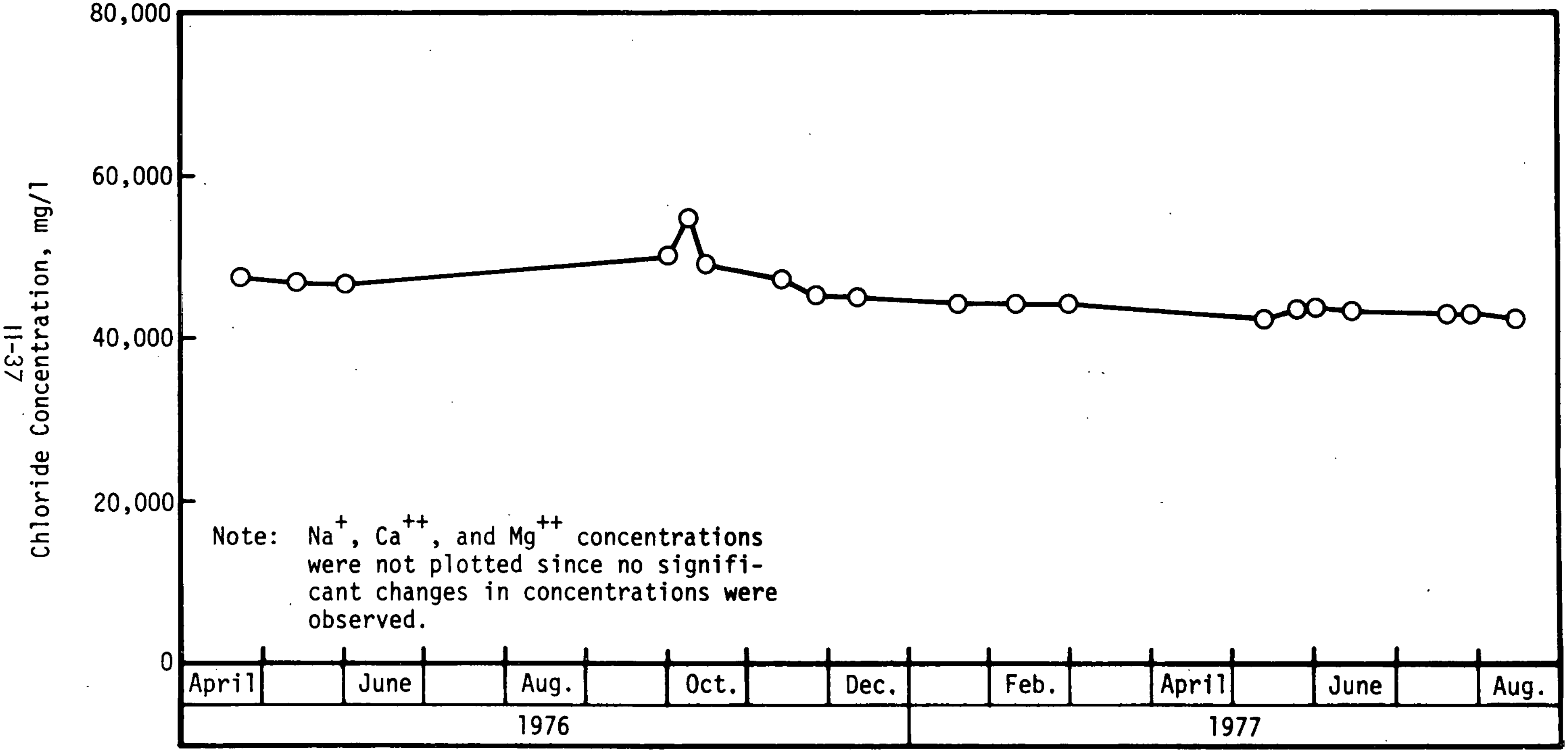


FIGURE A-28

CHLORIDE CONCENTRATIONS IN SAMPLES PRODUCED FROM WELL MP-227

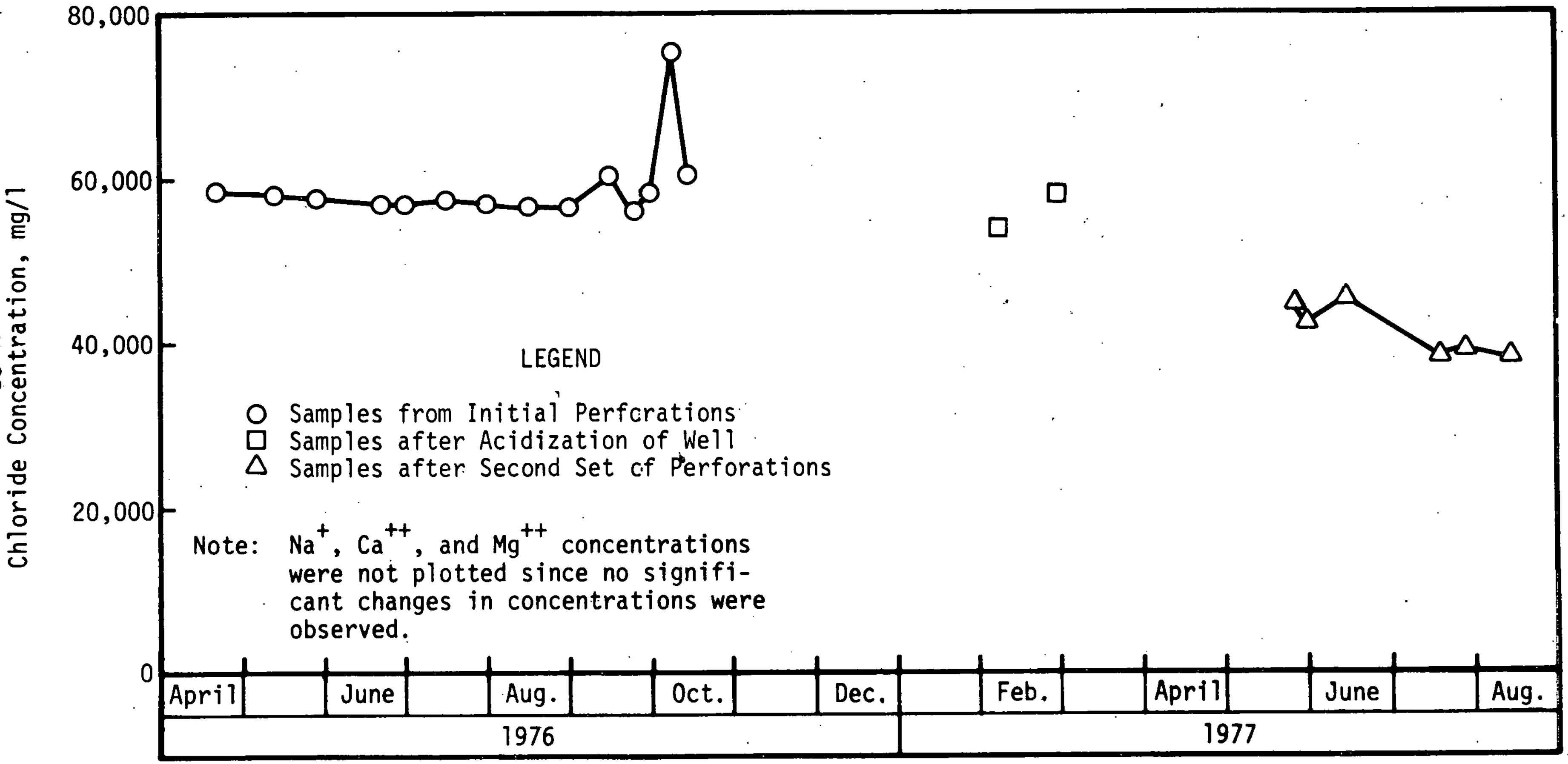
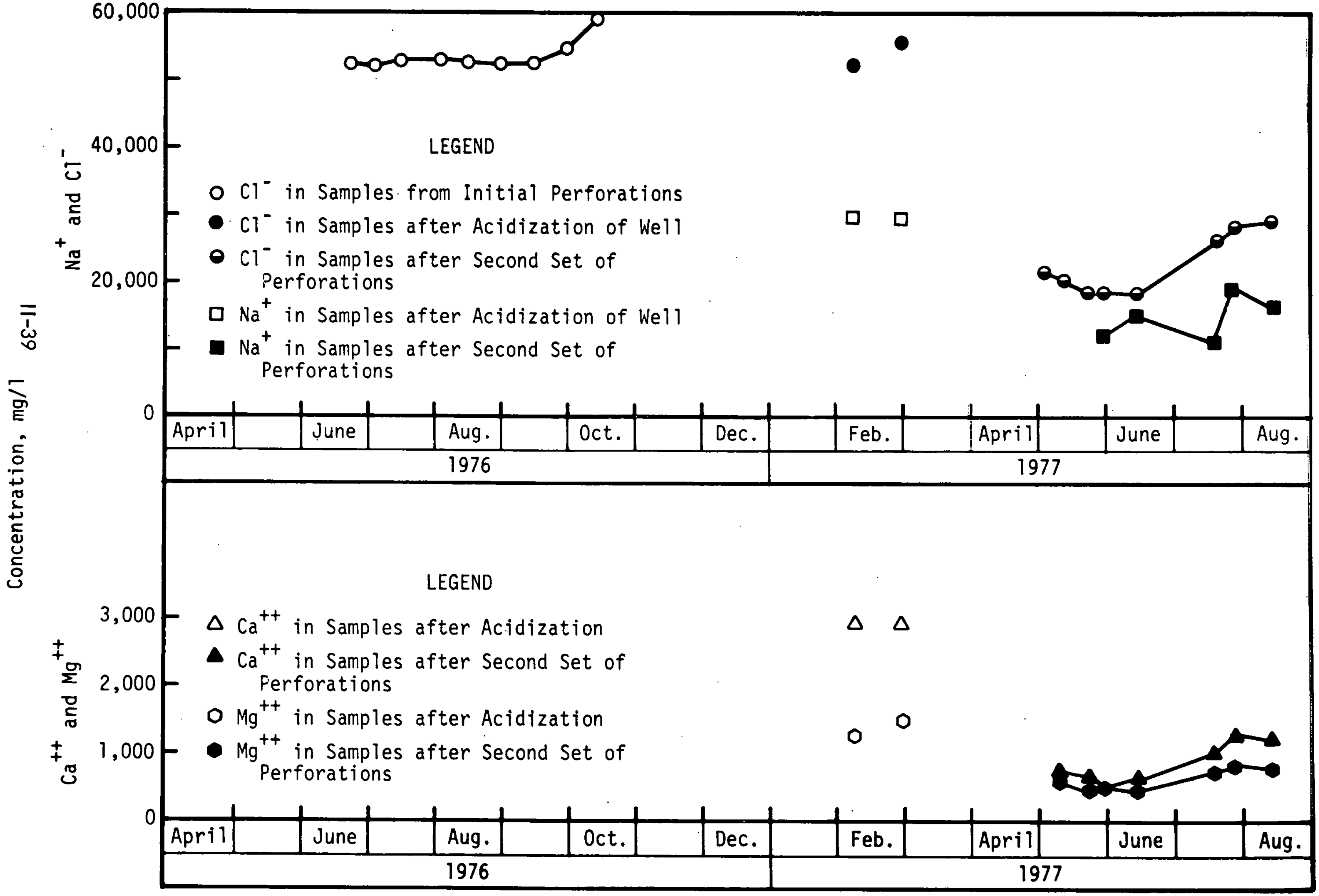


FIGURE A-29

SODIUM, CHLORIDE, CALCIUM, AND MAGNESIUM ION CONCENTRATIONS IN SAMPLES PRODLCED FROM WELL MP-228



APPENDIX B

CORING AND CORE ANALYSES

Tables and Figures

TABLE B1

ROUTINE CORE ANALYSIS RESULTS

VERSUS DEPTH FOR WELL MP-227

Depth, feet	Permeability to Air, md	Porosity, percent	Grain Density, gm/cc	Bulk Density, gm/cc	Comments
668.1	700	28.7	2.68	1.91	Fluid Saturations Not Measured
668.7	940	29.4	2.68	1.89	
669.2	790	29.9	2.68	1.88	
669.3	770	29.5	2.69	1.89	
669.6	830	26.9	2.69	1.96	
670.3	470	28.8	2.70	1.92	
671.9	420	28.0	2.69	1.93	
672.0	270	27.5	2.70	1.95	
673.4	980	29.5	2.68	1.89	
674.3	810	27.6	2.69	1.94	
675.8	810	29.0	2.70	1.92	
676.4	104	24.6	2.74	2.07	
676.9	540	28.2	2.69	1.90	
677.5	490	27.5	2.68	1.94	
678.9	1160	29.0	2.68	1.90	
679.6	650	28.2	2.68	1.92	
679.7	220	26.1	2.70	2.00	
Arithmetic Averages	664	28.1	2.69	1.93	

TABLE B2

ROUTINE CORE ANALYSIS RESULTS

VERSUS DEPTH FOR WELL MP-228

Depth, feet	Permeability to Air, md	Porosity, percent	Grain Density, gm/cc	Bulk Density, gm/cc	Comments
662.0	25.0	23.9	2.70	2.05	Fluid Saturations Not Measured
662.9	47.0	25.3	2.69	2.01	
664.5	131.0	26.4	2.71	2.00	
665.8	370.0	26.9	2.71	1.98	
666.7	0.29	6.4	2.76	2.58	
667.0	Broken	26.9	2.69	1.97	
668.5	540.0	29.0	2.70	1.92	
669.0	225.0	23.0	2.72	2.09	
669.8	400.0	28.4	2.69	1.92	
670.6	810.0	30.8	2.70	1.87	
671.9	660.0	29.6	2.70	1.90	
672.2	1150.0	32.1	2.71	1.84	
674.0	750.0	30.7	2.69	1.87	
674.6	694.0	28.8	2.68	1.91	
675.1	Broken	29.3	2.69	1.90	
676.0	500.0	29.0	2.70	1.92	
677.5	650.0	29.3	2.70	1.91	
677.8	590.0	29.1	2.69	1.90	
678.8	Broken	28.8	2.69	1.92	
680.7	0.4	19.3	2.85	2.30	
Arithmetic Averages	443.7	26.6	2.71	1.99	

FIGURE B-1

CAPILLARY PRESSURE DATA FOR CORE FROM WELL MP-106

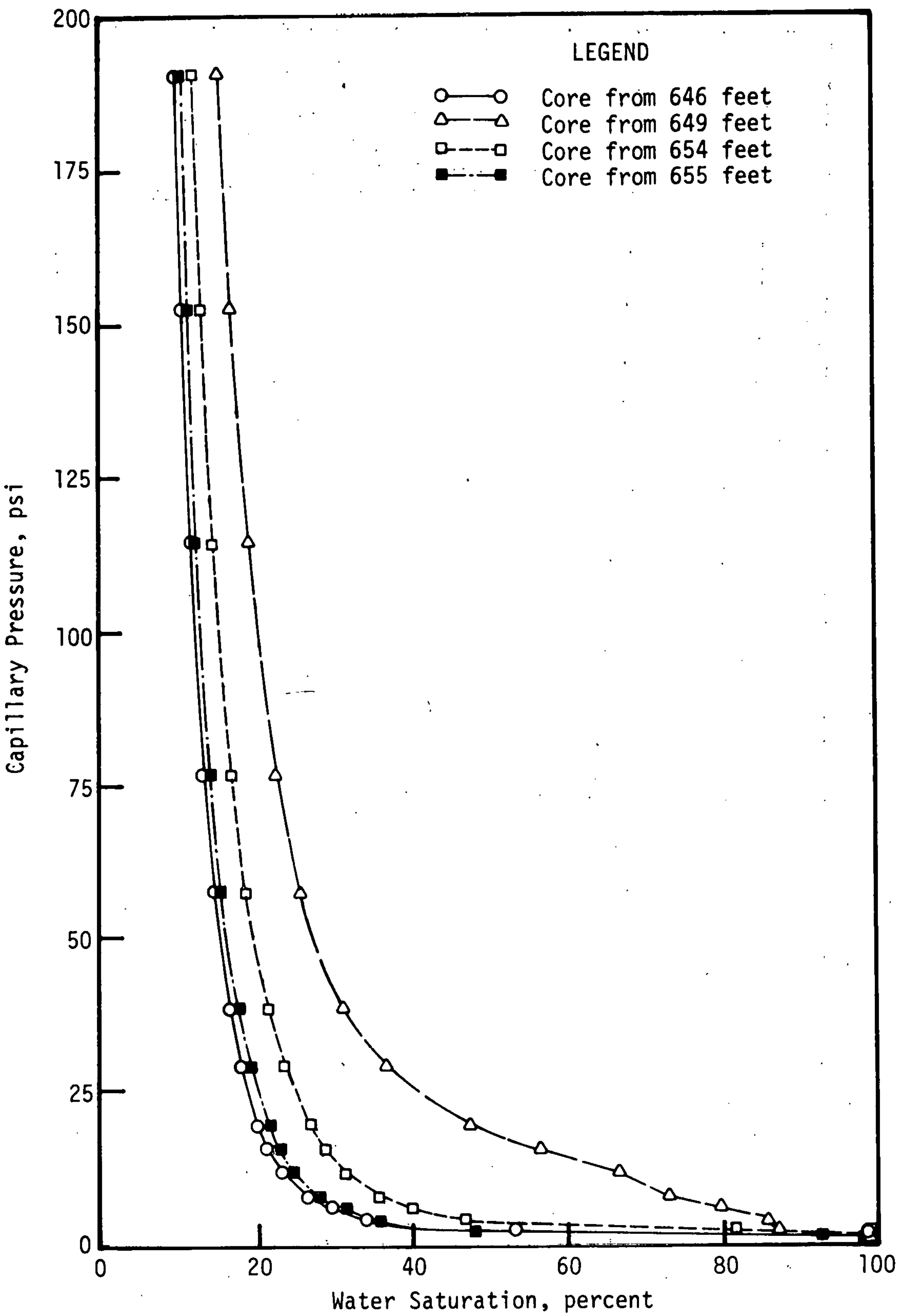


FIGURE B-2

CAPILLARY PRESSURE DATA FOR CORE FROM WELL MP-110

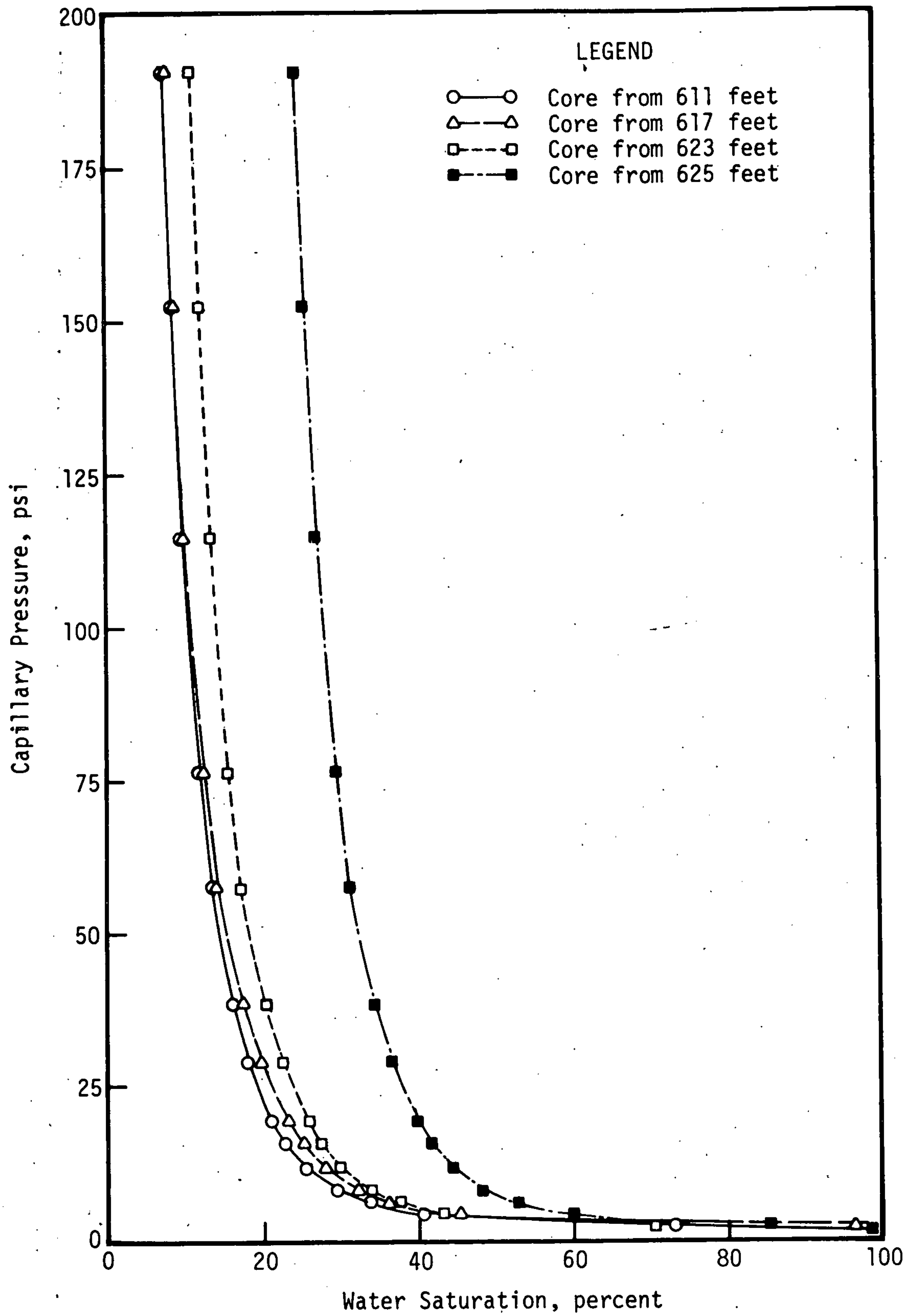
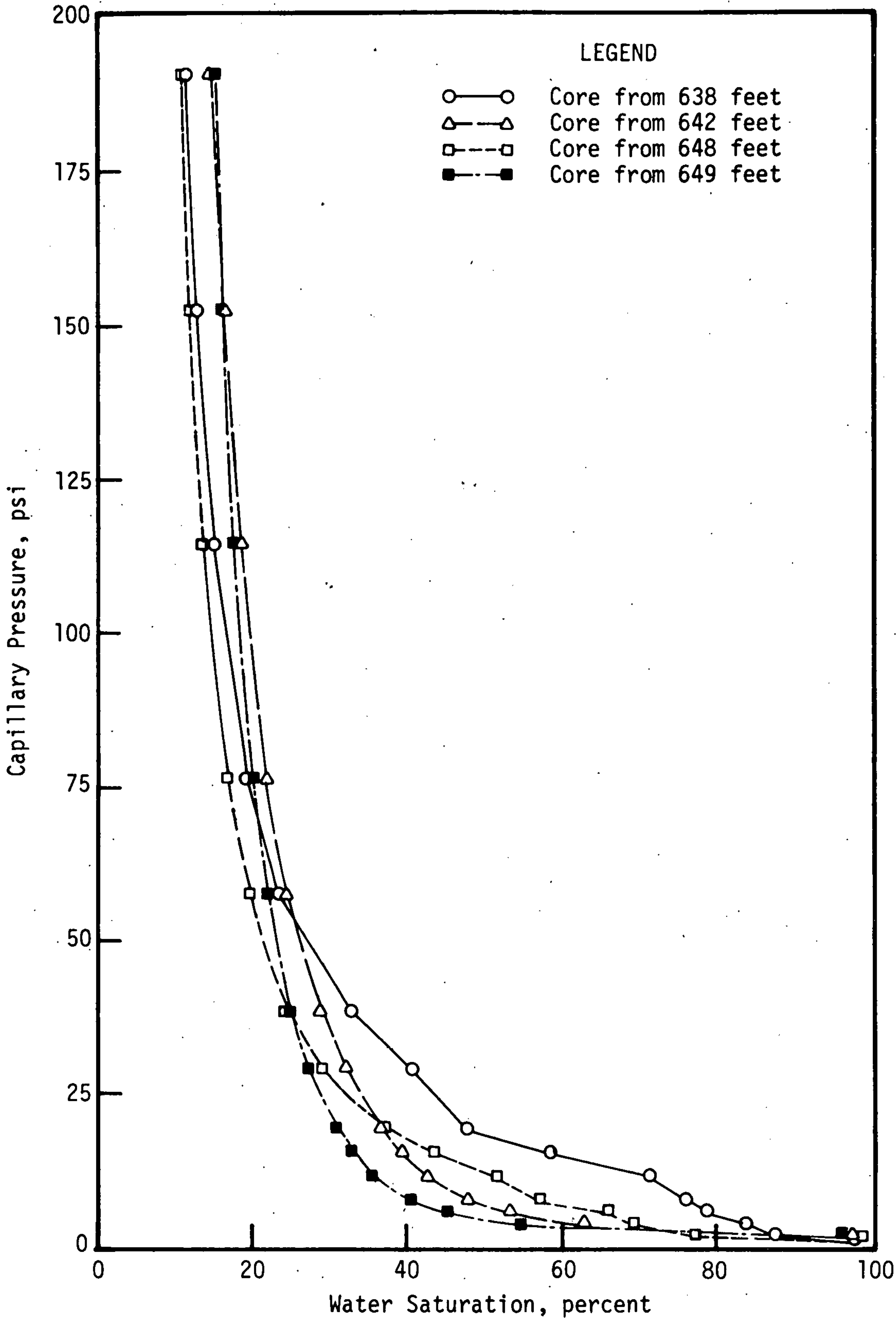


FIGURE B-3

CAPILLARY PRESSURE DATA FOR CORE FROM WELL MP-122



APPENDIX C

OBSERVATION WELL LOGGING

Table and Figures

TABLE C1

COMPARISON OF SALINITIES AT THE PERFORATIONS

AS DETERMINED FROM WELL LOGGING AND FROM THE

SALINITIES OF SAMPLES PRODUCED FROM OBSERVATION WELLS

	Well Logging			Produced Samples	
Well Number	Logging Run Number	Date Well Log Run	Salinity as NaCl from Well Logs, ppm	Date Sample Taken	Salinity as NaCl from Chloride Analyses, ppm
MP-131	Cased Hole #5	3-07-77	22,500 (original)*	2-09-77	17,050
	Cased Hole #6	6-29-77	24,600 (original)*	6-15-77	30,000
MP-132	Cased Hole #3	3-07-77	77,000 (original)*	3-01-77	69,800
	Cased Hole #4	6-29-77	51,200 (original)*	6-15-77	71,050
				7-20-77	60,450
MP-227	Cased Hole #3	3-07-77	108,500 (top)*	3-01-77	88,700‡
			26,900 (bottom)*		
	Cased Hole #4	6-29-77	81,700 (top)*	6-15-77	70,200‡
			24,600 (bottom)*		
				7-20-77	60,050‡
MP-228	Cased Hole #2	3-07-77	62,800 (top)*	3-01-77	86,350
	Cased Hole #3	6-29-77	37,800 (bottom)*	6-15-77	29,850
				7-20-77	41,450

*"Original" means at the original perforations. "Top" means at the top perforations which are the original perforations. "Bottom" means at the bottom perforations.

‡These are composite samples--a mixture of fluids from the top and bottom perforations.

FIGURE C-1

PROJECT LAYOUT SHOWING LOCATION OF THE OBSERVATION WELLS

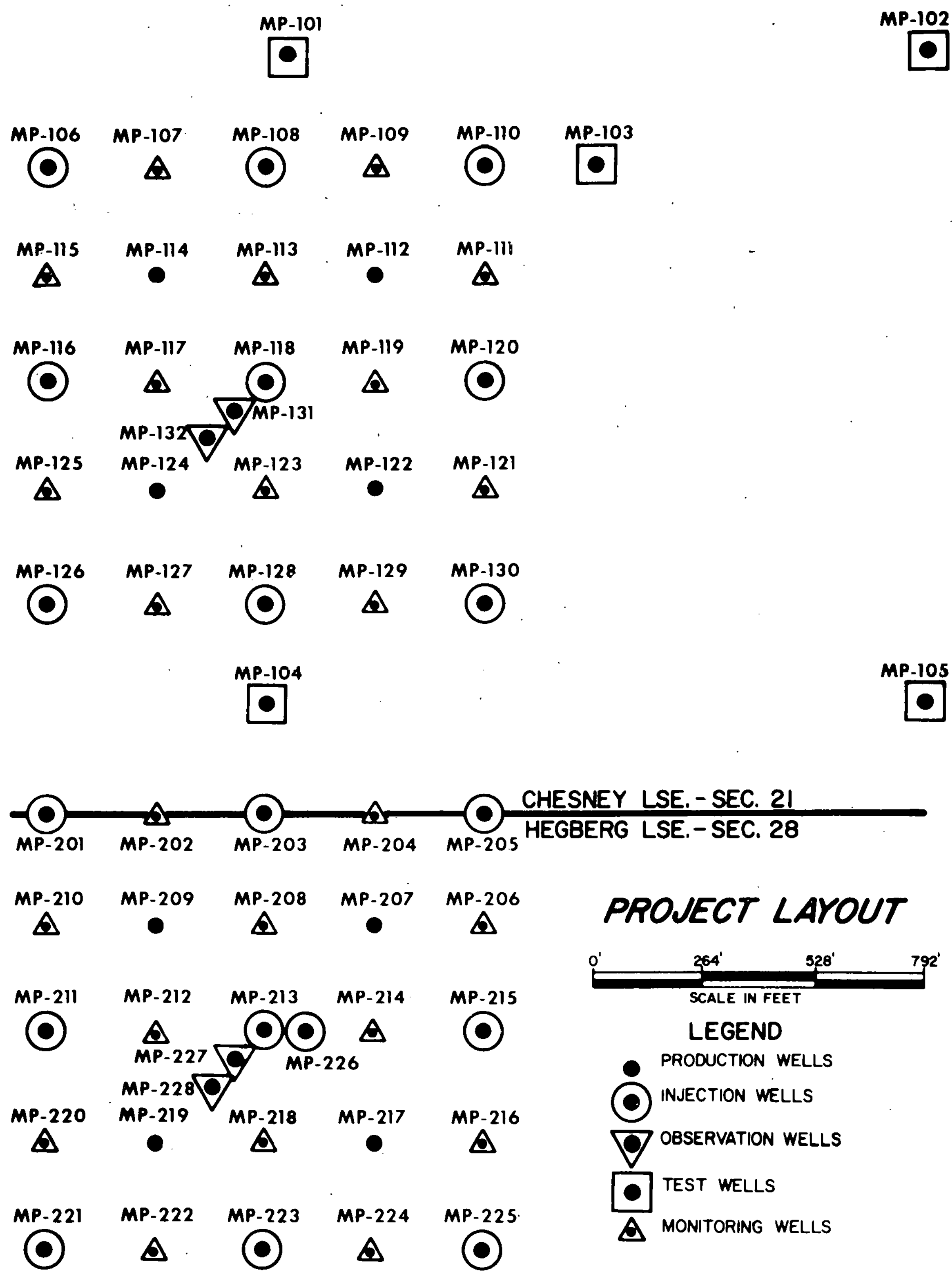
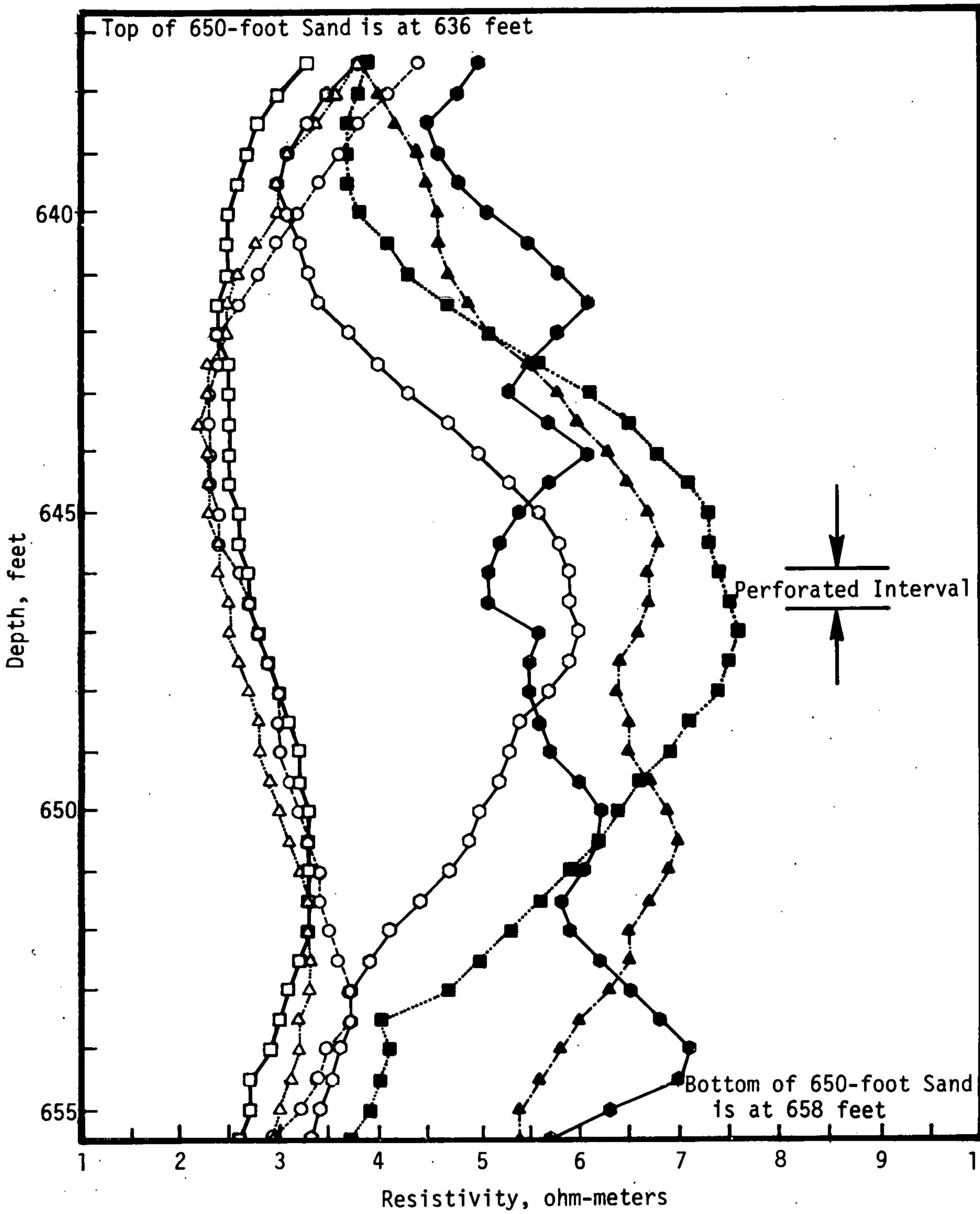


FIGURE C-2

RESISTIVITY VERSUS DEPTH FOR WELL MP-131

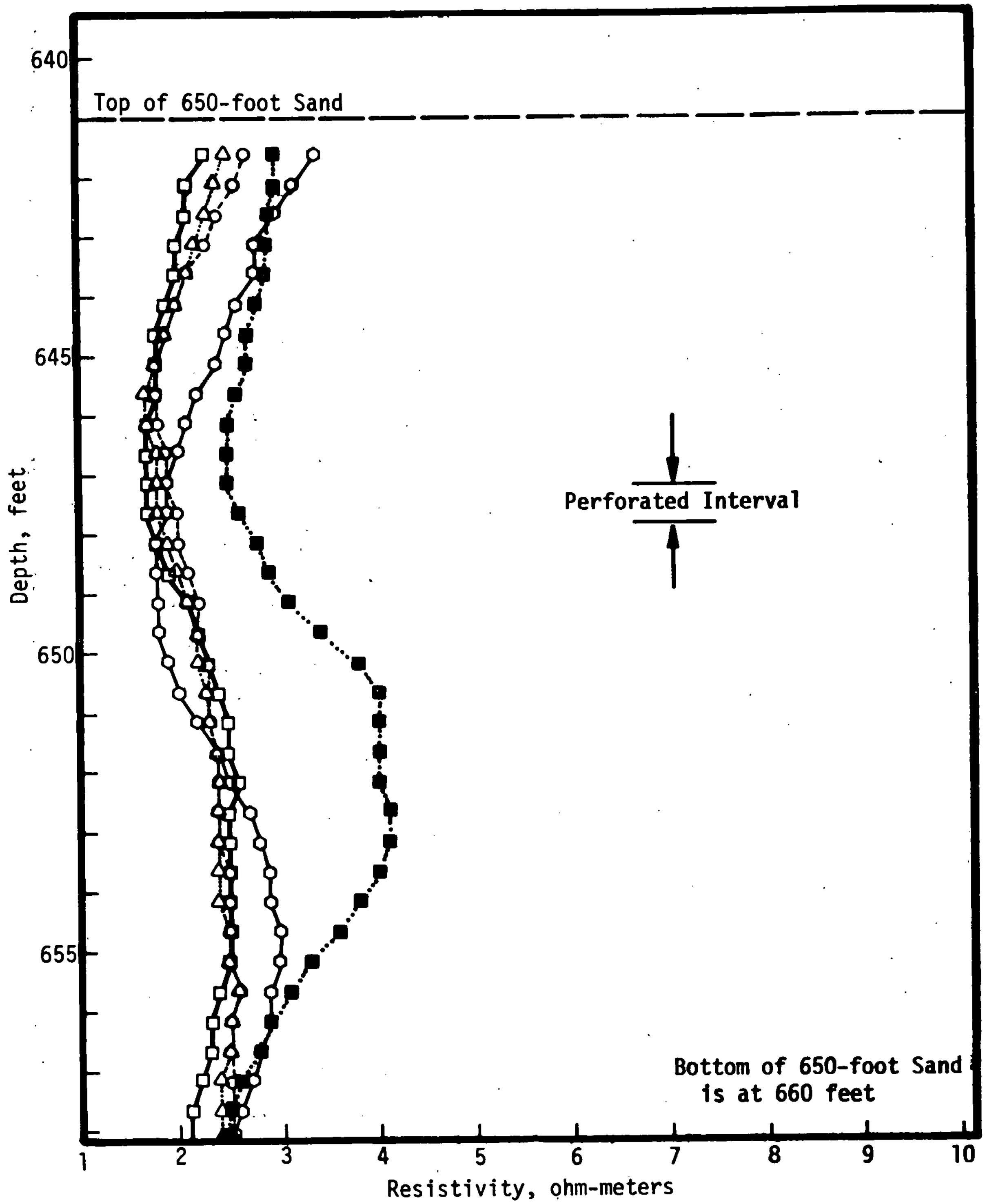


LEGEND

- Open-hole Log, March 21, 1976
- Cased-hole Log, Run #1, March 30, 1976
- Cased-hole Log, Run #2, May 18, 1976
- Cased-hole Log, Run #3, July 13, 1976
- Cased-hole Log, Run #4, November 1, 1976
- Cased-hole Log, Run #5, March 7, 1977
- Cased-hole Log, Run #6, June 29, 1977

FIGURE C-3

RESISTIVITY VERSUS DEPTH FOR WELL MP-132

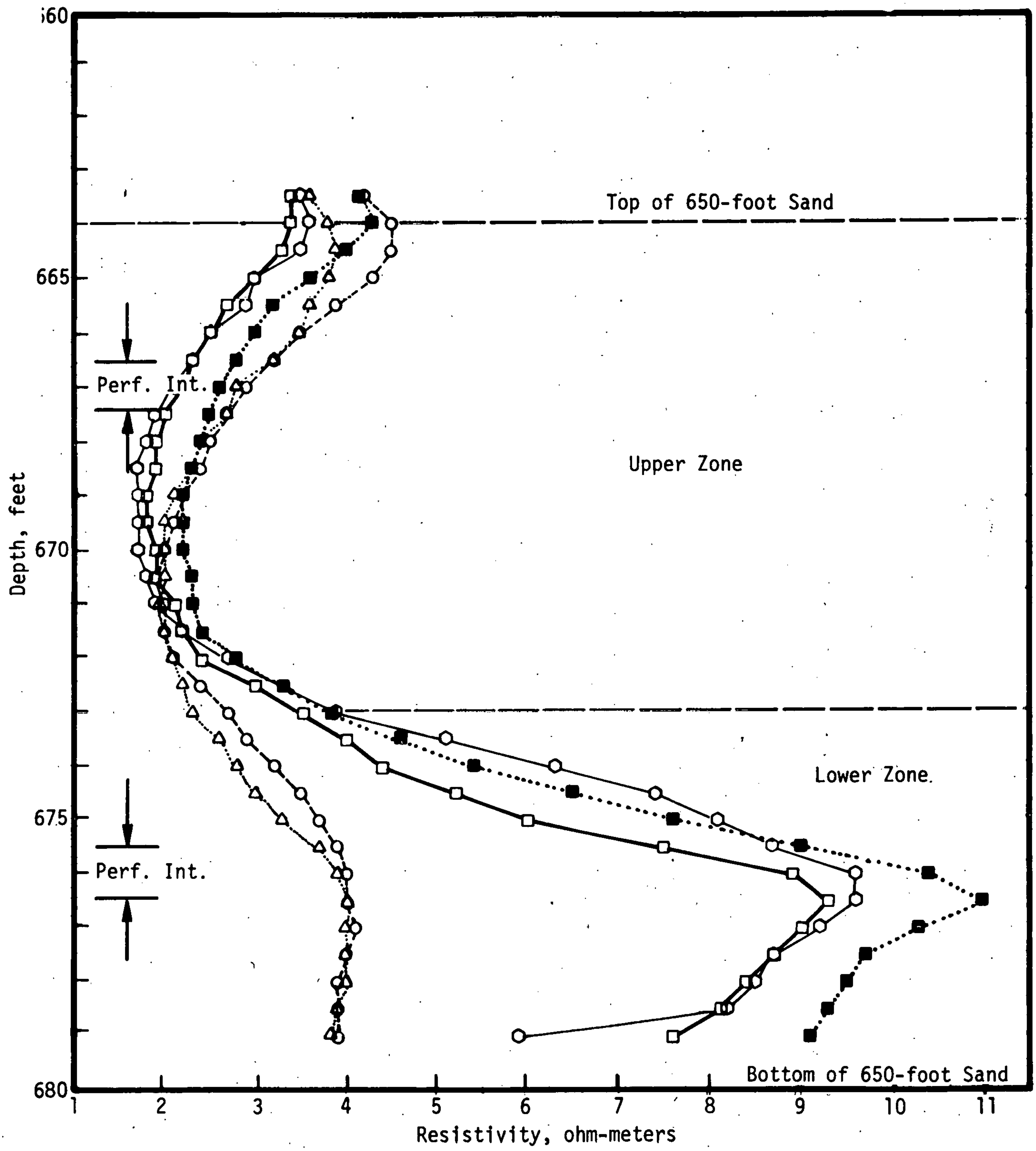


LEGEND

○--○ Open-hole Log, March 25, 1976
△--△ Cased-hole Log, Run #1, March 30, 1976
□—□ Cased-hole Log, Run #2, November 1, 1976
○—○ Cased-hole Log, Run #3, March 7, 1977
■.....■ Cased-hole Log, Run #4, June 29, 1977

FIGURE C-4

RESISTIVITY VERSUS DEPTH FOR WELL MP-227

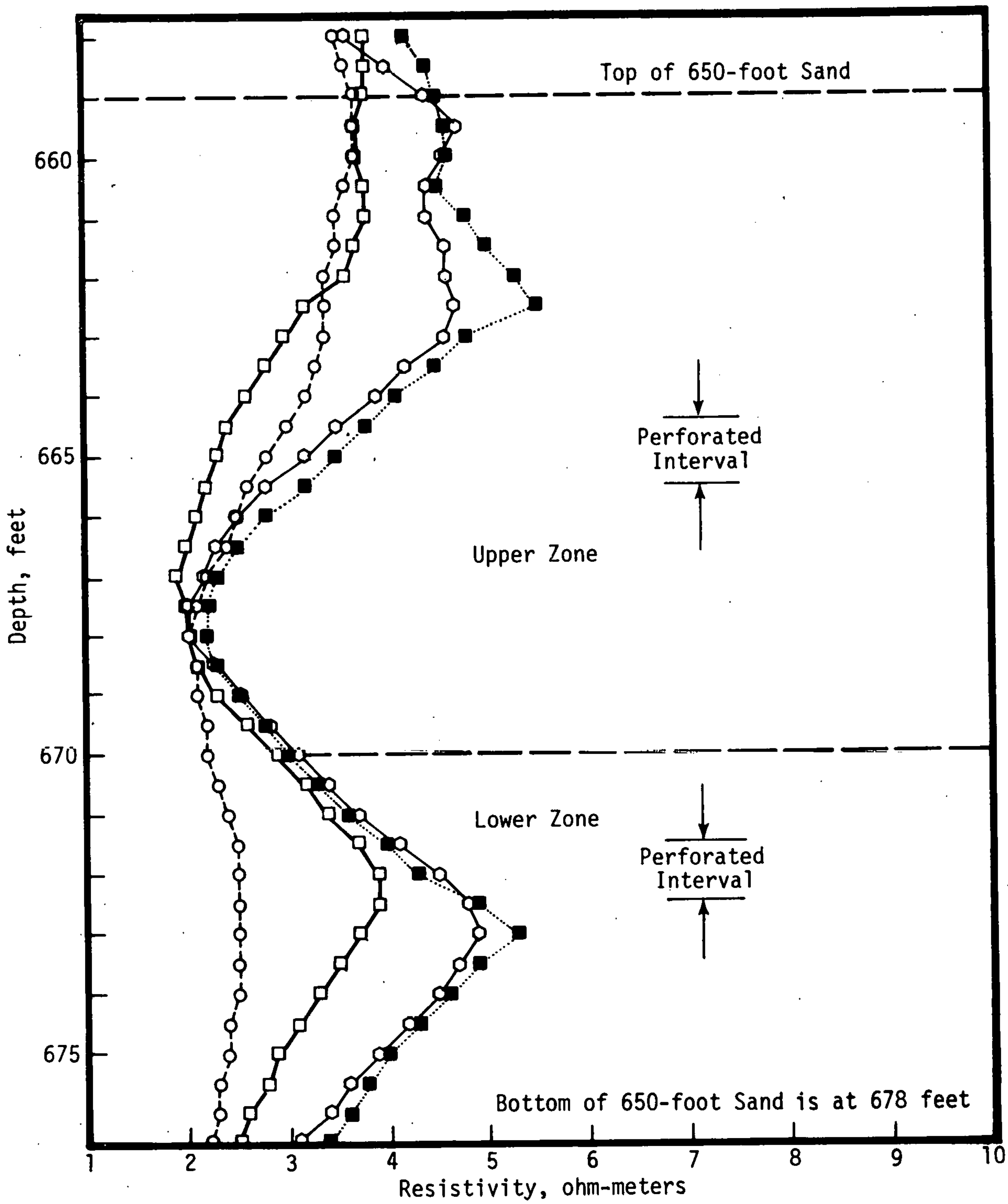


LEGEND

- O---O Open-hole Log, March 17, 1976
- △·····△ Cased-hole Log, Run #1, March 30, 1976
- □—□ Cased-hole Log, Run #2, November 1, 1976
- O—O Cased-hole Log, Run #3, March 7, 1977
- ■·····■ Cased-hole Log, Run #4, June 29, 1977

FIGURE C-5

RESISTIVITY VERSUS DEPTH FOR WELL MP-228



LEGEND

o--o Open-hole Log, April 3, 1976
□—□ Cased-hole Log, Run #1, November 1, 1976
o—o Cased-hole Log, Run #2, March 7, 197
■·····■ Cased-hole Log, Run #3, June 29, 197

APPENDIX D

PRESSURE TRANSIENT TESTING

Tables and Figures

TABLE D1

RESULTS OF INJECTION WELL PRESSURE FALL-OFF TESTS

FOR NORTH (CHESNEY) PATTERN WELLS

Well Number	Formation Thickness, feet		Permeability-Thickness, millidarcy-feet		Permeability, millidarcies		Wellbore Damage Factor (skin)	
	Second Annual Project Report§	From Logs*	Second Annual Project Report§	March-April, 1977	Second Annual Project Report§	March-April, 1977‡	Second Annual Project Report§	March-April, 1977‡
MP-106	19.0	17.5	405	743	21.2	42.5	-2.1	-0.4
MP-108	18.5	17.0	468	994	25.3	58.5	1.4	4.6
MP-110	19.0	18.5	--	868	--	46.9	--	7.5
MP-116	19.0	19.5	833	801	43.8	41.1	-1.1	0.2
MP-118	16.0	20.0	761	900	47.6	45.0	-1.2	2.7
MP-120	18.0	20.0	492	982	27.3	49.1	-0.2	3.0
MP-126	18.0	17.0	1000	1257	55.6	73.9	-0.2**	4.3
MP-128	17.3	22.5	717**	1133	41.4**	50.4	-0.6**	2.9
MP-130	19.0	19.0	615**	1193	32.4**	62.8	-1.2**	3.3

§From Table E4, Second Annual Project Report.[1] These data were obtained before the start of fluid injection in November, 1975.

*From Table C10, First Annual Project Report.[2]

**After cleanout, see Table E5, Second Annual Project Report.[1]

‡Using thickness reported under the column heading "From Logs."

1Rosenwald, G. W., R. J. Miller, and J. Vairogs (editors), El Dorado Micellar-Polymer Demonstration Project (Second Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-76/4, November, 1976.

2Rosenwald, G. W., and R. J. Miller (editors), El Dorado Micellar-Polymer Demonstration Project (First Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-75/1, October, 1975.

TABLE D2

RESULTS OF INJECTION WELL PRESSURE FALL-OFF TESTS

FOR SOUTH (HEGBERG) PATTERN WELLS

Well Number	Formation Thickness, feet		Permeability-Thickness, millidarcy-feet		Permeability, millidarcies		Wellbore Damage Factor (skin)	
	Second Annual Project Report§	From Logs*	Second Annual Project Report§	January-February, 1977	Second Annual Project Report§	January-February, 1977‡	Second Annual Project Report§	January-February, 1977‡
MP-201	18.0	10.5	541	309	30.0	29.4	0	-0.33
MP-203	17.0	20.0	382	259	22.7	15.2	-1.8	-1.2
MP-205	21.0	22.0	494	387	23.5	17.6	-1.5	5.2
MP-211	14.5	16.5	526	774	36.3	46.9	-2.1	2.1
MP-213/226	11.0	9.5	248	224	22.5	23.6	2.6	-2.5
MP-215	17.0	18.5	380	258	22.6	13.9	-2.3	3.9
MP-221	18.0	20.0	350	1097	19.5	54.9	-3.4	11.0
MP-223	18.0	15.0	197	362	10.0	24.1	-1.5	-1.1
MP-225	21.0	21.0	337	402	16.1	19.1	-3.0	6.6

§From Table E4, Second Annual Project Report.[1] These data were obtained before the start of fluid injection in November, 1975.

*From Table C10, First Annual Project Report.[2]

‡Using thickness reported under the column heading "From Logs."

[1]Rosenwald, G. W., R. J. Miller, and J. Vairogs (editors), El Dorado Micellar-Polymer Demonstration Project (Second Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-76/4, November, 1976.

[2]Rosenwald, G. W., and R. J. Miller (editors), El Dorado Micellar-Polymer Demonstration Project (First Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-75/1, October, 1975.

TABLE D3

CALCULATION OF FORMATION DAMAGE FACTOR

(SKIN) FOR WELL MP-114

Assume the steady-state flow equation is applicable:

$$q = \frac{7.08\ kh\ (P_e - P_w)}{\mu\beta[\ln\ (r_e/r_w) + S]}$$

or

$$S = \frac{7.08\ kh\ (P_e - P_w)}{q\mu\beta} - \ln r_e/r_w$$

where

kh = 0.625 darcy-ft (average of injection wells surrounding well MP-114)

P_e = 295 psig (from buildup test)

P_w = 5.5 psig (measured)

q = 42 BWPD

μ = 1 cp

β = 1 bbl/bbl

r_e = 210 ft (3.2 acre drainage area)

r_w = $\sqrt{0.1}$ ft

substituting,

$$S = \frac{7.08 \times 0.625\ (295 - 5.5)}{42 \times 1 \times 1} - \ln \frac{210}{\sqrt{0.1}}$$

S = (+) 24

TABLE D4

RESULTS OF PRODUCTION WELL BUILDUP TESTS

Well Number	Month Tested	Formation Thickness, feet: Second Annual Project Report[§]	Formation Thickness, feet: From Logs[*]	Permeability-Thickness, millidarcy-feet: Second Annual Project Report[§]	Permeability-Thickness, millidarcy-feet: February-March, 1977	Permeability, millidarcies: Second Annual Project Report[§]	Permeability, millidarcies: February-March, 1977[‡]	Wellbore Damage Factor (skin): Second Annual Project Report[§]	Wellbore Damage Factor (skin): February-March, 1977[‡]
MP-207	February, 1977	16.5	20.0	302	466	18.3	23.3	5.7	16.0
MP-219	February, 1977	15.5	15.5[**]	551	597	35.6	38.5	-1.3	4.8
MP-114	March, 1977	18.5	20.0	--	--	--	--	--	24.0
MP-122	March, 1977	15.0	13.5	728	633	48.5	46.9	1.8	0.8

[§] From Table E4, Second Annual Project Report.[1] These data were obtained before the start of fluid injection in November, 1975.

[*] From Table C10, First Annual Project Report.[2]

[**] From Table E3, Second Annual Project Report[1] (not included in First Annual Project Report).

[‡] Using thickness reported under the column heading "From Logs."

[1] Rosenwald, G. W., R. J. Miller, and J. Vairogs (editors), El Dorado Micellar-Polymer Demonstration Project (Second Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-76/4, November, 1976.

[2] Rosenwald, G. W., and R. J. Miller (editors), El Dorado Micellar-Polymer Demonstration Project (First Annual Report) Oak Ridge, Tennessee: United States Energy Research and Development Administration, Report No. BERC/TPR-75/1, October, 1975.

TABLE D5

RESULTS OF INTERFERENCE TEST FROM WELL MP-110 TO WELL MP-112

From Well	To Well	ΔP_1, Inches of Water	Δt_1, hr	q, bbl/day	$k_e h$, md-ft	h, ft	k_e, md	r, ft	k_ϕ, md
MP-110	MP-112	1700	33.33	235	NC	18.5	NC	359	32.4

NC = Not calculated because of completion geometry.

TABLE D6

MONITORING WELL PRESSURES

PRESSURE AT 800 FEET MEAN SEA LEVEL*

Well Number	December, 1976	February, 1977	April, 1977
MP-107	202	236.4	253.6
MP-109	151	182.5	235.5
MP-111	135	169.7	208.1
MP-113	154	182.9	240.5
MP-115	207	250.5	255.9
MP-117	175	209.9	257.7
MP-119	145	175.8	219.8
MP-121	155	204.5	NM
MP-123	148	205.8	225.2
MP-125	189	220.2	248.6
MP-127	144	207.2	226.5
MP-129	163	215.3	239.1
MP-202	NM	212.1	226.1
MP-204	165	228.8	213.5
MP-206	NM	218.9	176.7
MP-208	154	196.9	171.7
MP-210	163	203.6	194.7
MP-212	160	198.6	179.3
MP-214	132	185.5	132.5
MP-216	136	187.2	132.5
MP-218	150	179.8	150.9
MP-220	122	198.6	178.9
MP-222	161	189.0	166.7
MP-224	135	179.3	124.1
MP-101	NM	209.4	205.8
MP-103	NM	176.7	196.9
MP-104	NM	231.9	235.1

NM = Not measured.

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*Pressures are in psig.

FIGURE D-1

EXAMPLE OF A POOR INJECTIVITY PROFILE; INJECTIVITY FOR WELL MP-106

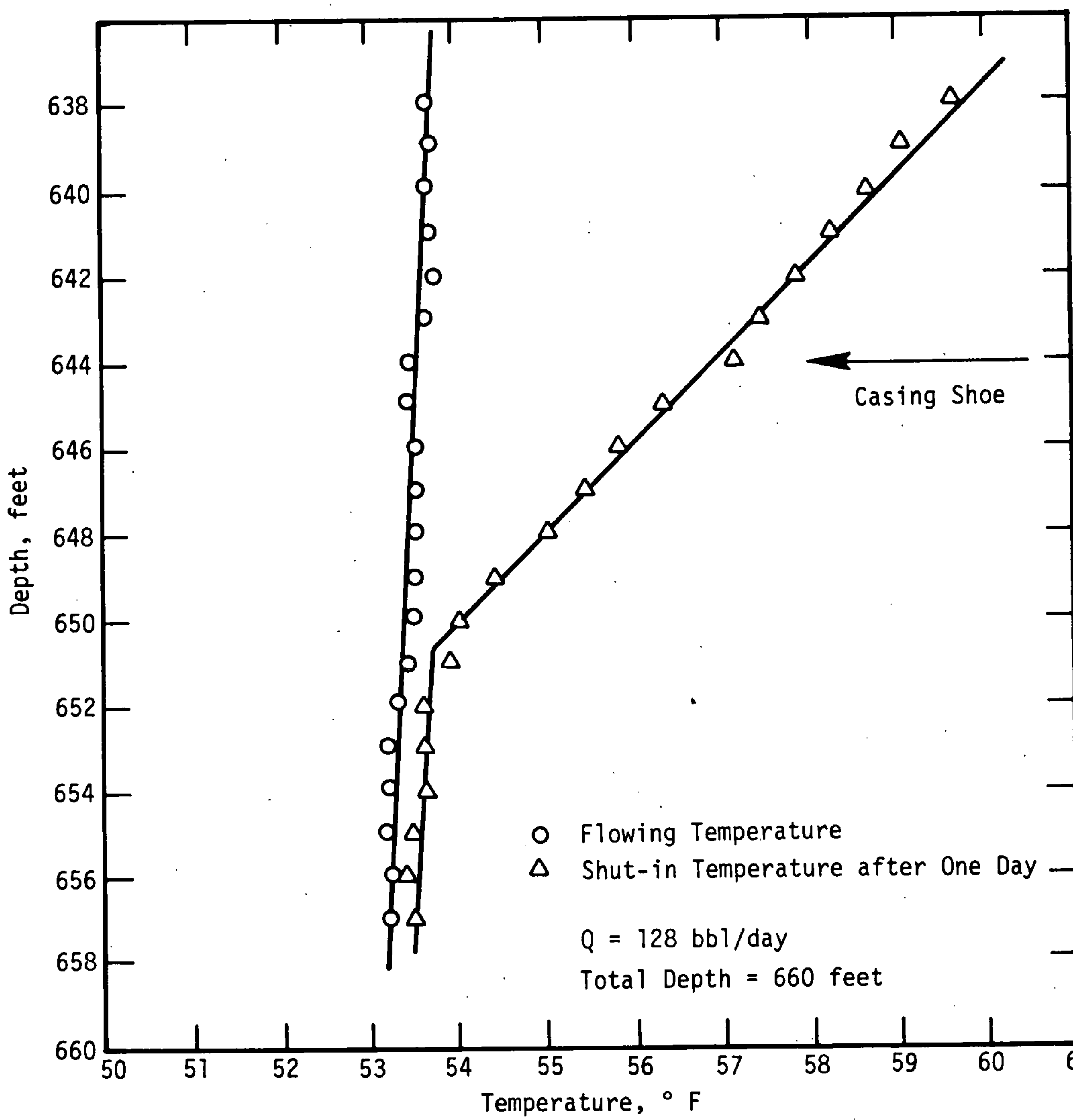


FIGURE D-2

EXAMPLE OF A GOOD INJECTIVITY PROFILE; INJECTIVITY FOR WELL MP-110

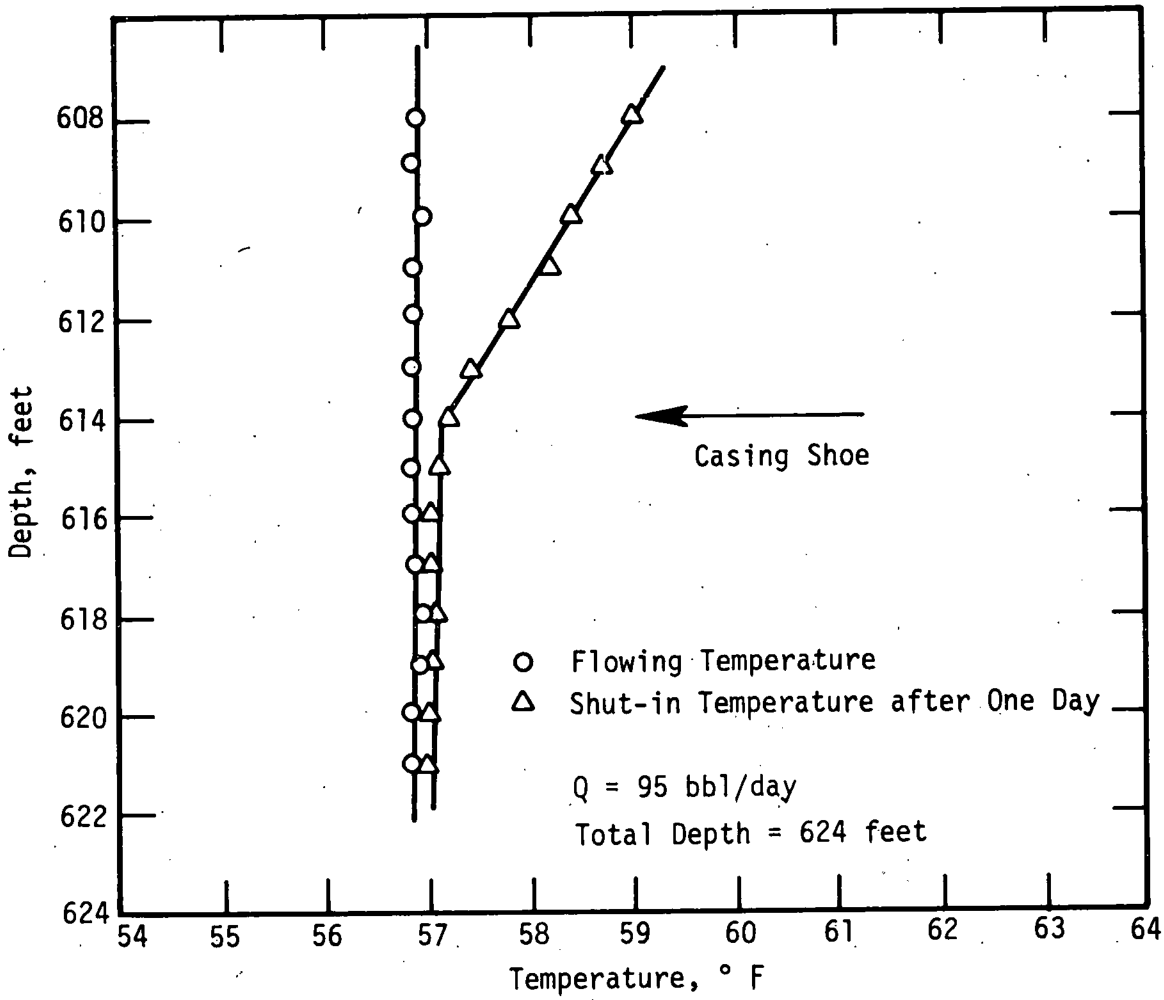


FIGURE D-3

TEMPERATURE PROFILE FOR WELL MP-203 WHILE INJECTING SOLUBLE OIL AT SEVEN BARRELS PER DAY

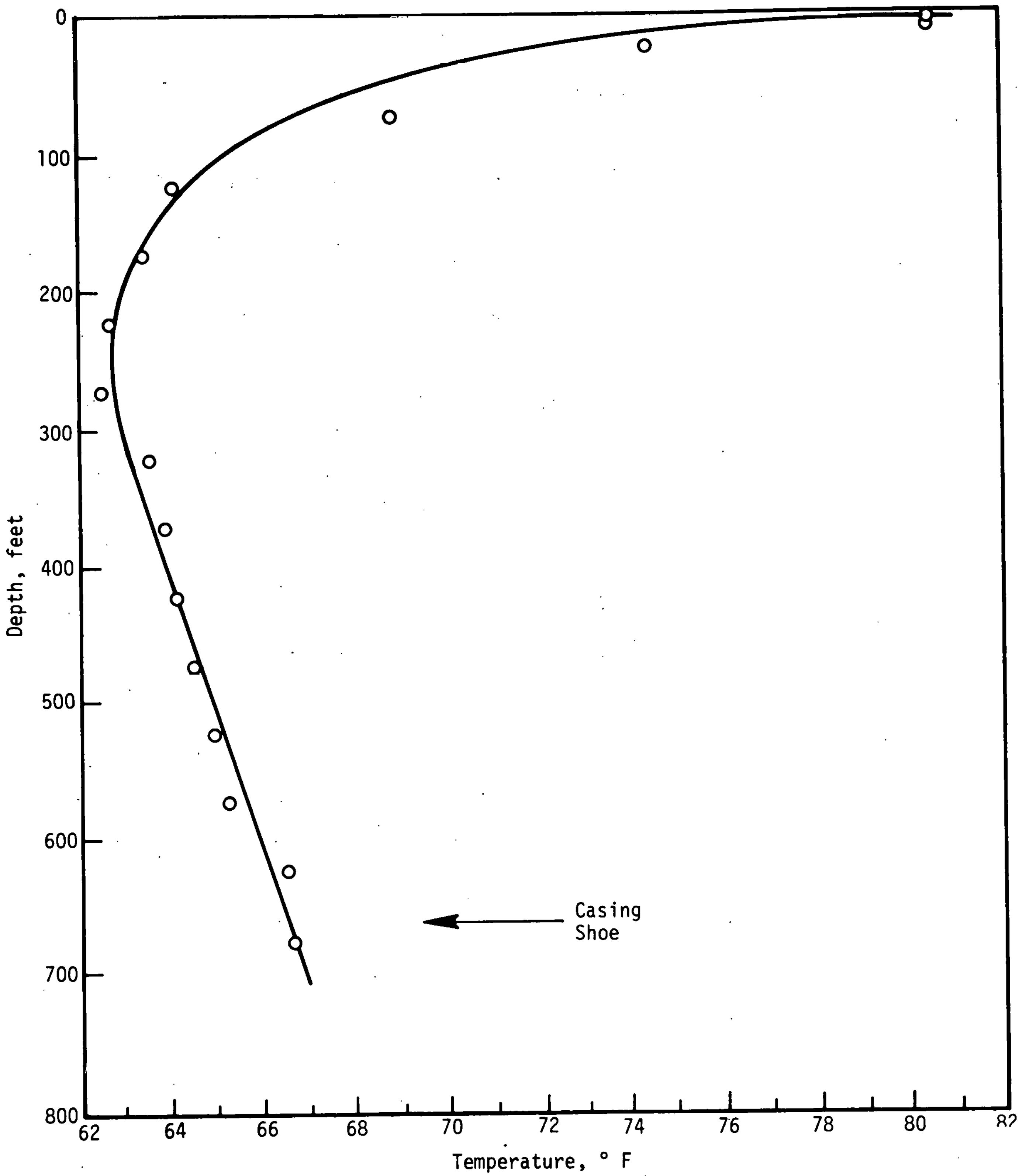
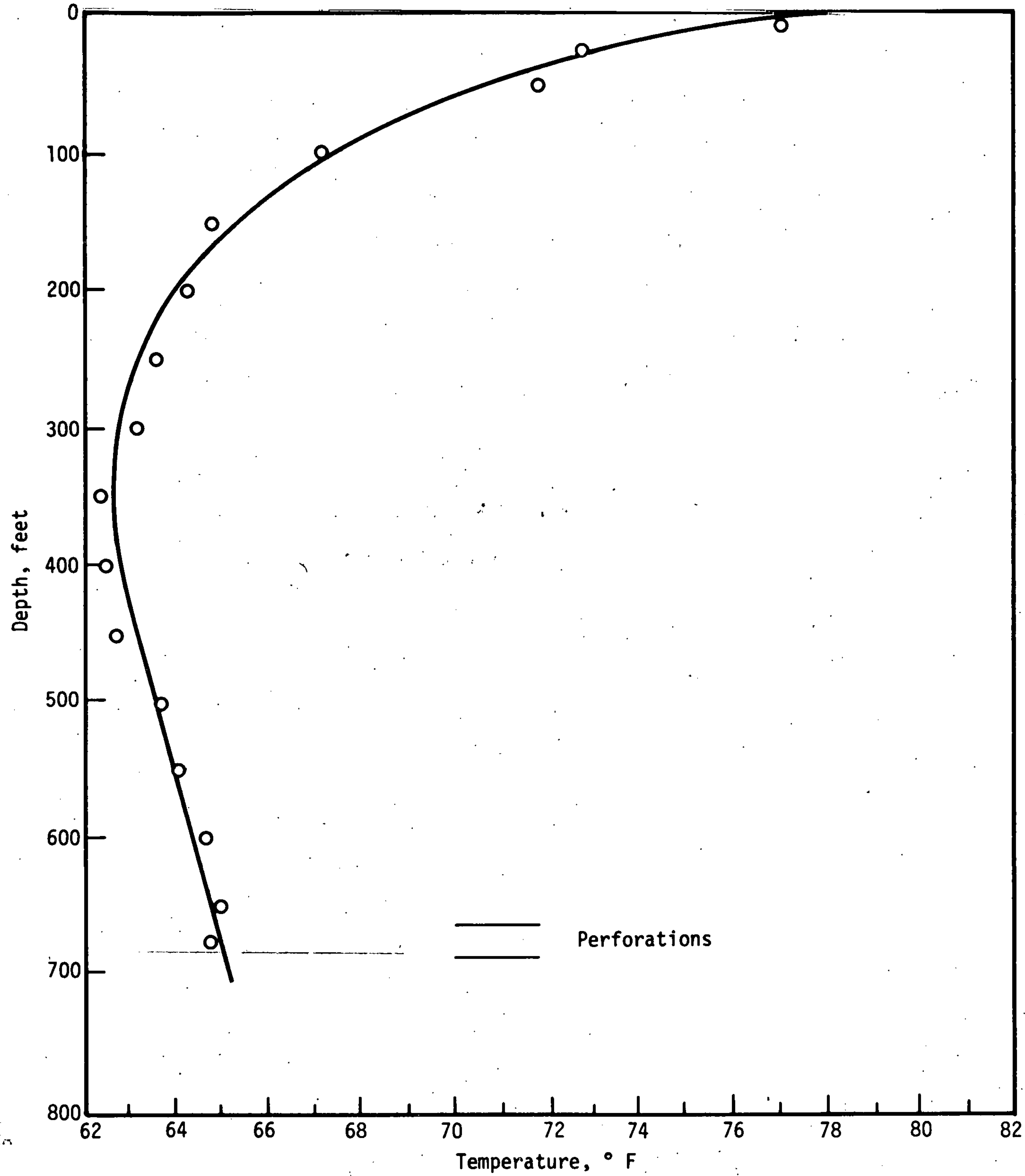


FIGURE D-4

TEMPERATURE PROFILE FOR WELL MP-225 WHILE INJECTING SOLUBLE OIL AT TEN BARRELS PER DAY



APPENDIX E

PERFORMANCE PREDICTION

Tables and Figures

TABLE E1

DESIRED PREFLUSH AND MICELLAR FLUID INJECTION IN HEGBERG PATTERN§

Well Number	Percentage Distribution	Preflush Volume, bbl	Micellar Fluid Volume, bbl	Porosity-Thickness Product, feet	Diameter of Front,* feet
MP-201	9.398	11,341	4,253	3.5235	93
MP-203	12.493	15,076	5,653	4.9200	91
MP-205	11.495	13,872	5,202	4.7600	88
MP-211	11.363	13,712	5,142	4.0706	95
MP-213	7.672	9,258	3,472	2.4691	100
MP-215	12.965	15,646	5,867	4.5658	96
MP-221	11.267	13,596	5,099	4.9180	86
MP-223	11.261	13,589	5,096	3.4860	102
MP-225	12.086	14,585	5,469	4.6767	92
		120,675	45,253		

§Based on effective confined pore volume of 804,500 bbl.

*At end of micellar fluid injection.

TABLE E2

DESIRED PREFLOOD II AND MICELLAR FLUID

INJECTION IN CHESNEY PATTERN[§]

Well Number	Percentage Distribution	Preflood II Volume, bbl	Micellar Fluid Volume, bbl
MP-106	10.667	35,789	10,737
MP-108	11.759	39,453	11,836
MP-110	9.247	31,027	9,308
MP-116	12.383	41,547	12,464
MP-118	14.029	47,071	14,121
MP-120	11.206	37,599	11,280
MP-126	9.985	33,502	10,051
MP-128	11.767	39,480	11,844
MP-130	8.958	30,057	9,017
		335,525	100,658

[§]Based on effective confined pore volume of 894,257 bbl.

TABLE E3

REVISED OIL RECOVERY SCHEDULE FOR

THE NORTH (CHESNEY) PATTERN

WITH S_{orc} EQUAL TO 15 PERCENT

Months After Completion of Chemical Injection	Production Rate, bbl/day		Water-Oil Ratio	Cumulative Production, barrels x 10^{-3}		Cumulative Injection, bbl x 10^{-3}
	Oil	Water		Oil	Water	
6	0	900	--	0	164	164
12	107	793	7.4	6.6	322	328
18	224	676	3.0	41.7	452	492
24	161	739	4.6	76.0	581	657
30	104	796	7.7	99.8	722	821
36	77	823	10.6	115	870	985
42	61	839	13.8	127	1,022	1,149
48	50	850	17.1	137	1,177	1,313
54	42	858	20.6	145	1,333	1,477
60	36	864	24.3	152	1,490	1,642
66	31	869	27.6	158	1,648	1,806
72	28	872	31.7	163	1,807	1,970

TABLE E4

REVISED OIL RECOVERY SCHEDULE FOR

THE SOUTH (HEGBERG) PATTERN WITH

S_{orc} EQUAL TO 15 PERCENT

Months After Completion of Chemical Injection	Production Rate, bbl/day		Water-Oil Ratio	Cumulative Production, barrels x 10^{-3}		Cumulative Injection, bbl x 10^{-3}
	Oil	Water		Oil	Water	
6	0	724	--	0	132	132
12	16	708	44.6	0.1	264	264
18	140	584	4.2	16.8	379	396
24	163	561	3.4	46.4	482	528
30	104	620	6.0	69.7	591	660
36	74	650	8.7	85.2	707	792
42	59	665	11.2	97.0	827	924
48	51	673	13.2	106.8	950	1,056
54	43	681	15.7	115.3	1,073	1,189
60	38	686	18.2	122.3	1,198	1,321
66	33	691	21.2	128.7	1,324	1,453
72	30	694	23.4	134.3	1,450	1,585

FIGURE E-1

NET THICKNESS OF UPPER ZONE
EL DORADO MICELLAR-POLYMER PROJECT

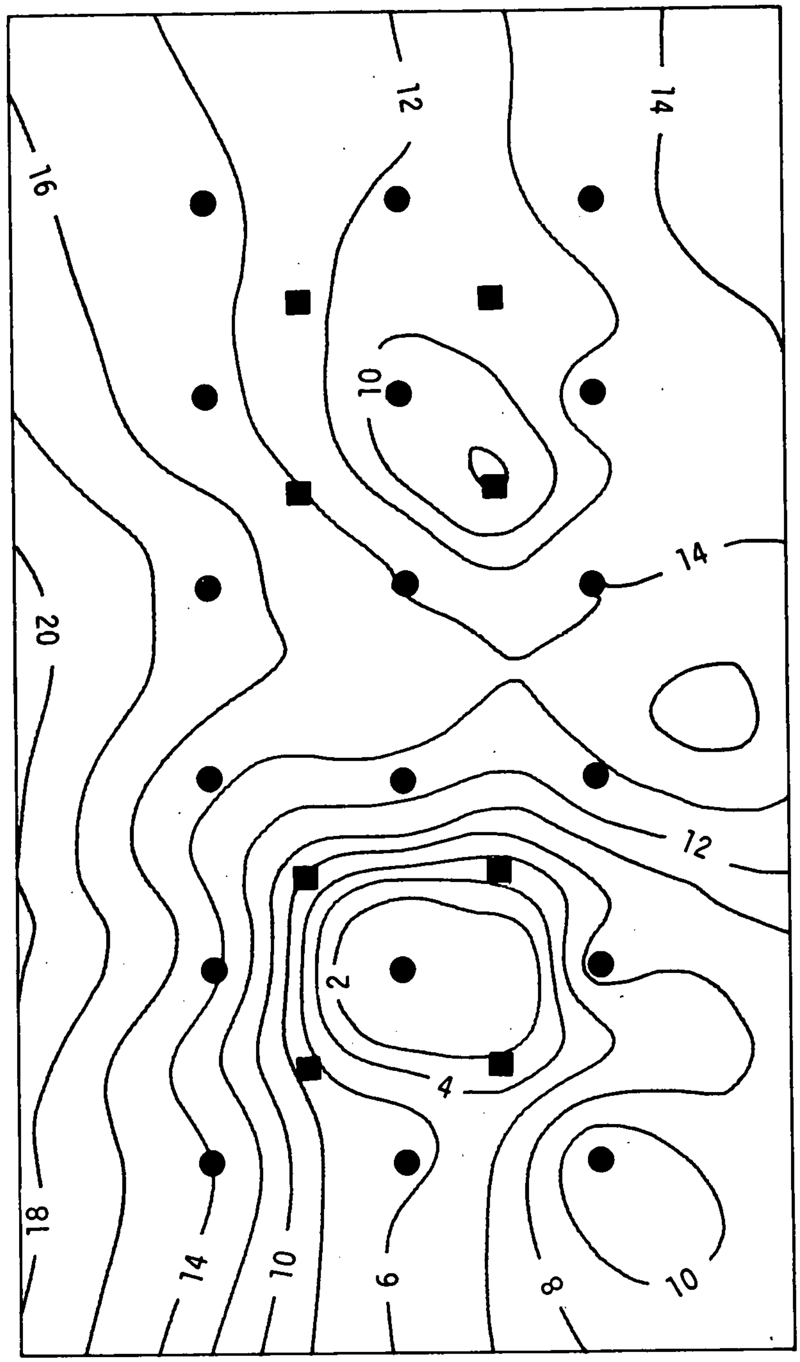


FIGURE E-2

PERMEABILITY OF UPPER ZONE
EL DORADO MICELLAR-POLYMER PROJECT

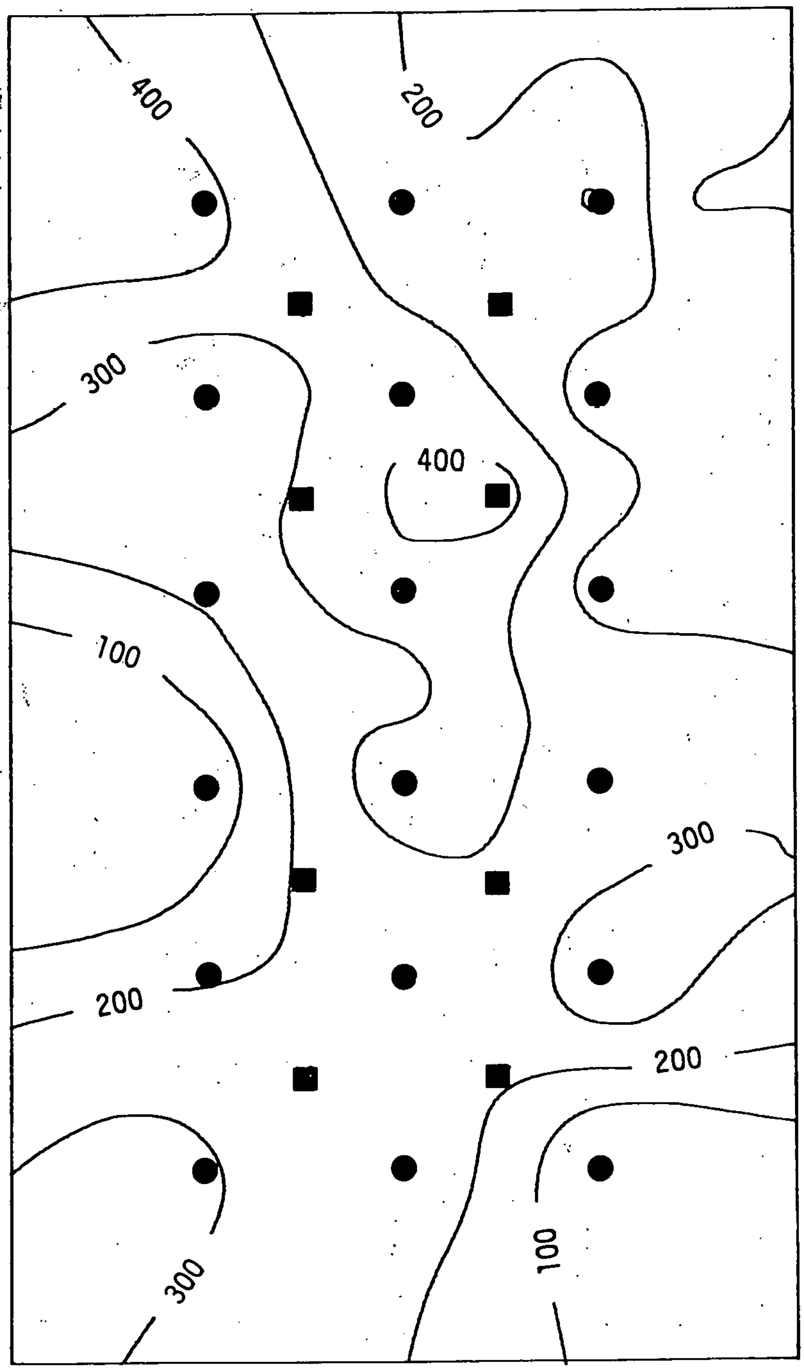


FIGURE E-3

POROSITY OF UPPER ZONE
EL DORADO MICELLAR-POLYMER PROJECT

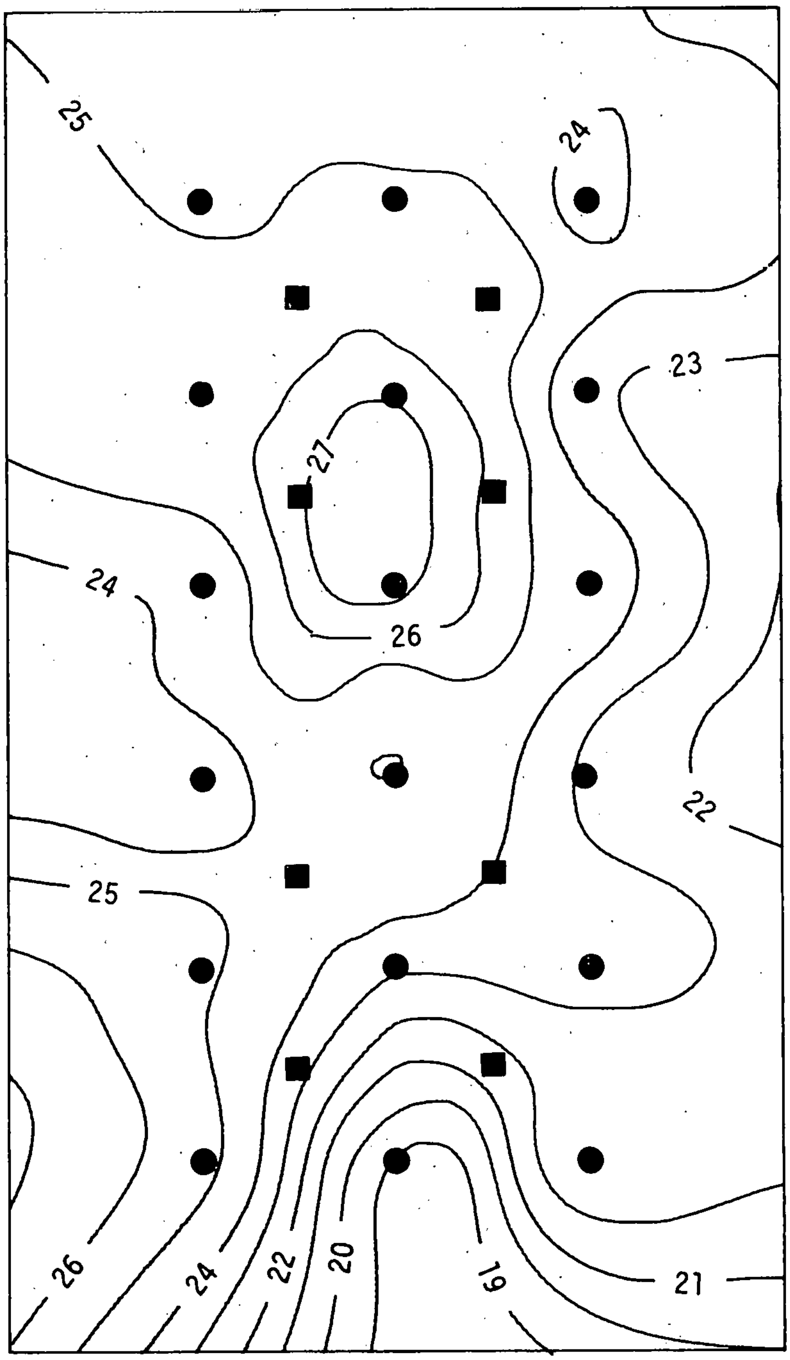


FIGURE E-4

NET THICKNESS OF LOWER ZONE
EL DORADO MICELLAR-POLYMER PROJECT

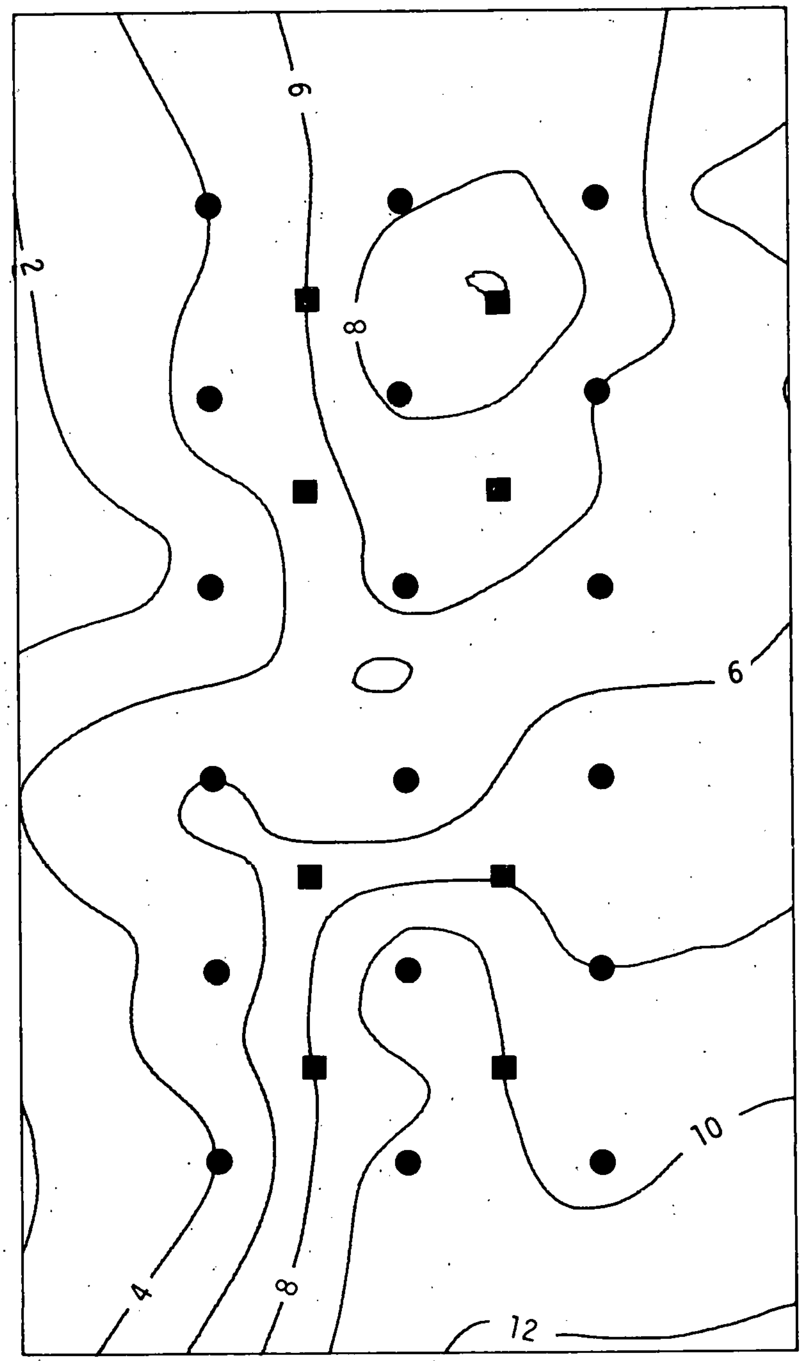


FIGURE E-5

PERMEABILITY OF LOWER ZONE

EL DORADO MICELLAR-POLYMER PROJECT

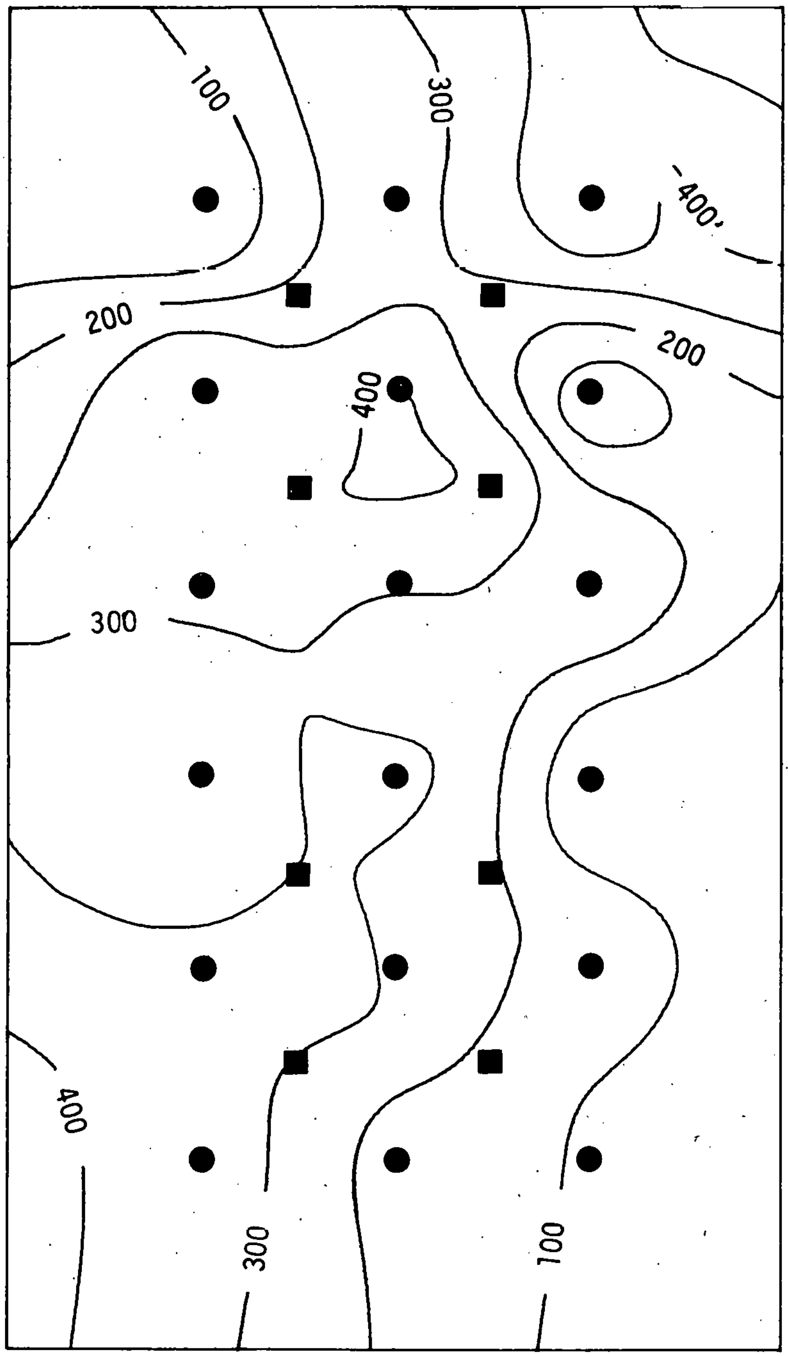


FIGURE E-6

POROSITY OF LOWER ZONE
EL DORADO MICELLAR-POLYMER PROJECT

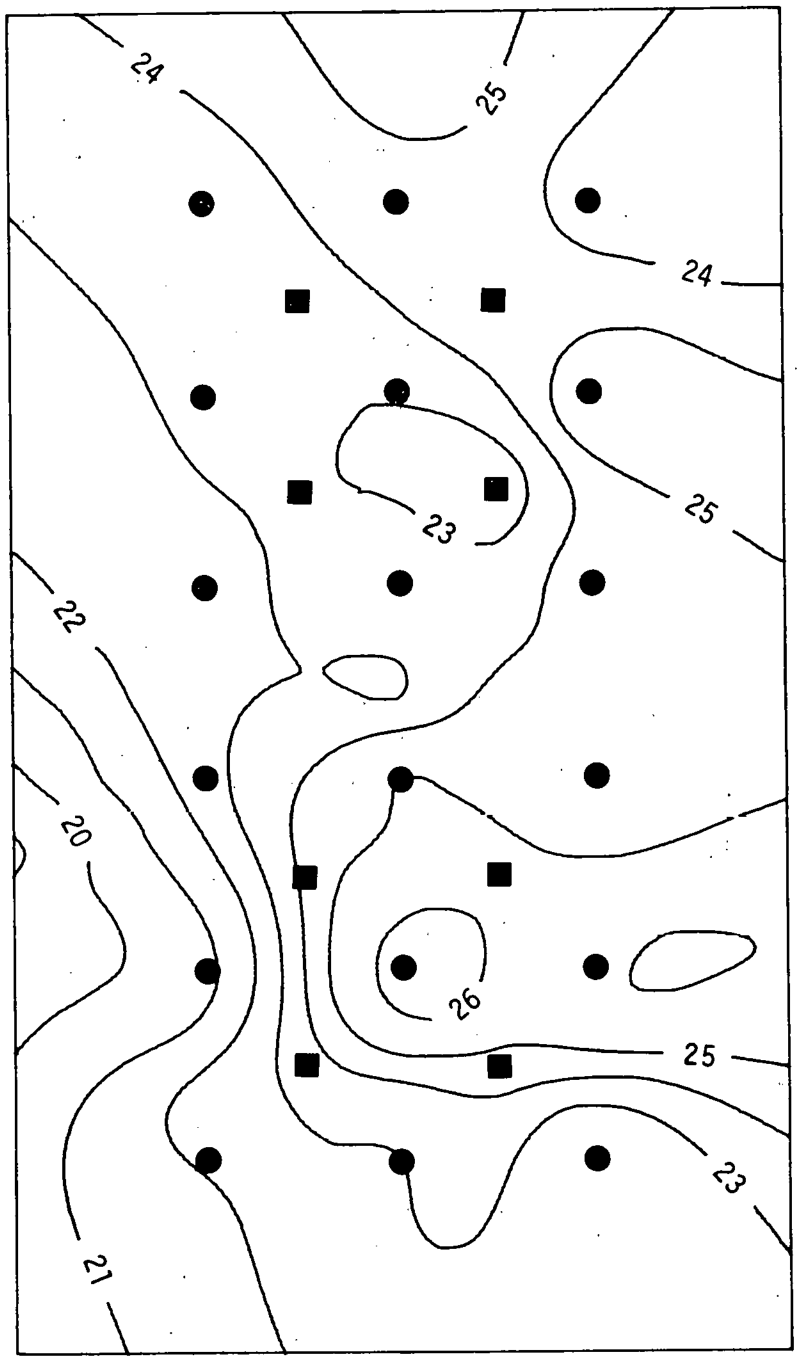


FIGURE E-7

AREAL SWEEP WITH ACTUAL WELL RATES AVERAGED OVER THE PERIOD

NOVEMBER, 1975, TO MAY, 1976

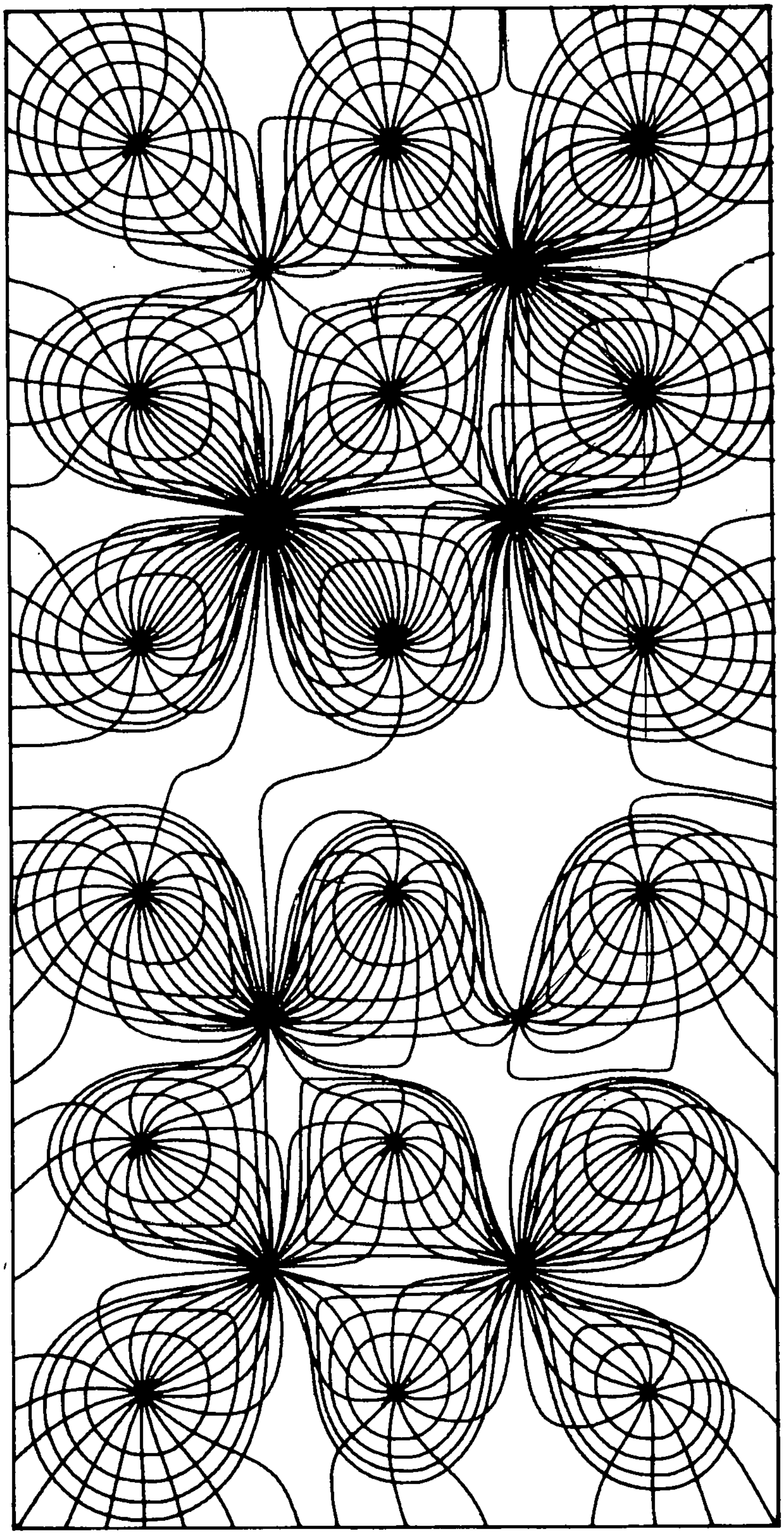


FIGURE E-8

HEGBERG PATTERN AREAL SWEEP WITH ANISOTROPIC PERMEABILITY

Permeability in NE-SW Direction is
Twice Permeability in NW-SE Direction

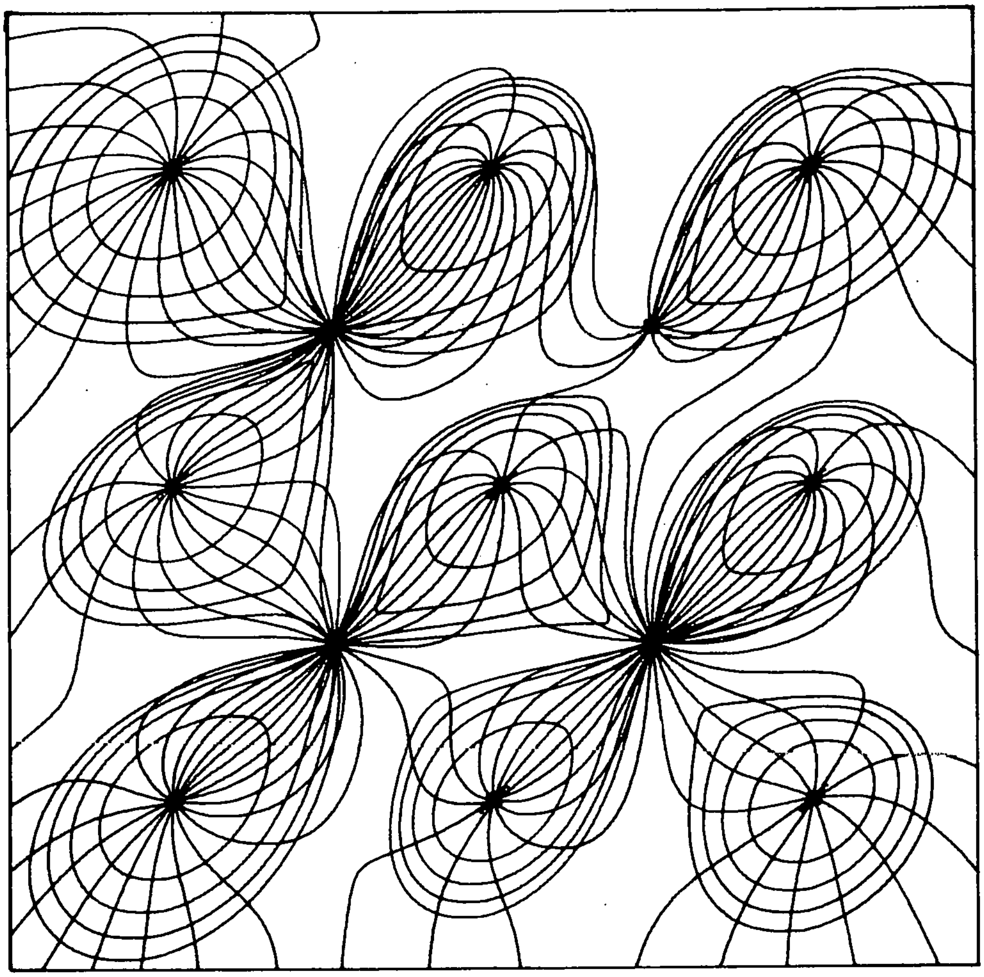


FIGURE E-9

HEGBERG PATTERN AREAL SWEEP WITH ANISOTROPIC PERMEABILITY

Permeability in NW-SE Direction is
Twice Permeability in NE-SW Direction

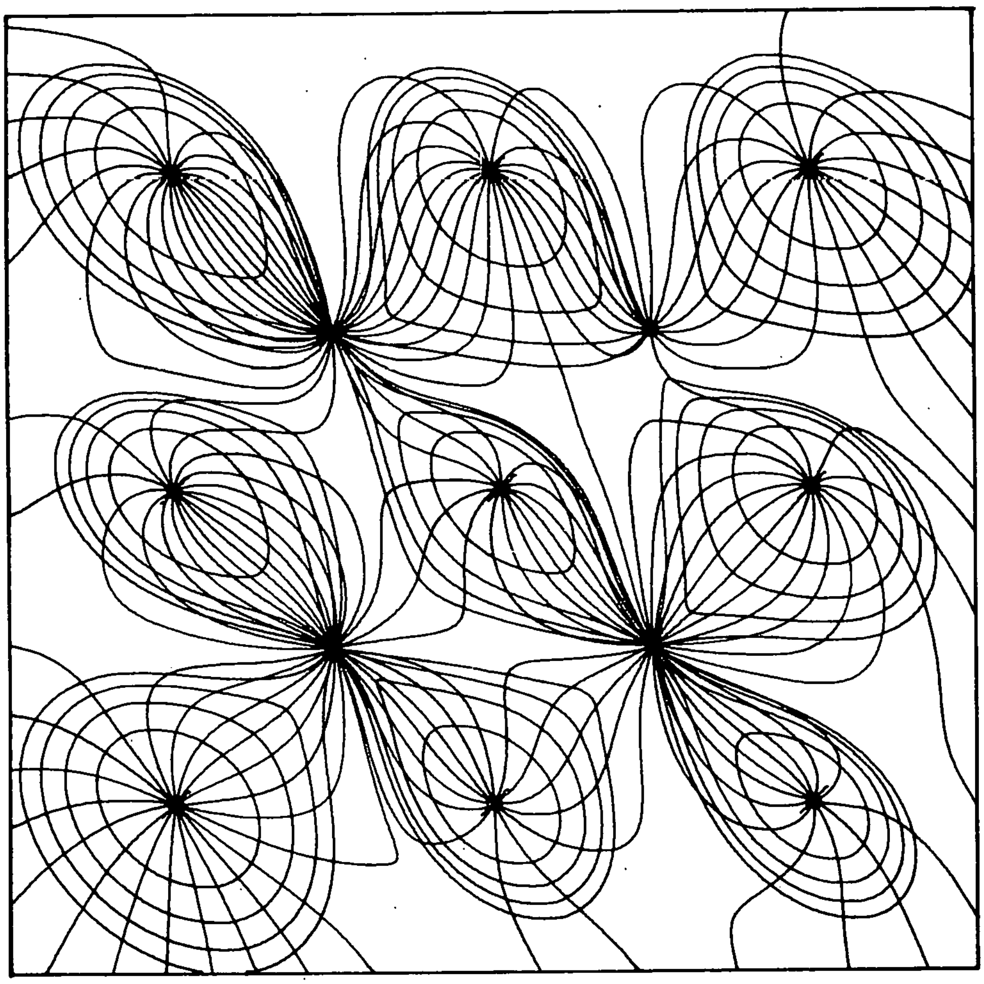
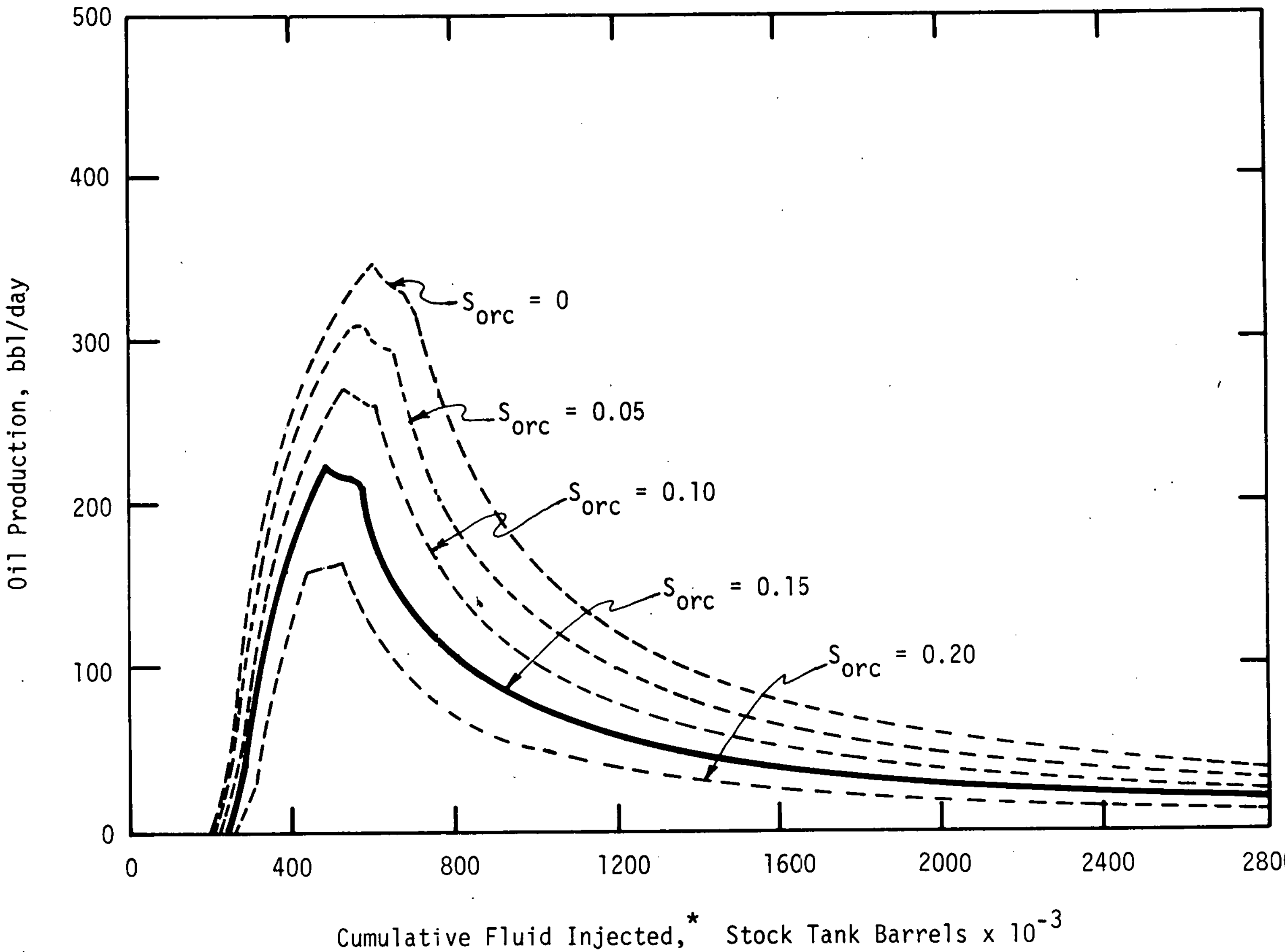


FIGURE E-10

FORECAST OF THE OIL PRODUCTION RATE

FOR THE NORTH PATTERN

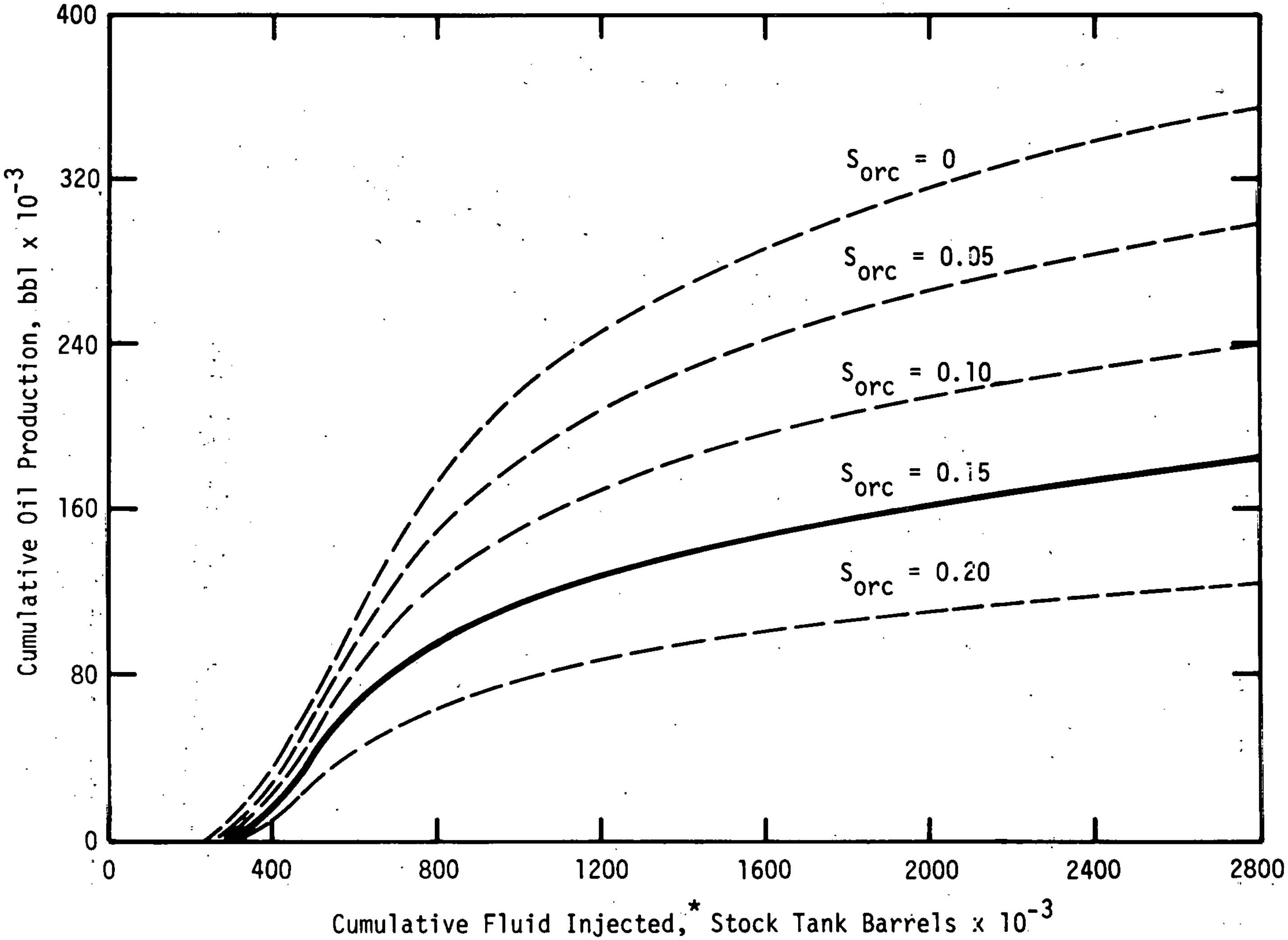


*Fluid injected after the micellar fluid.

FIGURE E-11

FORECAST OF THE CUMULATIVE OIL PRODUCTION

FOR THE NORTH PATTERN



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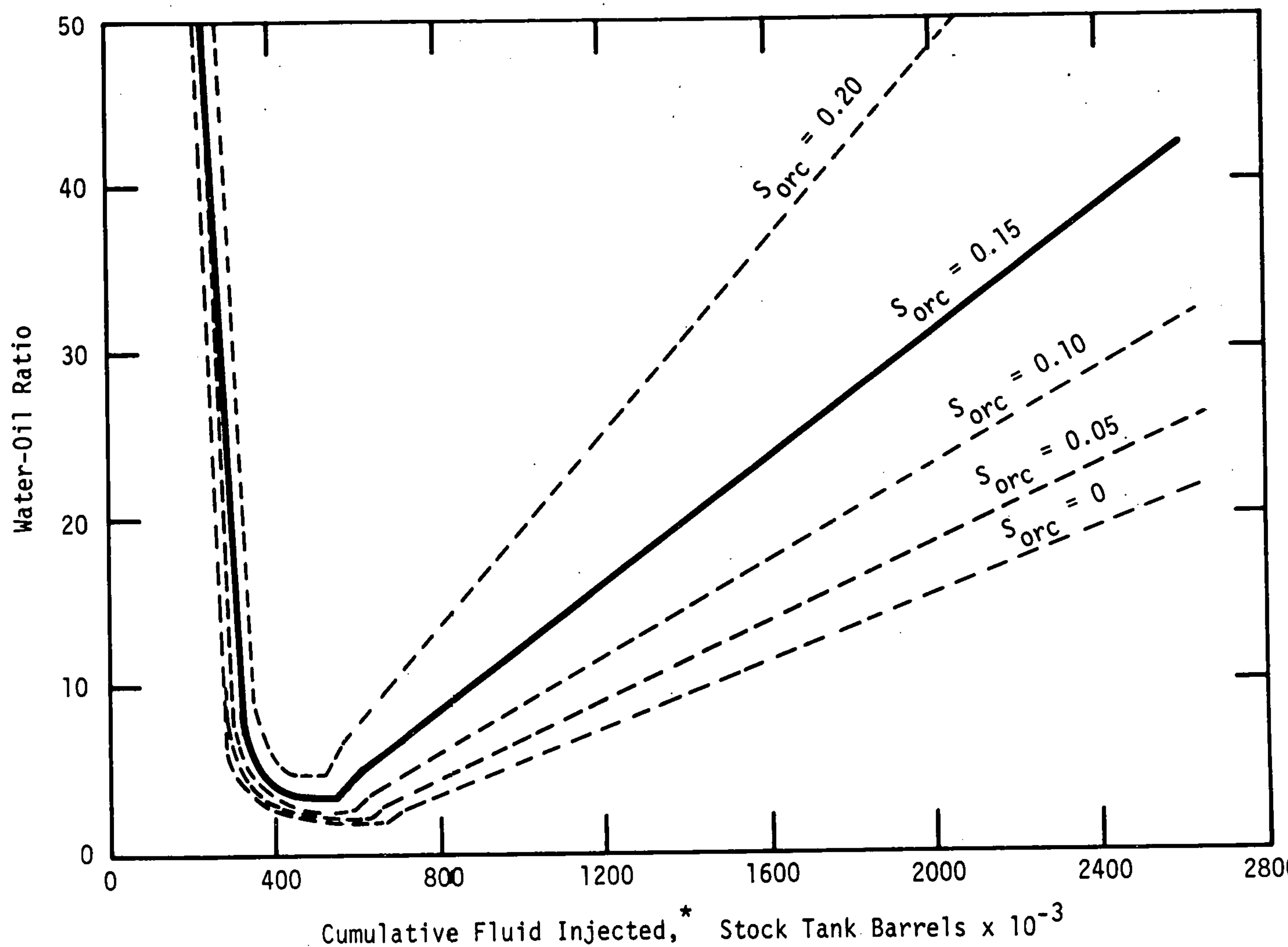
*Fluid injected after the micellar fluid.

FIGURE E-12

FORECAST OF THE WATER-OIL RATIO

FOR THE NORTH PATTERN

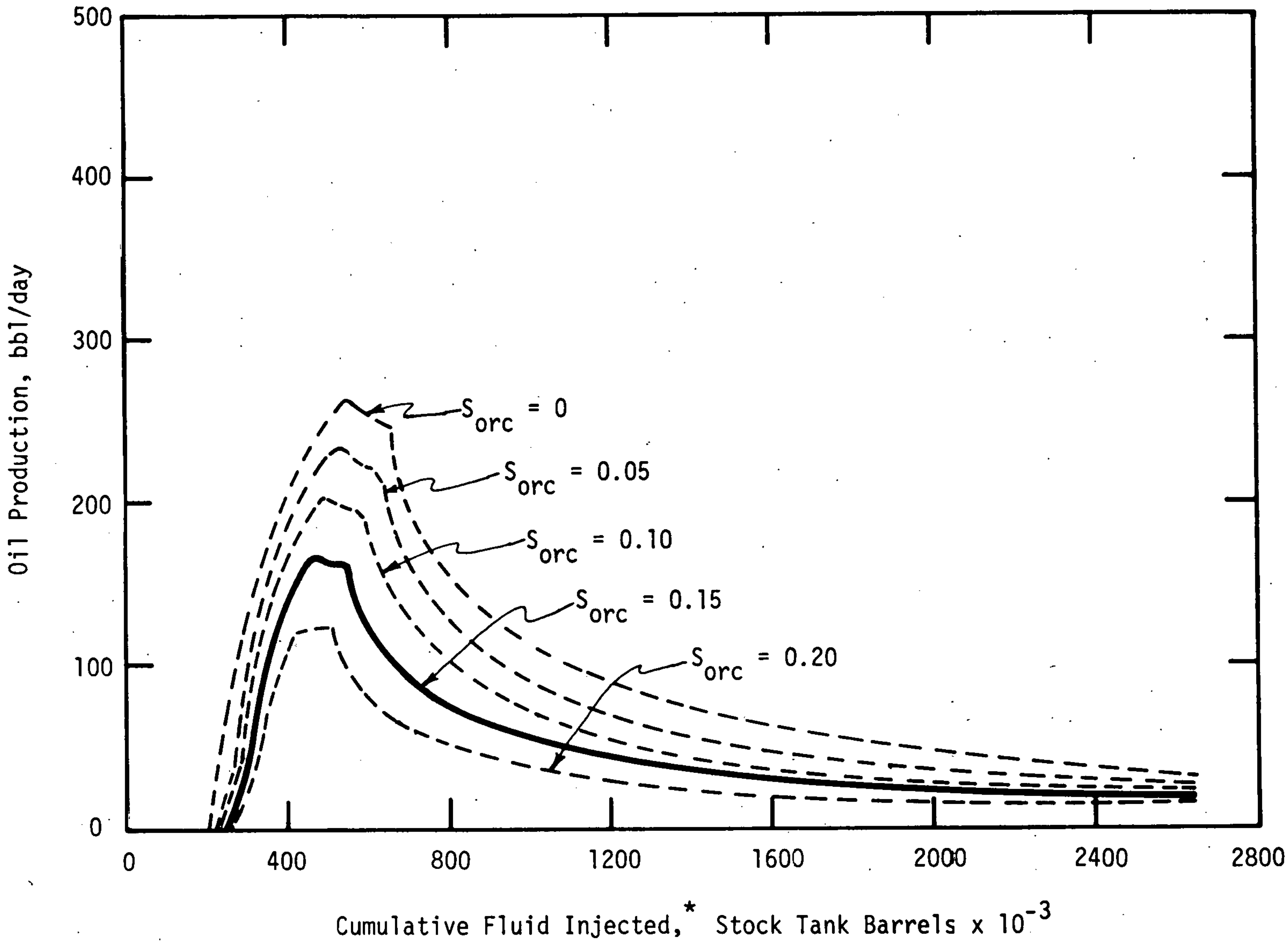


*Fluid injected after the micellar fluid.

FIGURE E-13

FORECAST OF THE OIL PRODUCTION RATE

FOR THE SOUTH PATTERN



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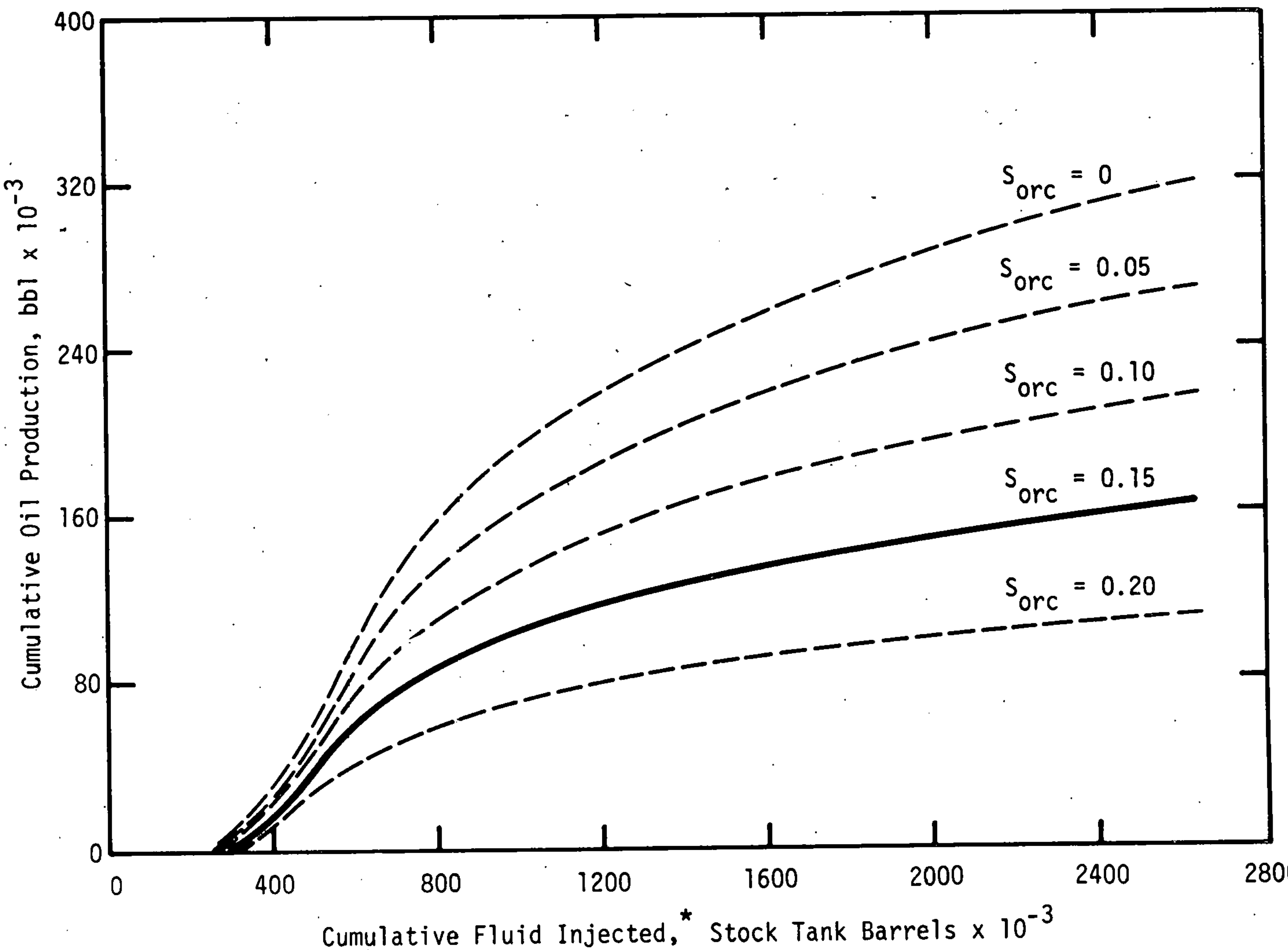
*Fluid injected after the micellar fluid.

FIGURE E-14

FORECAST OF THE CUMULATIVE OIL PRODUCTION FOR THE SOUTH PATTERN

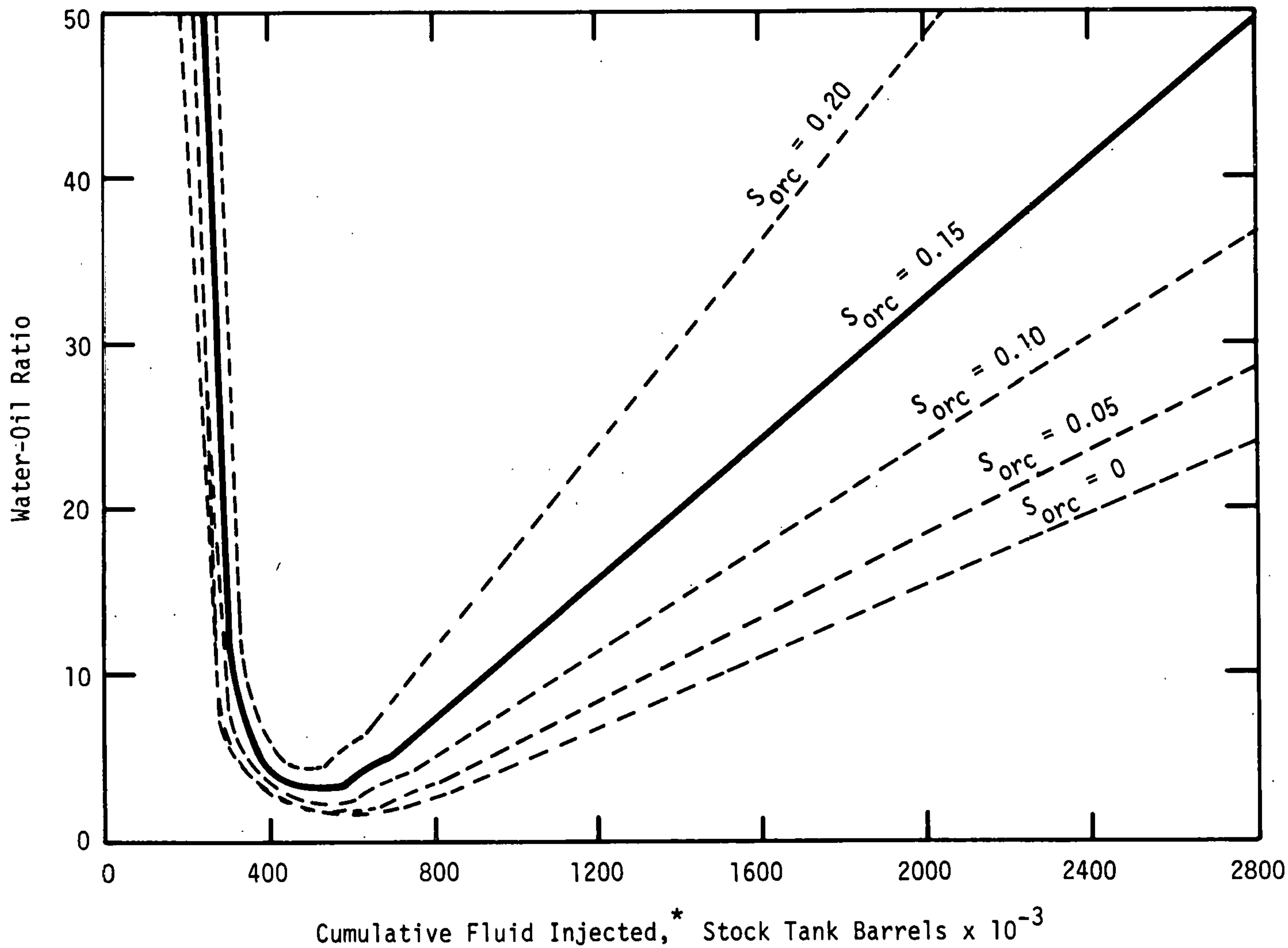


*Fluid injected after the micellar fluid.

FIGURE E-15

FORECAST OF THE WATER-OIL RATIO

FOR THE SOUTH PATTERN



*Fluid injected after the micellar fluid.

FIGURE E-16

OBSERVED PRESSURES, DECEMBER 3-5, 1976

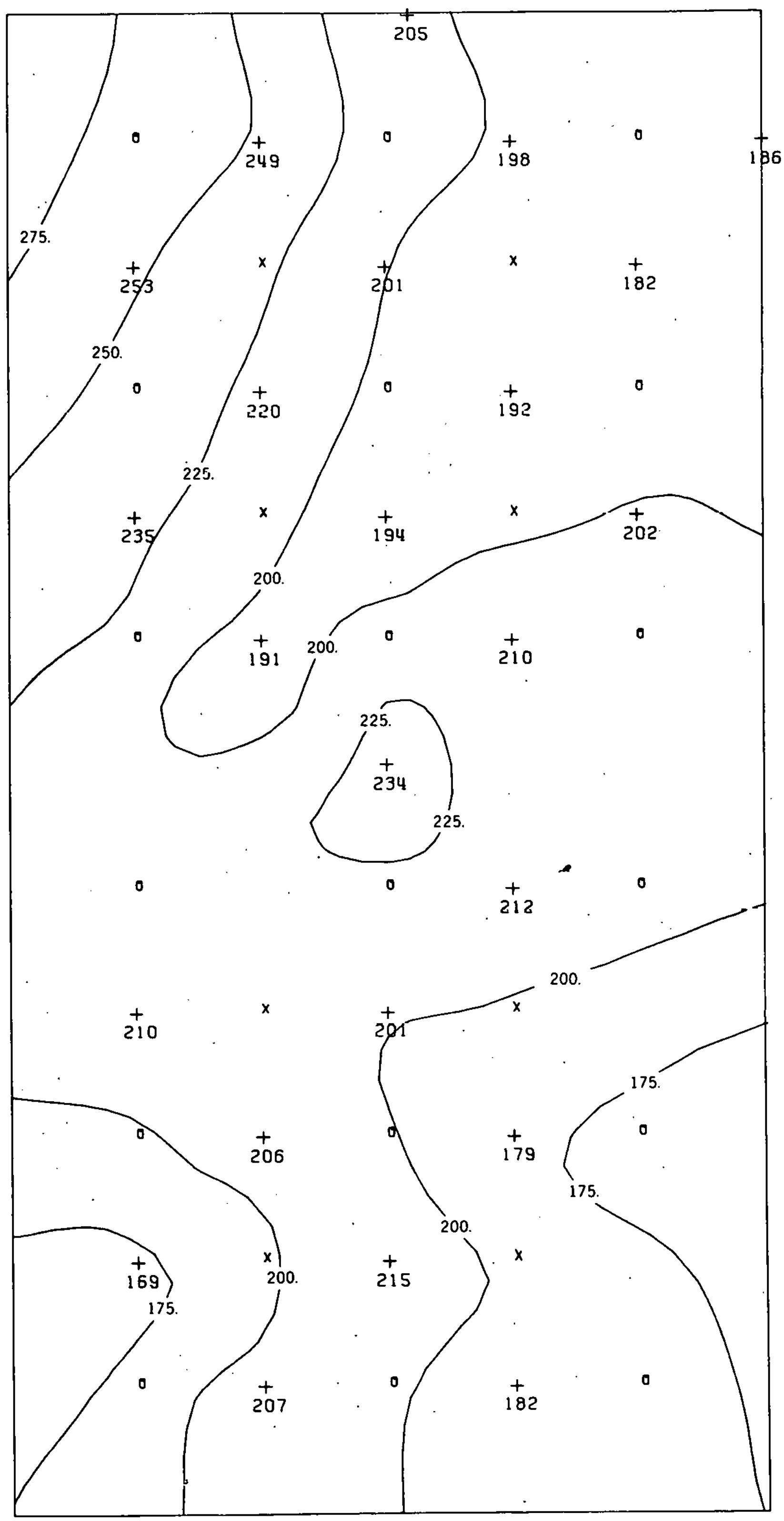


FIGURE E-17

THEORETICALLY COMPUTED PRESSURES, DECEMBER 7, 1976

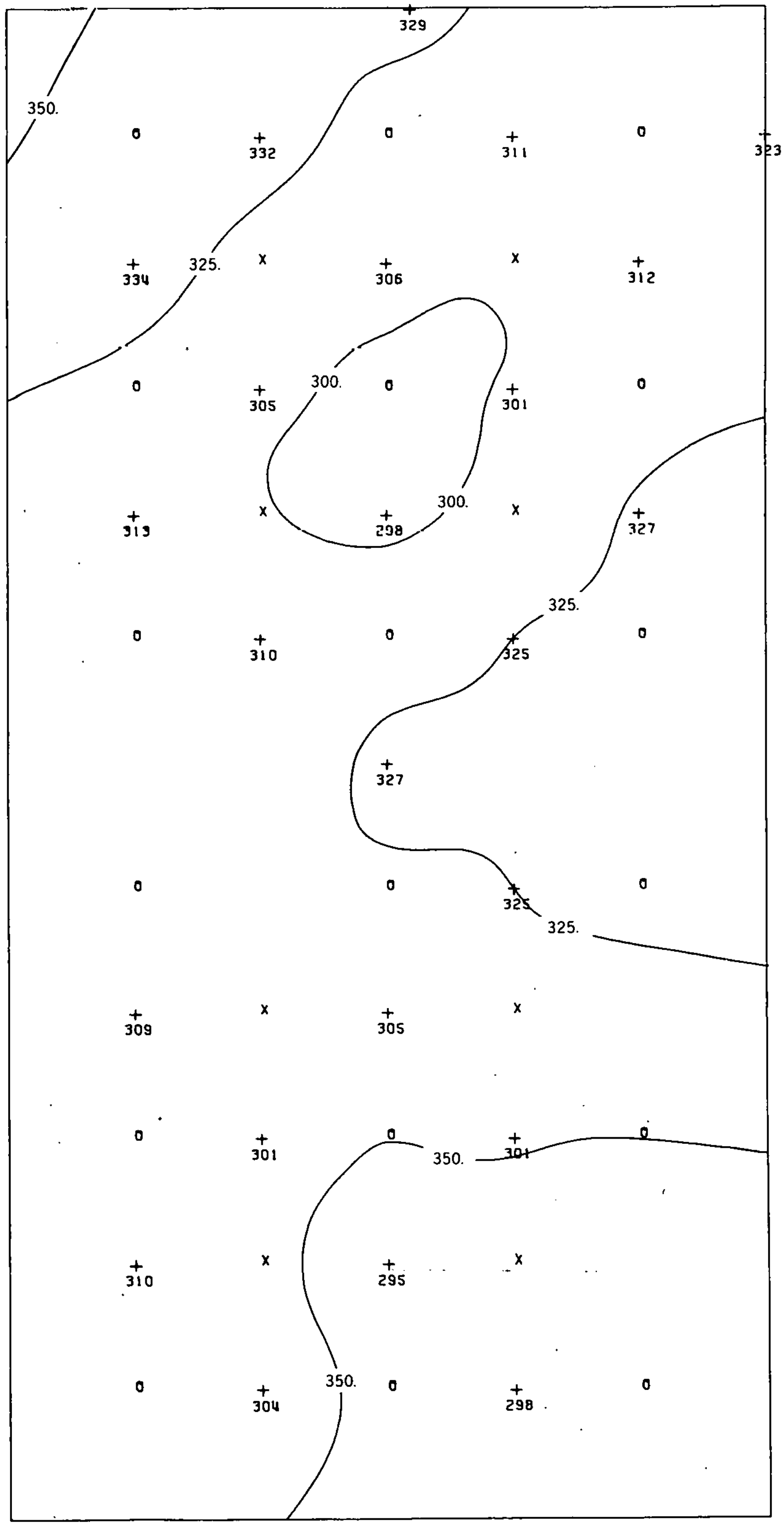


FIGURE E-18
DIFFERENCE BETWEEN COMPUTED AND OBSERVED PRESSURES
DECEMBER 3-7, 1976

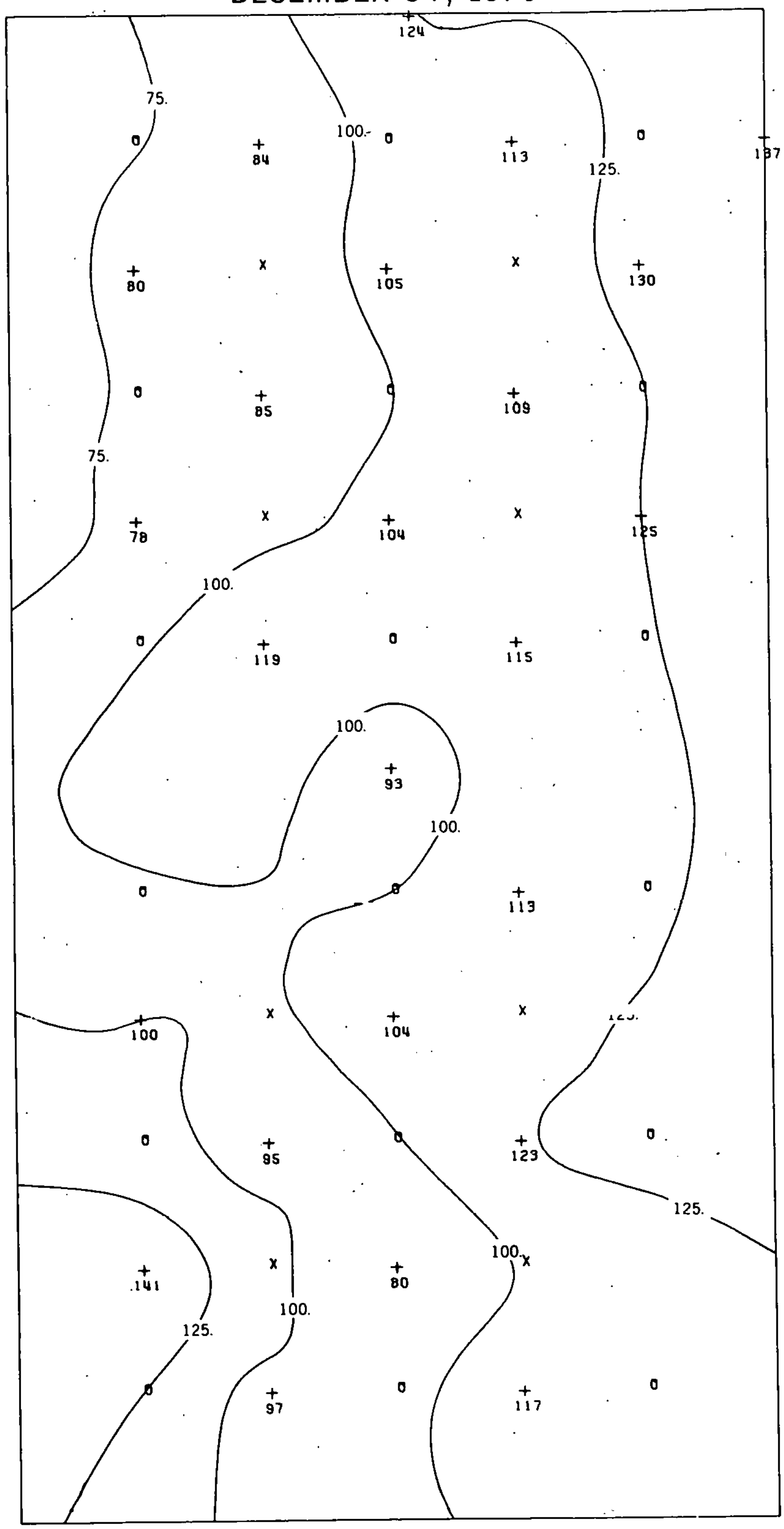


FIGURE E-19

SAMPLE SALINITY DATA FROM WELL MP-131 AS USED FOR DISPERSION CALCULATIONS

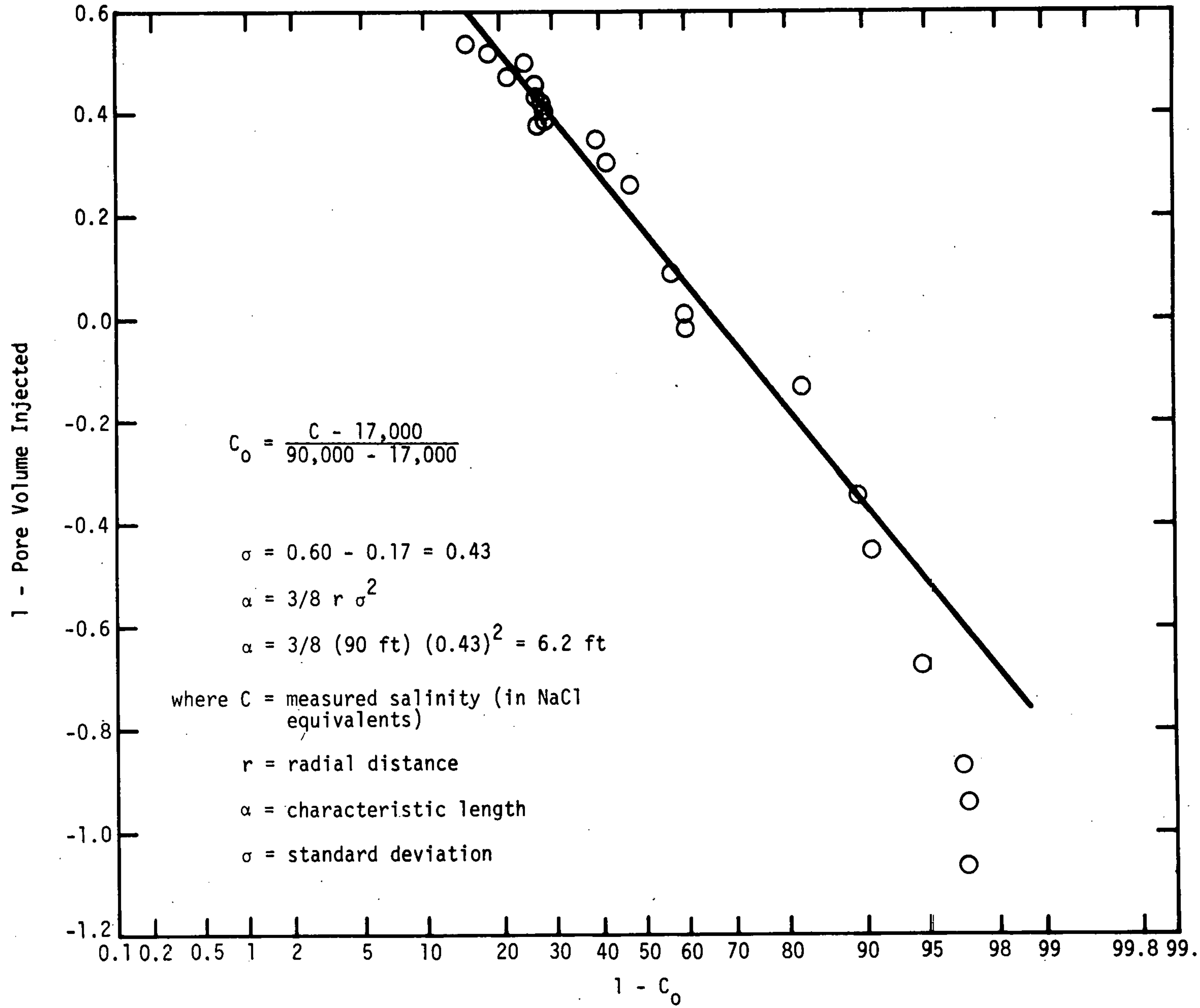
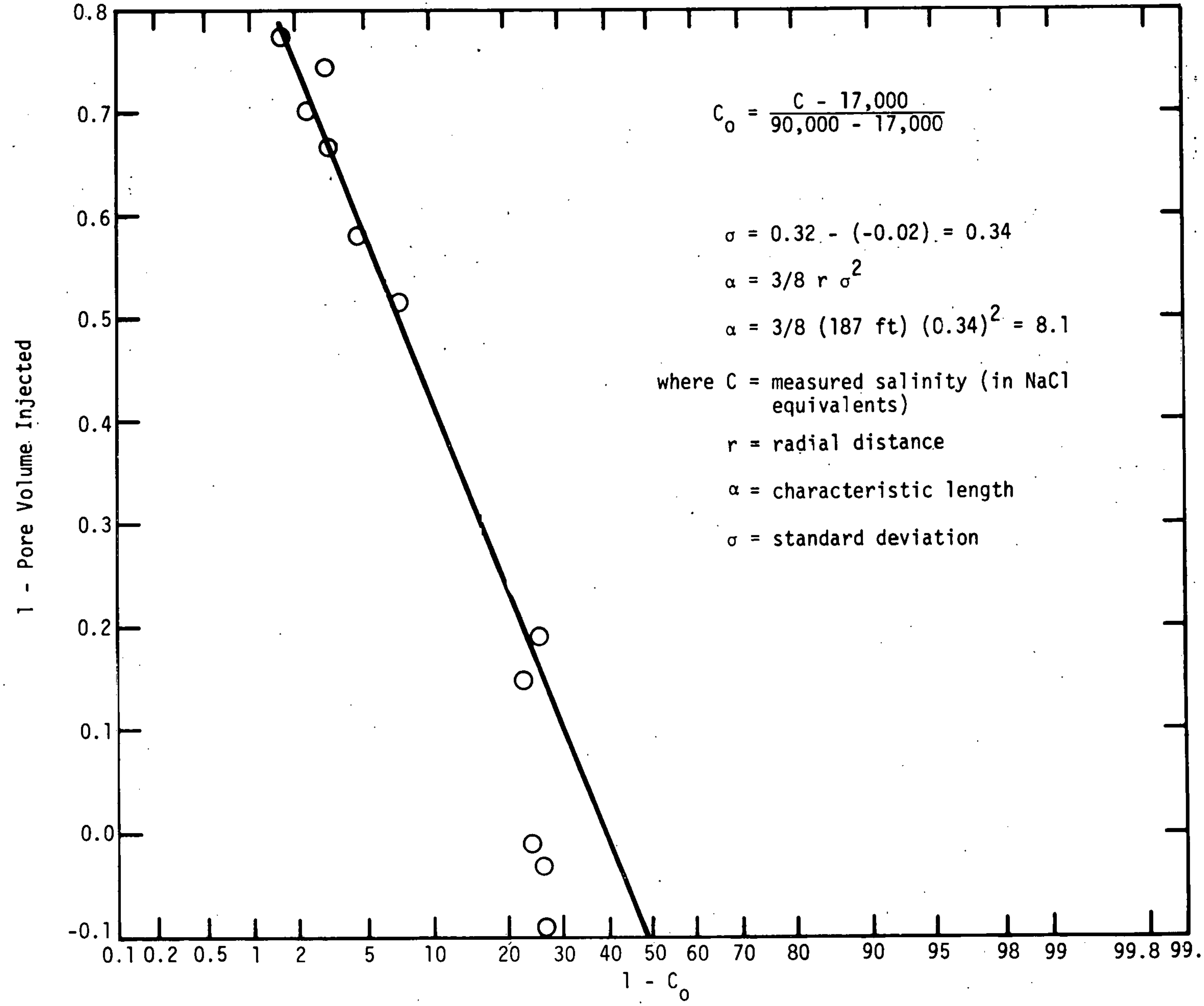


FIGURE E-20

SAMPLE SALINITY DATA FROM WELL MP-132 AS USED FOR DISPERSION CALCULATIONS



$$C_o = \frac{C - 17{,}000}{90{,}000 - 17{,}000}$$

$\sigma = 0.32 - (-0.02) = 0.34$

$\alpha = 3/8\ r\ \sigma^2$

$\alpha = 3/8\ (187\ \text{ft})\ (0.34)^2 = 8.1$

where C = measured salinity (in NaCl equivalents)

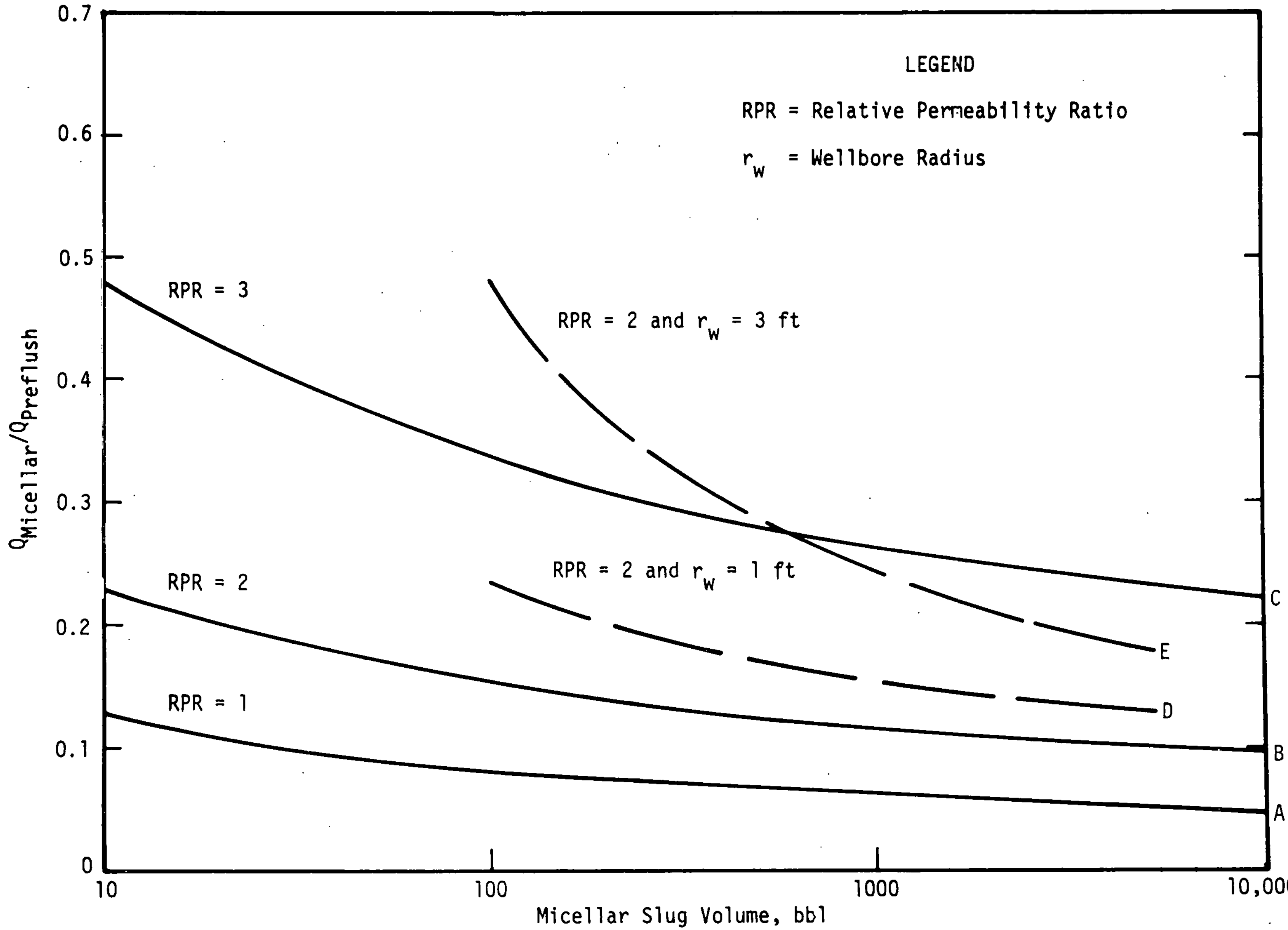
r = radial distance

α = characteristic length

σ = standard deviation

FIGURE E-21

PREDICTED LOSS OF INJECTIVITY FOR THE SOUTH PATTERN DUE TO THE HIGH VISCOSITY OF THE MICELLAR SLUG FOR VARIOUS RELATIVE PERMEABILITY RATIOS



APPENDIX F

FORMATION INJECTIVITY TESTS

Tables and Figures

TABLE F1

SUMMARY OF INJECTION INTO WELL MP-225

Approximate Dates	Type Fluid Injected	Temperature, °F	Viscosity, cp	Volume Injected, bbl	Final Rate, bbl/day	$Q/\Delta P$, bbl/day-psi
Nov. 18, 1975-May 18, 1976	Pretreatment (2 wt % NaCl solution)	68	1.05	10,451	79	0.30
	Micellar Water	68	0.99	361	85	0.33
May 20, 1976	50-50 Mixture (micellar oil-micellar water)	68	24*	9	3	0.01
May 21, 1976	Pretreatment (2 wt % NaCl solution)	113	0.65	7	84	0.32
May 21, 1976	50-50 Mixture (micellar oil-micellar water)	103	~18*	4.2	~29	0.11
May 21, 1976	Pretreatment (2 wt % NaCl solution)	98	0.75	1.5	36	0.14
May 22, 1976	Pretreatment (2 wt % NaCl solution)	166	0.39	4.5	72	0.28
May 24-25, 1976	Micellar Oil	71	~48*	~4	~9	0.03
May 25, 1976	Pretreatment (2 wt % NaCl solution)	121	0.60	3.2	44	0.17
May 26, 1976	Micellar Water	68	0.99	41.2	86	0.33
May 27-June 2, 1976	Preflush	68	0.99	339	50	0.19

*Measured at 6 rpm using a Brookfield LVT viscometer with UL adaptor.

TABLE F2

SUMMARY OF INJECTION INTO WELL MP-211

Approximate Dates	Type Fluid Injected	Temperature, °F	Viscosity, cp	Volume Injected, bbl	Final Rate, bbl/day	$Q/\Delta P$, bbl/day-psi
Nov. 18, 1975-May 29, 1976	Pretreatment (2 wt % NaCl solution)	68	1.05	12,473	--	--
May 29, 1976	Micellar Water	68	0.99	50.9	100	0.38
May 29-June 2, 1976	Preflush	68	0.99	396.9	93	0.36
June 2, 1976	Micellar Water	68	0.99	40.8	92	0.35
June 2-June 4, 1976	Micellar Oil	120	$\sim$25*	5.6	$\sim$6	0.02
June 4-June 9, 1976	Pretreatment II (1 wt % NaCl solution)	68	1.0	491	76	0.29
June 9-June 10, 1976	Micellar Water	68	1.0	93	$\sim$89	--
June 10, 1976	Micellar Oil	100	$\sim$44*	4.3	3.2	--
June 10-June 15, 1976	Micellar Water	68	1.0	100	99	--

*Measured at 6 rpm using a Brookfield LVT viscometer with UL adaptor.

TABLE F3

SUMMARY OF INJECTION EVENTS FOR WELL MP-202

Dates	Event	Volume, bbl	Final Rate, bbl/day	Bottom-hole Pressure, psi	ΔP, psi	Wellhead Pressure, psi	Viscosity, cp	$Q/\Delta P$, bbl/day-psi	$Q\mu/\Delta P$, bbl-cp/day-psi
Nov. 15, 1976- Nov. 17, 1976	Injected micellar water	75	72	466	278.5	200	1	0.26	0.26
Nov. 17, 1976	Ran fall-off test and acidized								
Nov. 18, 1976- Nov. 21, 1976	Injected micellar water	285	137	465	277.5	200	1	0.50	0.50
Nov. 21, 1976- Nov. 23, 1976	Ran fall-off test								
Nov. 23, 1976- Dec. 1, 1976	Injected preflush	602	53	482	294.5	200	1	0.18	0.18
Dec. 1, 1976- Dec. 2, 1976	Lines froze while switching to micellar water.								
Dec. 2, 1976	Injected hot micellar water	17	105	482	294.5	200	1	0.36	0.36
Dec. 2, 1976- Dec. 3, 1976	Injected GCCO[‡]	15	20	500	312.5	260	6[*]	0.06	0.38
Dec. 3, 1976	Injected cold micellar water	4	15	497	309.5	200	1	0.05	0.05
Dec. 3, 1976- Dec. 4, 1976	Injected hot micellar water	45	54	484	296.5	200	1	0.18	0.18

[‡] GCCO is Greenwood County crude oil.

[*] Measured at 6rpm using Brookfield LVT viscometer with UL adaptor.

TABLE F3

SUMMARY OF INJECTION EVENTS FOR WELL MP-202

(continued)

Dates	Event	Volume, bbl	Final Rate, bbl/day	Bottom-hole Pressure, psi	ΔP, psi	Wellhead Pressure, psi	Viscosity, cp	Q/ΔP, bbl/day-psi	Qμ/ΔP, bbl-cp/day-psi
Dec. 4, 1976	Injected hot GCCO	4	10	486	298.5	265	6*	0.03	0.18
Dec. 4, 1976-Dec. 5, 1976	Injected hot micellar water	21	41	486	298.5	200	1	0.14	0.14
Dec. 6, 1976	Acidized with 500 gal 15% HCl, 1000 gal HF, 500 gal 15% HCl; flushed lines with 16 bbl micellar water.								
Dec. 6, 1976-Dec. 7, 1976	Injected cold micellar water	102	120	486	298.5	200	1	0.40	0.40
Dec. 7, 1976-Dec. 15, 1976	Shut in, treated GCCO with "No-Wax"								
Dec. 15, 1976-Dec. 16, 1976	Injected cold micellar water	70	100	412	224.5	160	1	0.44	0.44
Dec. 16, 1976-Dec. 17, 1976	Injected cold GCCO	25	41	491	303.5	250	6*	0.14	0.81
Dec. 17, 1976-Dec. 29, 1976	Shut in. Flushed lines with 18 bbl micellar water, waited on micellar oil test.								
Dec. 29, 1976-Dec. 30, 1976	Injected cold micellar water	44	57	475	287.5	200	1	0.20	0.20
Dec. 30, 1976-Dec. 31, 1976	Injected cold micellar oil	8	17	489	301.5	225	31*	0.06	1.75

TABLE F3

SUMMARY OF INJECTION EVENTS FOR WELL MP-202

(continued)

Dates	Event	Volume, bbl	Final Rate, bbl/day	Bottom-hole Pressure, psi	ΔP, psi	Wellhead Pressure, psi	Viscosity, cp	Q/ΔP, bbl/day-psi	Qμ/ΔP, bbl-cp/day-psi
Dec. 31, 1976- Jan. 6, 1977	Shut in. Winterized injectivity setup.								
Jan. 6, 1977- Jan. 7, 1977	Injected cold micellar water	67	80	510	322.5	201	1	0.25	0.25
Jan. 7, 1977- Jan. 8, 1977	Shut in to run fall-off test Filled lines with six bbl GCCO.								
Jan. 8, 1977- Jan. 21, 1977	Treated GCCO with Magna D-Wax 950W (it was later determined 950W was not the proper concentration).								
Jan. 21, 1977- Feb. 4, 1977	Dumped oil treated with 950W. Treated GCCO with Magna D-Wax 950.								
Feb. 4, 1977- Feb. 6, 1977	Injected cold micellar water	98	62	505	285	201	1	0.22	0.22
Feb. 6, 1977- Feb. 9, 1977	Injected cold micellar oil	41	11	30	310	270	39.5*	0.04	1.40
Feb. 9, 1977- Feb. 10, 1977	Injected cold micellar water	42	60	530	310	255	1	0.19	0.19
Feb. 10, 1977- Feb. 13, 1977	Injected cold micellar oil	41	14	534	314	265	39.5*	0.04	1.76

TABLE F3

SUMMARY OF INJECTION EVENTS FOR WELL MP-202

(continued)

Dates	Event	Volume, bbl	Final Rate, bbl/day	Bottom-hole Pressure, psi	ΔP, psi	Wellhead Pressure, psi	Viscosity, cp	$Q/\Delta P$, bbl/day-psi	$Q\mu/\Delta P$, bbl-cp/day-psi
Feb. 13, 1977- Feb. 15, 1977	Injected cold micellar water	91	63	523	303	240	1	0.21	0.21
Feb. 15, 1977- Feb. 16, 1977	Shut down. Ran fall-off test.								

TABLE F4

SUMMARY OF INJECTION EVENTS FOR WELL MP-109

Date	Event	Volume, bbl	Final Rate, bbl/day	Bottom-hole Pressure, psi	ΔP, psi	Wellhead Pressure, psi	Viscosity, cp	Q/ΔP, bbl/day-psi	Qμ/ΔP, bbl-cp/day-psi
Aug. 10, 1976	Ran injectivity profile								
Aug. 10, 1976	Injected preflood	859	210	538	269	260	1	0.78	0.78
Aug. 15, 1976	Ran fall-off test, Kh = 1038 md-ft, Skin = +1								
Aug. 20, 1976	Injected preflood	453	152	532	263	250	1	0.58	0.58
Aug. 23, 1976	Ran fall-off test								
Aug. 24, 1976	Injected preflood	118	120	497	228	205	1	0.53	0.53
Aug. 25, 1976	Injected micellar fluid (surfactant and Kelzan)	5.4	0.63	546	277	273	31*	0.002	0.07
Aug. 29, 1976	Injected preflood	1	0.21	547	278	260	1	0.0007	0.0007
Aug. 31, 1976	Swabbed 50 bbl at 20 bbl/hr								
Aug. 31, 1976	Injected preflood	5	8	∿495	226	200	1	0.035	0.035
Sept. 1, 1976	Swabbed 50 bbl at 20 bbl/hr								
Sept. 1, 1976	Injected preflood	25	40	∿495	226	200	1	0.177	0.177
Sept. 1, 1976	Shut down to move to well MP-121								

*Measured at 6 rpm using a Brookfield LVT viscometer with UL adaptor.

TABLE F5

SUMMARY OF INJECTION EVENTS FOR WELL MP-121

Date	Event	Volume, bbl	Final Rate, bbl/day	Bottom-hole Pressure, psi	ΔP, psi	Wellhead Pressure, psi	Viscosity, cp	$Q/\Delta P$, bbl/day-psi	$Q\mu/\Delta P$, bbl-cp/day-psi
Sept. 2, 1976	Injected preflood	55	120	398	168	115	1	0.71	0.71
Sept. 7, 1976	Ran injectivity profile								
Oct. 15, 1976	Injected preflood	440	142	490	260	200	1	0.55	0.55
Oct. 19, 1976	Ran fall-off test #1, K = 39 md, Skin = +1.38								
Oct. 20, 1976	Injected preflood	109	69	505	275	200	1	0.25	0.25
Oct. 21, 1976	Injected micellar (surfactant and Pfizer)	1.5	2.7	505	275	200	31.5*	0.01	0.30
Oct. 22, 1976	Circulated micellar fluid from well								
Oct. 22, 1976	Injected preflood	39	10	512	282	200	1	0.03	0.03
Oct. 25, 1976	Ran fall-off test #2								
Oct. 26, 1976	Acidized with 500 gal 15 percent HCl, 1000 gal HF, 500 gal 15 percent HCl								
Oct. 26, 1976	Injected preflood	498	185	446	216	130	1	0.86	0.86
Oct. 29, 1976	Ran fall-off test #3								
Oct. 30, 1976	Injected preflood	187	186	412	182	110	1	1.02	1.02
Oct. 30, 1976	Injected Pfizer Polymer 320 ppm solution	156	190	503	273	200	5.6*	0.70	3.90

*Measured at 6 rpm using a Brookfield LVT viscometer with UL adaptor.

TABLE F5

SUMMARY OF INJECTION EVENTS FOR WELL MP-121

(continued)

Date	Event	Volume, bbl	Final Rate, bbl/day	Bottom-hole Pressure, psi	ΔP, psi	Wellhead Pressure, psi	Viscosity, cp	Q/ΔP, bbl/day-psi	Qμ/ΔP, bbl-cp/day-psi
Nov. 1, 1976	Injected Pfizer 490 ppm solution	151	137	504	274	200	10.2*	0.50	5.10
Nov. 2, 1976	Injected Pfizer 740 ppm solution	191	87	504	274	200	19.3*	0.32	6.10
Nov. 4, 1976	Injected Pfizer 1095 ppm solution	203	60	506	276	200	38.6*	0.22	8.40
Nov. 7, 1976	Injected preflood	654	184	476	246	190	1	0.75	0.75
Nov. 11, 1976	Injected preflood	842	146	472	242	200	1	0.60	0.60
Nov. 17, 1976	Injected surfactant	17	96	471	241	200	2.6*	0.40	1.03
Nov. 17, 1976	Ran fall-off test #5								
Nov. 18, 1976	Tried to remix surfactant to mix with Pfizer polymer. Could not clean tank truck well enough.								
Nov. 19, 1976	Circulated surfactant to pit								
Nov. 19, 1976	Injected preflush	123	130	742	242	200	1	0.54	0.54
Nov. 21, 1976	Ran fall-off test #6, K = 44.9 md, Skin = +1.9								
Nov. 23, 1976	Shut down. Wait on additional chemicals.								
Mar. 8, 1977	Injected preflood	422	122	473	240	190	1	0.51	0.51

TABLE F5

SUMMARY OF INJECTION EVENTS FOR WELL MP-121

(continued)

Date	Event	Volume, bbl	Final Rate, bbl/day	Bottom-hole Pressure, psi	ΔP, psi	Wellhead Pressure, psi	Viscosity, cp	Q/ΔP, bbl/day-psi	Qμ/ΔP, bbl-cp/day-psi
Mar. 12, 1977	Injected micellar fluid (surfactant and Pfizer)	79	60	510	280	215	44*	0.21	9.40
Mar. 13, 1977	Injected preflood	136	89	470	240	200	1	0.37	0.37
Mar. 16, 1977	Ran fall-off test #7								
Mar. 16, 1977	Injected preflood	438	73	466	236	190	1	0.31	0.31
Mar. 22, 1977	Acidized #2 with 750 gal 15 percent HCl								
Mar. 22, 1977	Injected preflood	914	154	462	232	190	1	0.66	0.66
Mar. 28, 1977	Shut down due to bad preflush quality								
Mar. 29, 1977	Injected preflood	206	186	469	239	190	1	0.78	0.78
Mar. 30, 1977	Ran fall-off test #8								
Mar. 31, 1977	Injected preflood	62	186	469	239	190	1	0.78	0.78
Mar. 31, 1977	Injected Abbott Polymer 1095 ppm solution	133	59	460	230	190	40*	0.25	10.20
Apr. 2, 1977	Injected preflood	25	69	465	235	190	1	0.29	0.29
Apr. 2, 1977	Found leak in injection line. Shut down to run fall-off test #9.								
Apr. 4, 1977	Injected preflood	25	30	467	237	190	1	0.13	0.13

TABLE F5

SUMMARY OF INJECTION EVENTS FOR WELL MP-121

(continued)

Date	Event	Volume, bbl	Final Rate, bbl/day	Bottom-hole Pressure, psi	ΔP, psi	Wellhead Pressure, psi	Viscosity, cp	$Q/\Delta P$, bbl/day-psi	$Q\mu/\Delta P$, bbl-cp/day-psi
Apr. 5, 1977	Acidized #3 with 750 gal 15 percent HCl								
Apr. 5, 1977	Injected preflood	112	134	465	235	195	1	0.57	0.57
Apr. 6, 1977	Injected micellar (surfactant + Abbott)	86	60	518	288	230	29*	0.21	6.00
Apr. 7, 1977	Injected preflood	481	99	458	228	190	1	0.43	0.43
Apr. 13, 1977	Acidized #4 with 750 gal 15 percent HCl								
Apr. 13, 1977	Injected preflood	1122	120	469	239	190	1	0.50	0.50
Apr. 23, 1977	Injected Kelzan Polymer 1090 ppm solution	199	31	468	238	190	36.5*	0.13	4.80
Apr. 27, 1977	Injected preflood	31	34	480	250	190	1	0.14	0.14
Apr. 28, 1977	Acidized #5 with 750 gal 15 percent HCl								
Apr. 28, 1977	Injected preflood	237	105	465	235	190	1	0.46	0.45
Apr. 30, 1977	Injected micellar (surfactant + Kelzan)	80	8	470	240	195	22.5*	0.03	0.75
May 4, 1977	Injected preflood	115	26	470	240	190	1	0.11	0.11
May 9, 1977	Ran fall-off test #9								
May 11, 1977	Finished fall-off test. Shut down.								

TABLE F6

PFIZER BIOPOLYMER CONCENTRATIONS, SHEAR RATES, AND INJECTIVITY DURING INJECTIVITY TESTS AT DIFFERENT CONCENTRATIONS

Polymer Concentration, ppm	Viscosity at 6 rpm,* cp	Q, bbl/day	Bottom-hole Pressure, psig	$Q\mu/\Delta P$, bbl-cp/day-psi	Apparent Viscosity (Assuming $\frac{Q\mu}{\Delta P}$ = 1.04), cp	Calculated Shear Rate Γ, sec^{-1}	Calculated Viscosity, cp
0	1.0	190	413	1.04	1.00	--	--
320	5.8	160	505	3.37	1.79	926	--
490	10.2	140	505	5.19	2.04	811	2.8
740	19.3	100	505	7.02	2.86	579	4.4
1075	38.7	60	505	8.44	4.77	347	7.0

*Measured using a Brookfield LVT viscometer with UL adaptor.

TABLE F7

PFIZER BIOPOLYMER INJECTIVITY RESULTS FOR TEST

USING DIFFERENT RATES AT CONSTANT CONCENTRATION

Polymer Concentration, ppm	Viscosity, at 6 rpm,* cp	Q, bbl/day	Bottom-hole Pressure, psig	$Q\mu/\Delta P$, bbl-cp/day-psi	Apparent Viscosity at $\frac{Q\mu}{\Delta P}$ = 1.04, cp	Calculated Shear Rate Γ, sec^{-1}	Calculated Shear Stress μ, cp
740	19.3	50	402	5.61	3.58	290	5.7
740	19.3	70	450	6.14	3.27	405	5.0
740	19.3	90	493	6.60	3.04	521	4.6
740	19.3	100	505	7.02	2.86	579	4.4

*Measured using a Brookfield LVT viscometer with UL adaptor.

TABLE F8

COMPARISON OF INJECTIVITIES OF VARIOUS POLYMER SOLUTIONS

Mixture Description	Polymer Conc., ppm	Viscosity at 6 rpm,* cp	Rate,‡ bbl/day	Volume Injected, bbl	Calculated Shear Rate Γ, sec^{-1}	Calculated Shear Stress, μ, cp	Ratio of Injection Rates (Polymer or Polymer-Surfactant Rate Divided by Preflood Rate)
Preflood	--		186	187			--
Polymer (Pfizer)	1100	39	60	203	336	7.8	0.323
Preflood	--		122	422			--
Polymer (Pfizer) and Surfactant	990	44	60	79	315	10.0	0.492
Preflood	--		186	268			--
Polymer (Abbott)	1100	40	59	133	676	--	0.317
Preflood	--		134	112			--
Polymer (Abbott) and Surfactant	900	34	60	86	437	9.3	0.448
Preflood	--		120	1122			--
Polymer (Kelzan)	1100	40	31	199	1011	--	0.258
Preflood	--		105	237			--
Polymer (Kelzan) and Surfactant	900	30	8	80	274	10.1	0.076

Note: The fluctuation of injection pressures and viscosities of various polymer solutions was not considered.

*Measured using a Brookfield LVT viscometer with UL adaptor.

‡These are final rates; in most cases these rates appeared to be stabilized.

TABLE F9

RESERVOIR PARAMETERS AT WELL MP-121

Parameter	Symbol	Value
Wellbore Diameter	D	7 7/8 in
Net Pay	H	17.5 ft
Apparent Permeability	K	100.3 md
Porosity	ϕ	0.2357
Residual Oil Saturation	S_{or}	0.2305

FIGURE F-1

320 PPM PFIZER POLYMER SOLUTION INJECTIVITY AND FILTRATION TEST RESULTS

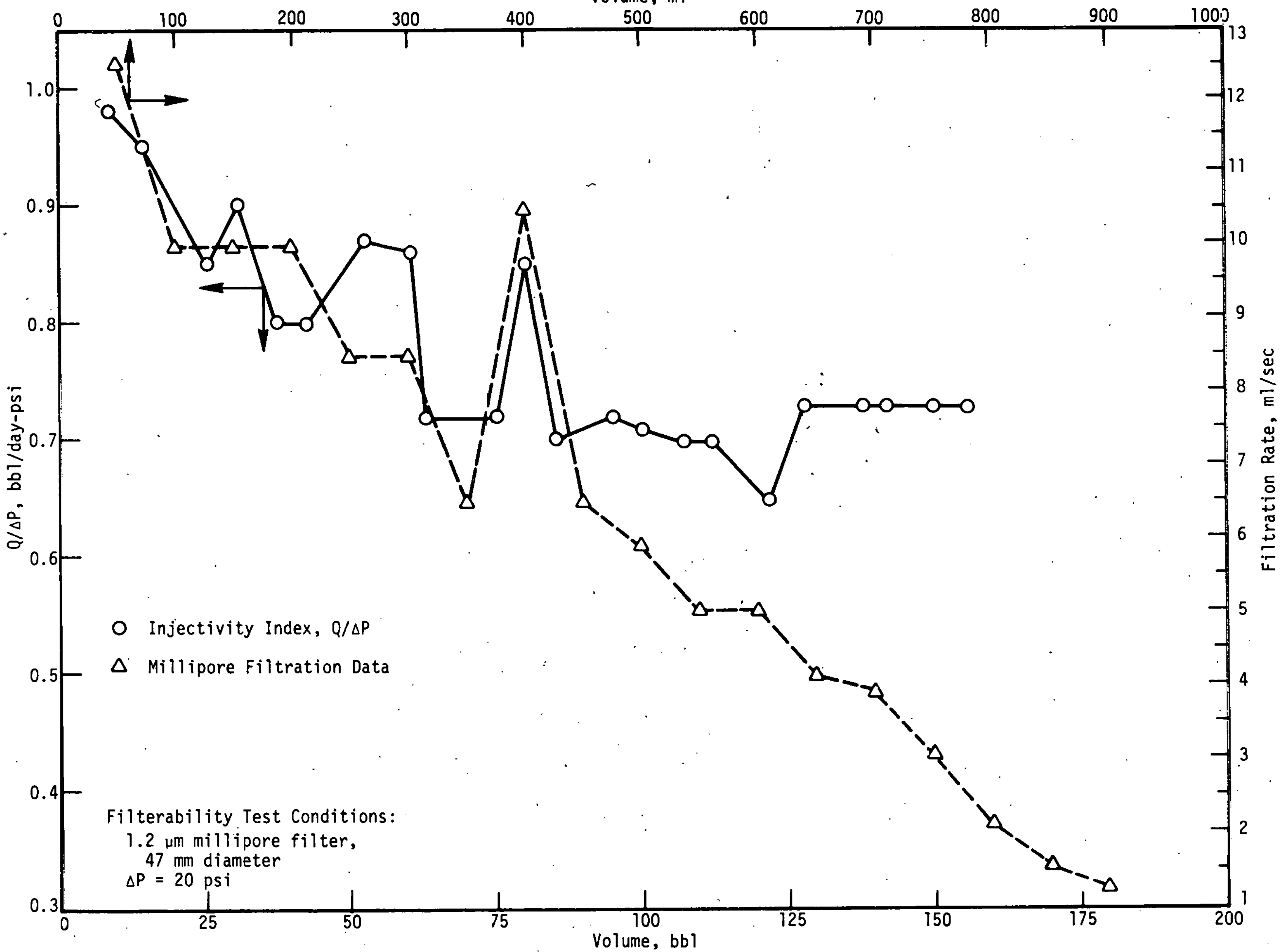


FIGURE F-2

490 PPM PFIZER POLYMER SOLUTION INJECTIVITY AND FILTRATION TEST RESULTS

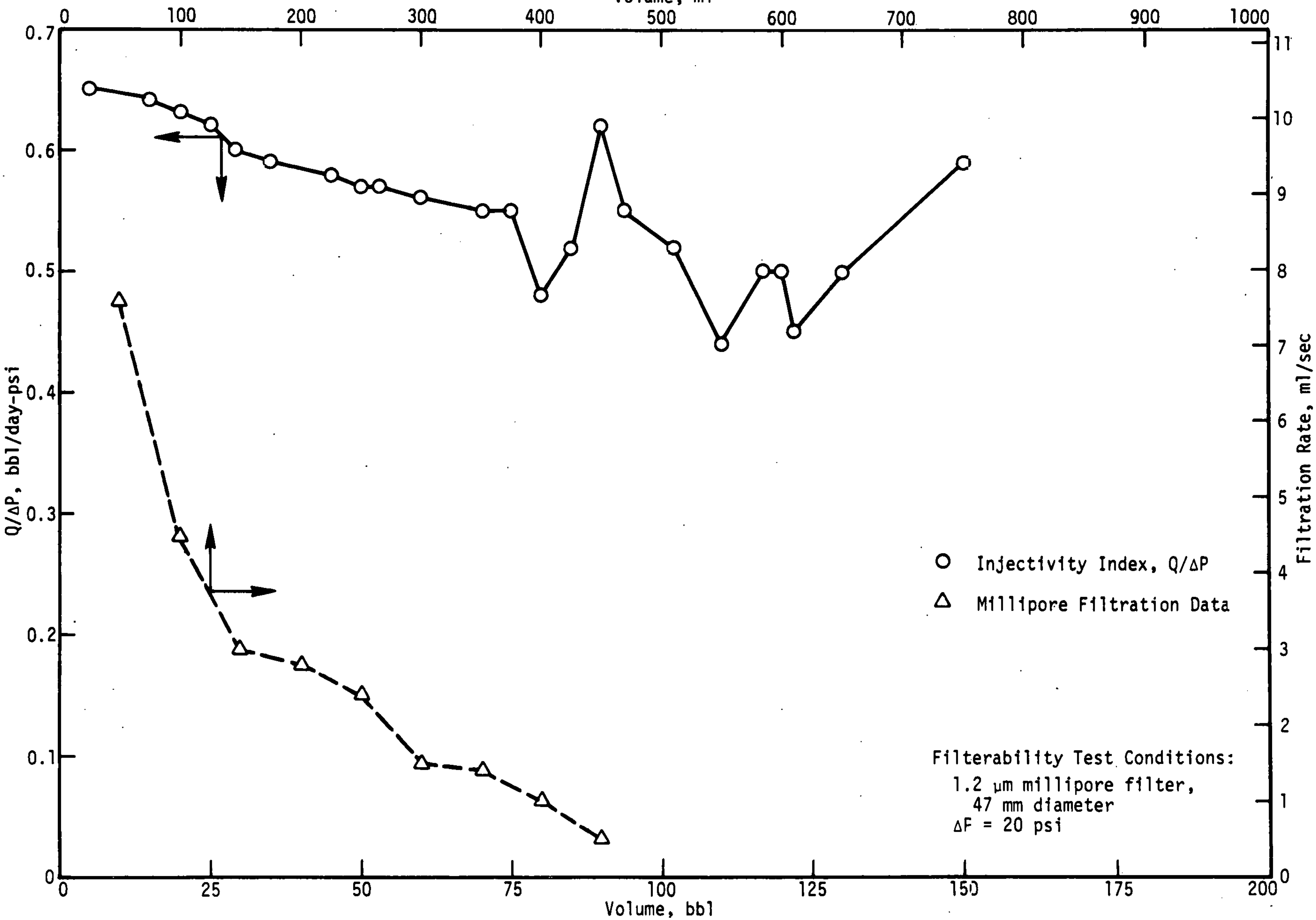


FIGURE F-3

740 PPM PFIZER POLYMER SOLUTION INJECTIVITY AND FILTRATION TEST RESULTS

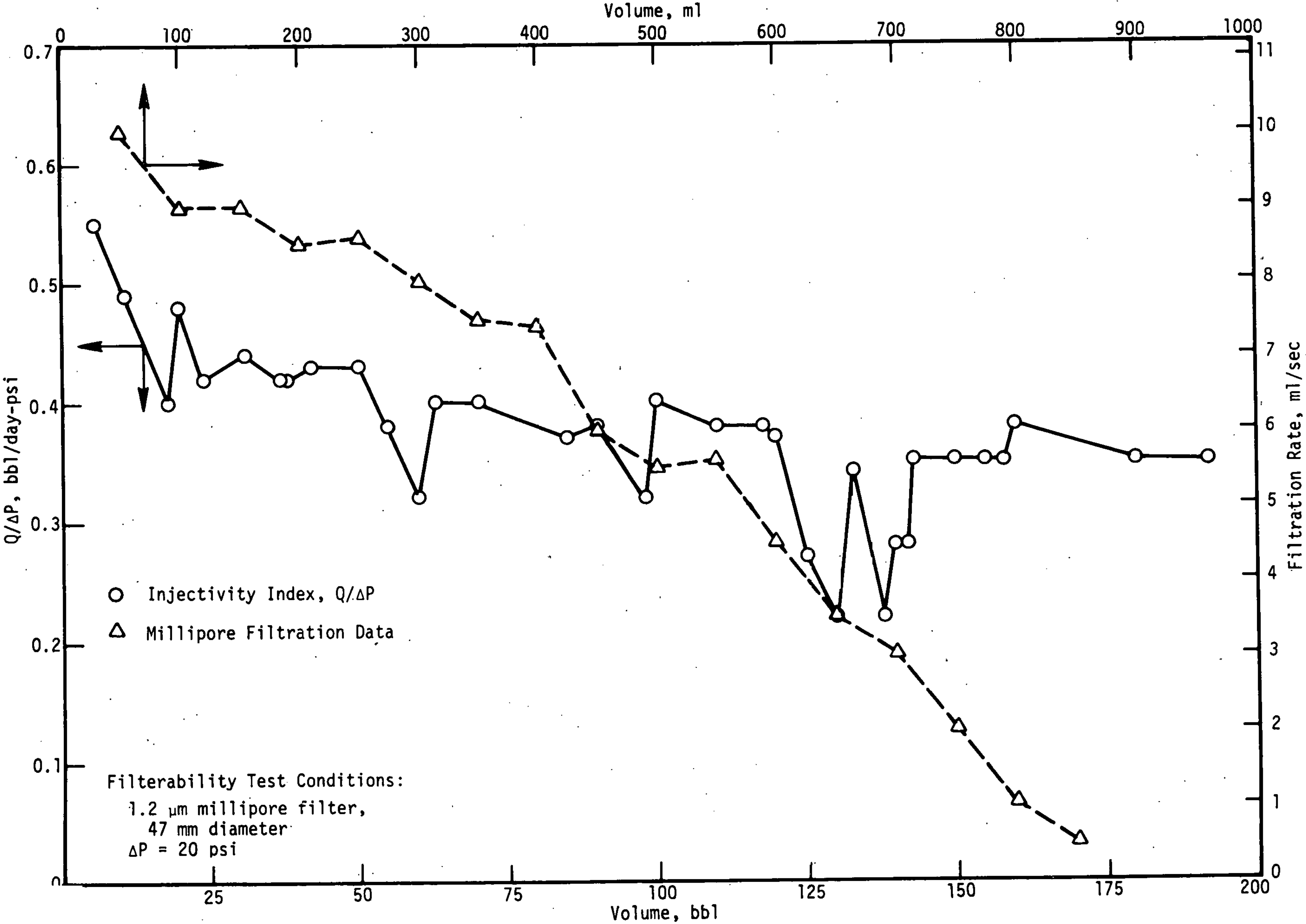


FIGURE F-4

1075 PPM PFIZER POLYMER SOLUTION INJECTIVITY AND FILTRATION TEST RESULTS

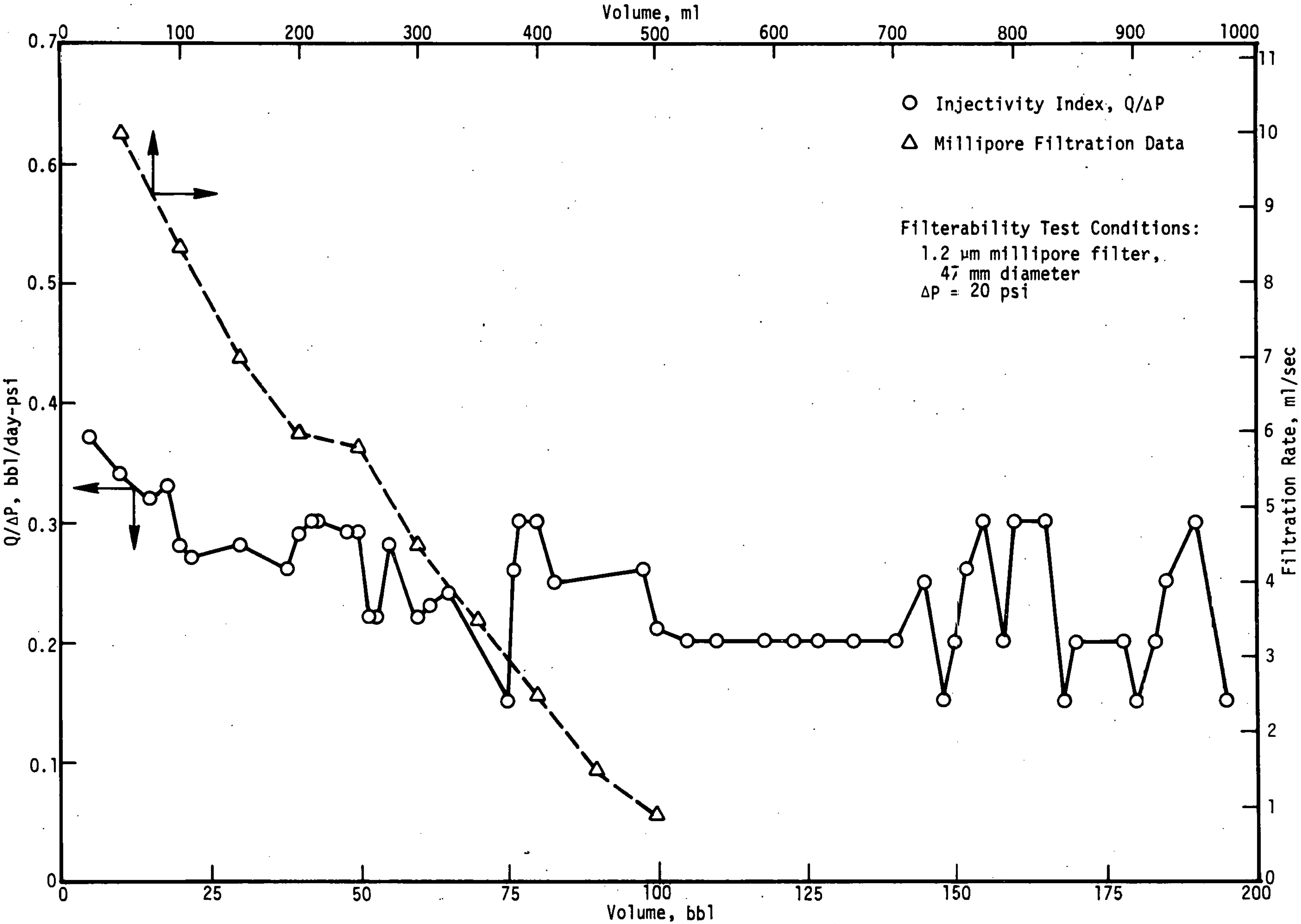


FIGURE F-5

MICELLAR SOLUTION MADE WITH PFIZER BIOPOLYMER INJECTIVITY AND FILTRATION TEST RESULTS

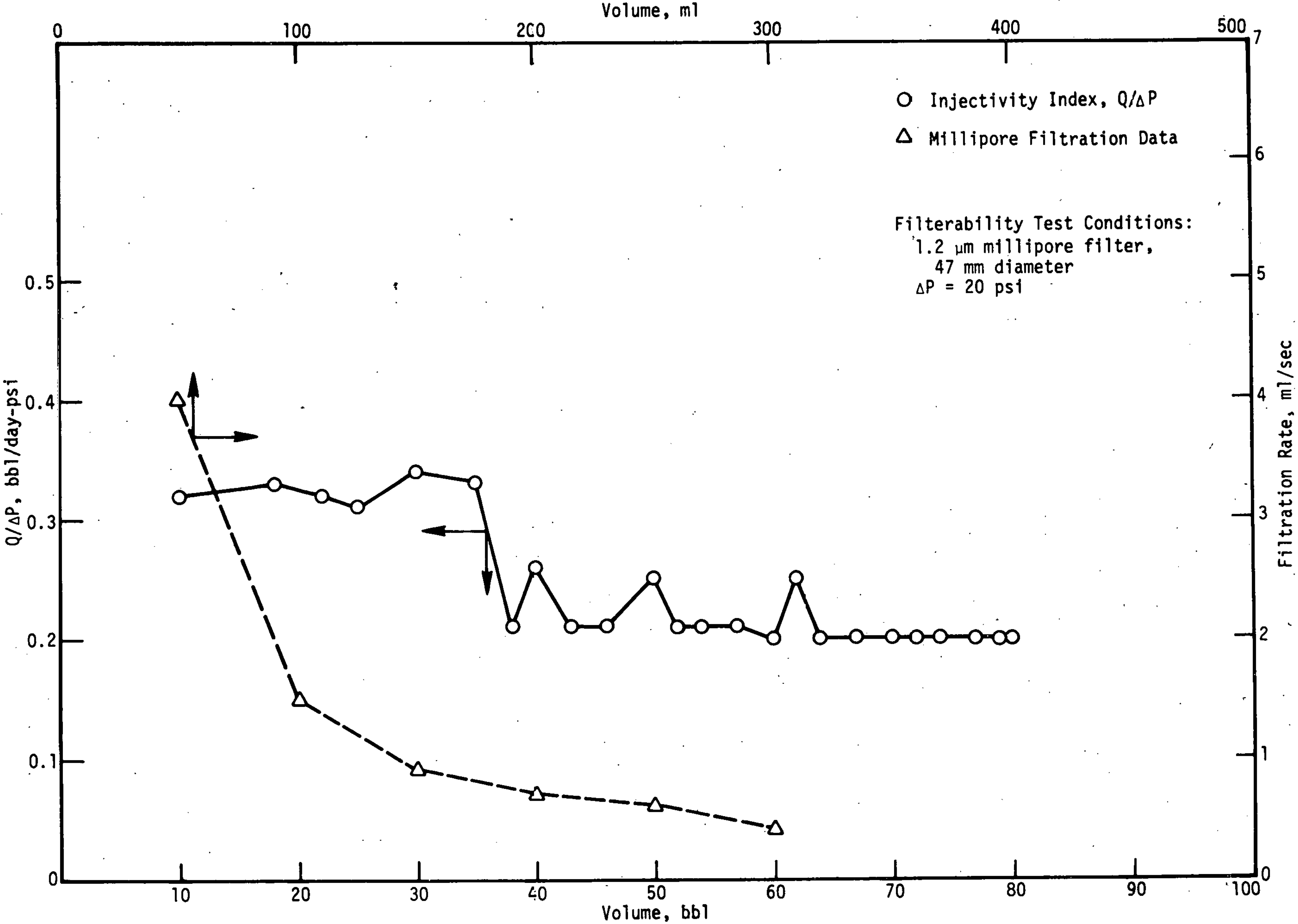
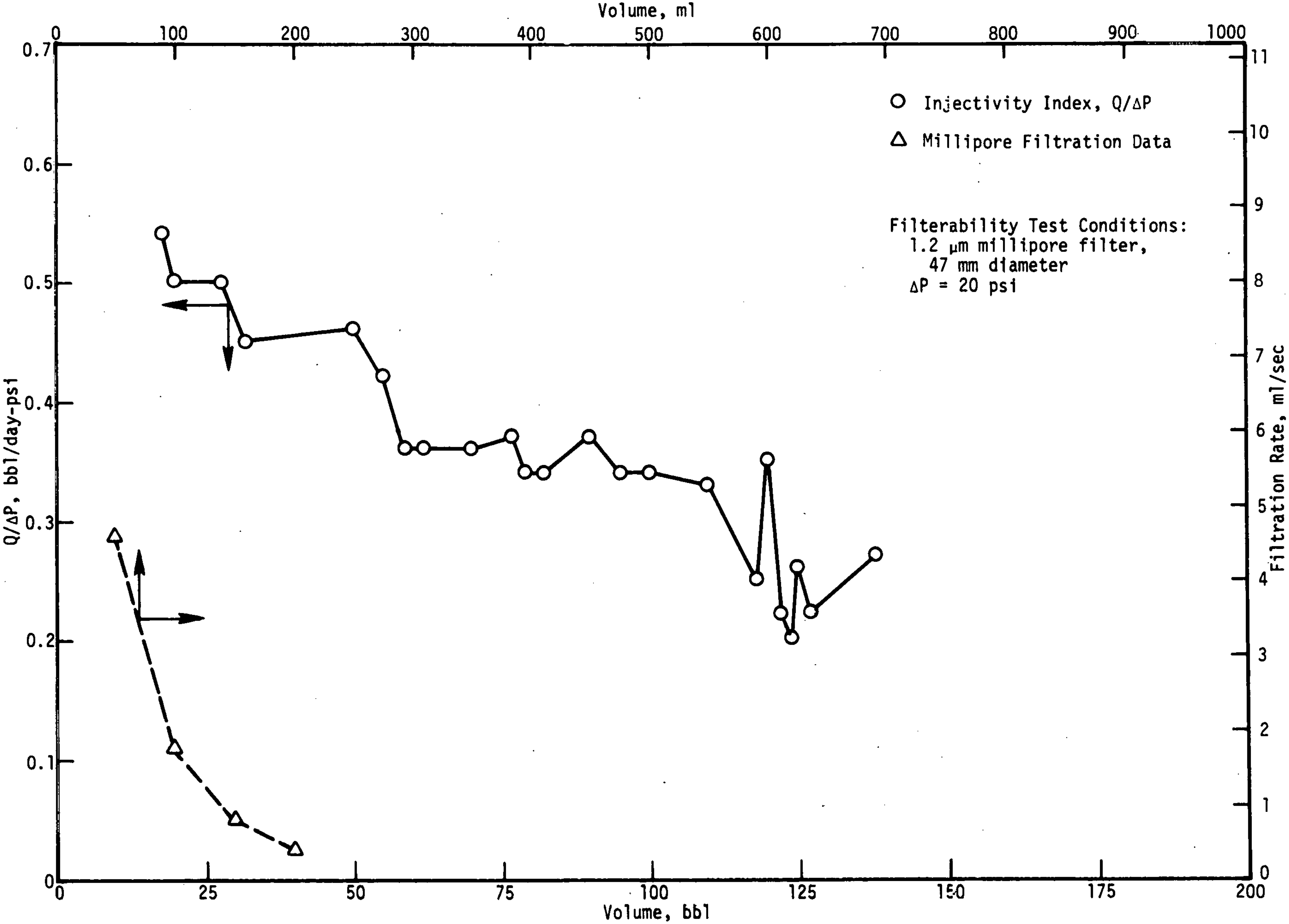


FIGURE F-6

1095 PPM ABBOTT POLYMER SOLUTION INJECTIVITY AND FILTRATION TEST RESULTS



III-11

FIGURE F-7

MICELLAR SOLUTION MADE WITH ABBOTT BIOPOLYMER INJECTIVITY AND FILTRATION TEST RESULTS

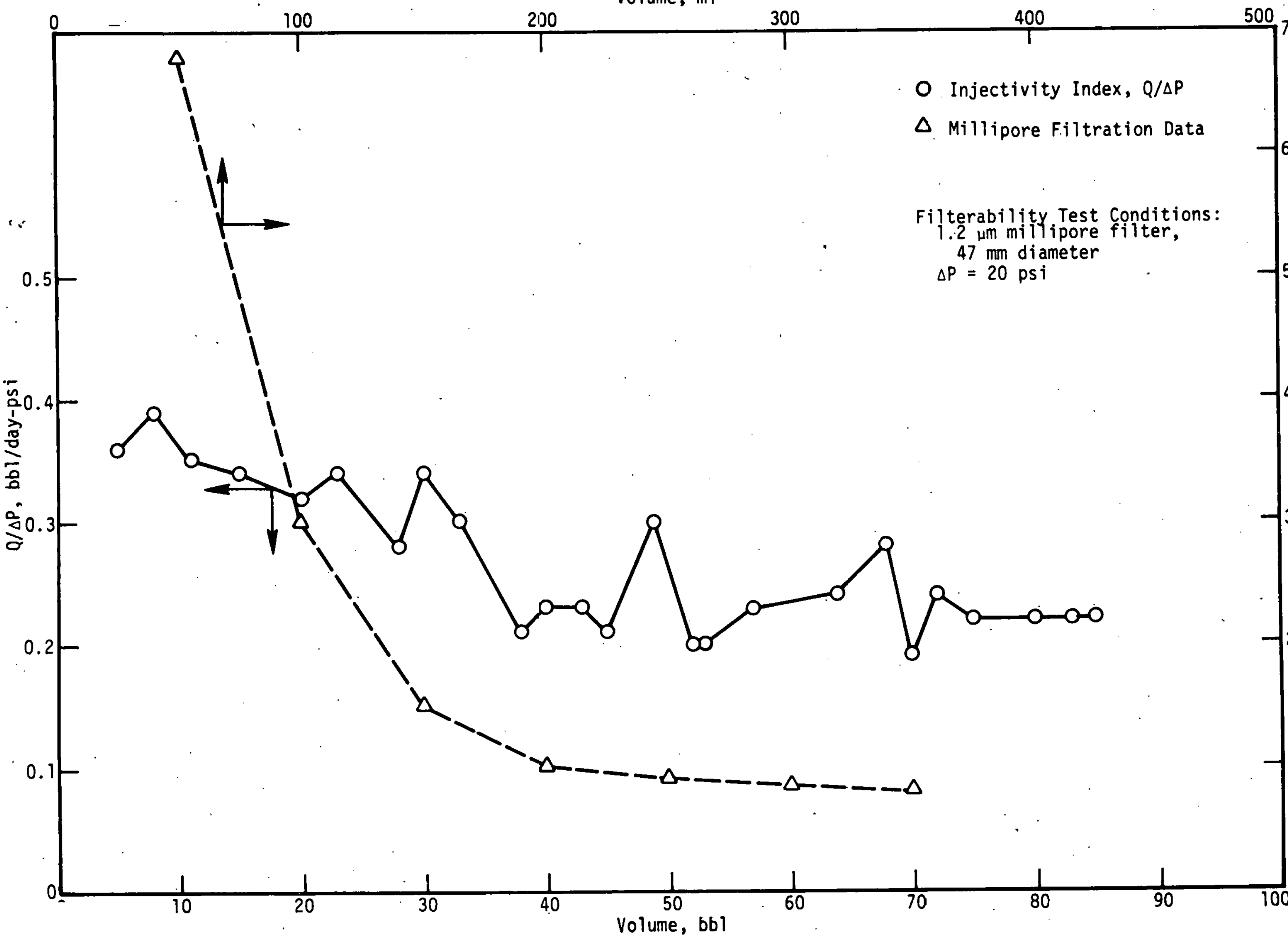


FIGURE F-8

1090 PPM KELZAN SS-4000 POLYMER SOLUTION INJECTIVITY AND FILTRATION TEST RESULTS

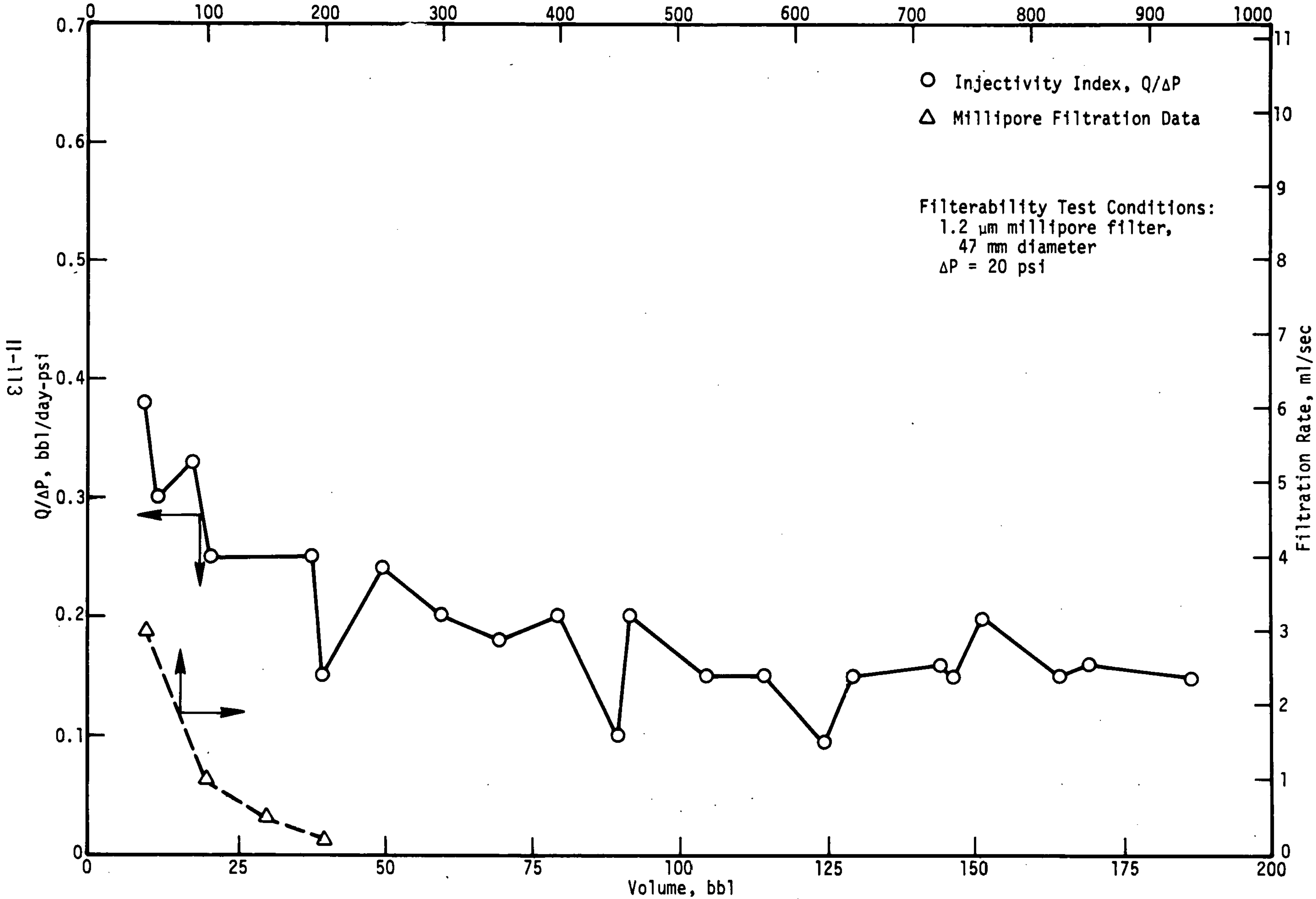


FIGURE F-9

MICELLAR SOLUTION MADE WITH KELZAN SS-4000 BIOPOLYMER INJECTIVITY AND FILTRATION TEST RESULTS

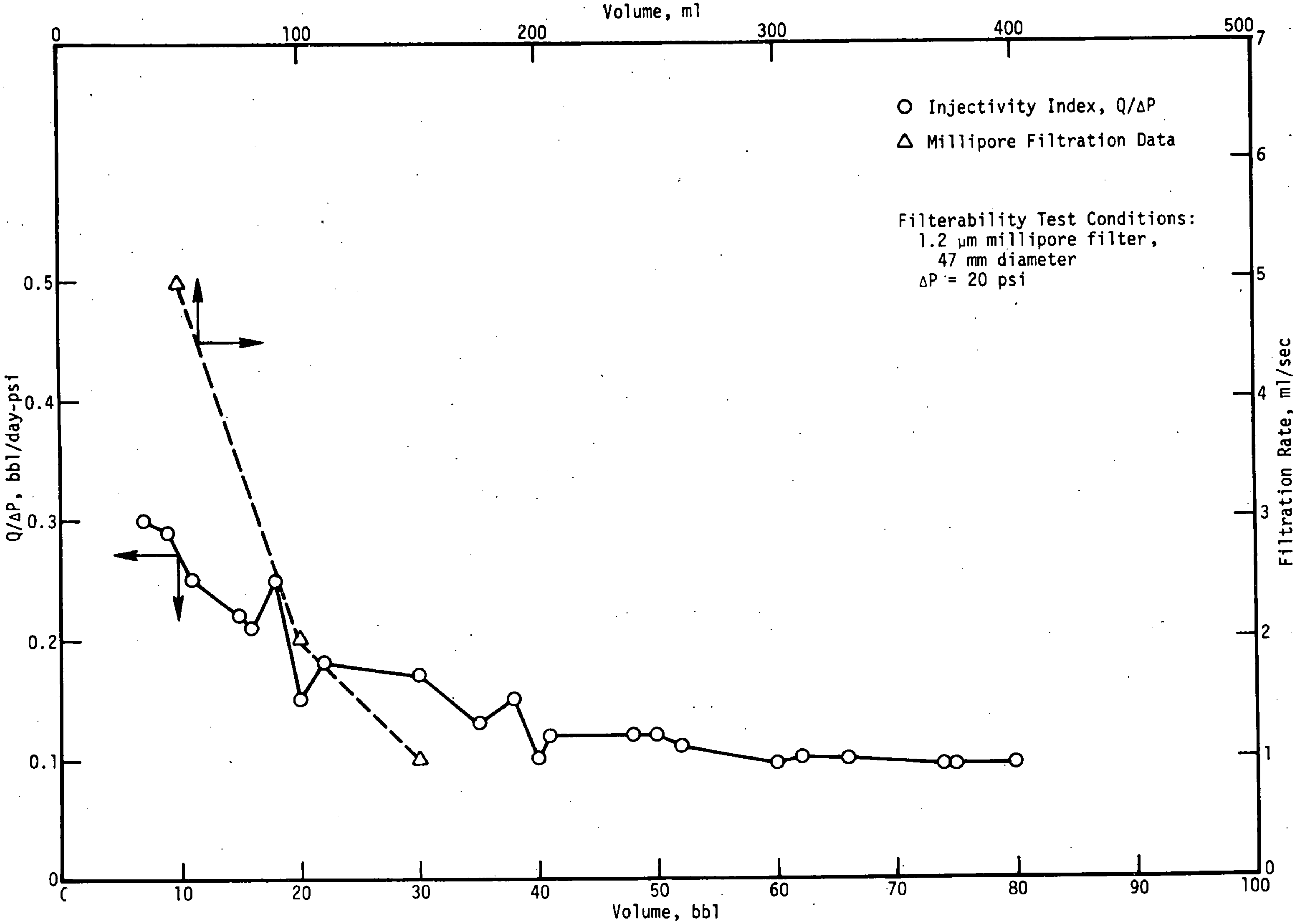


FIGURE F-10

FILTRATION TEST RESULTS FOR PREFLOOD USED TO MAKE 320 PPM PFIZER BIOPOLYMER SOLUTION

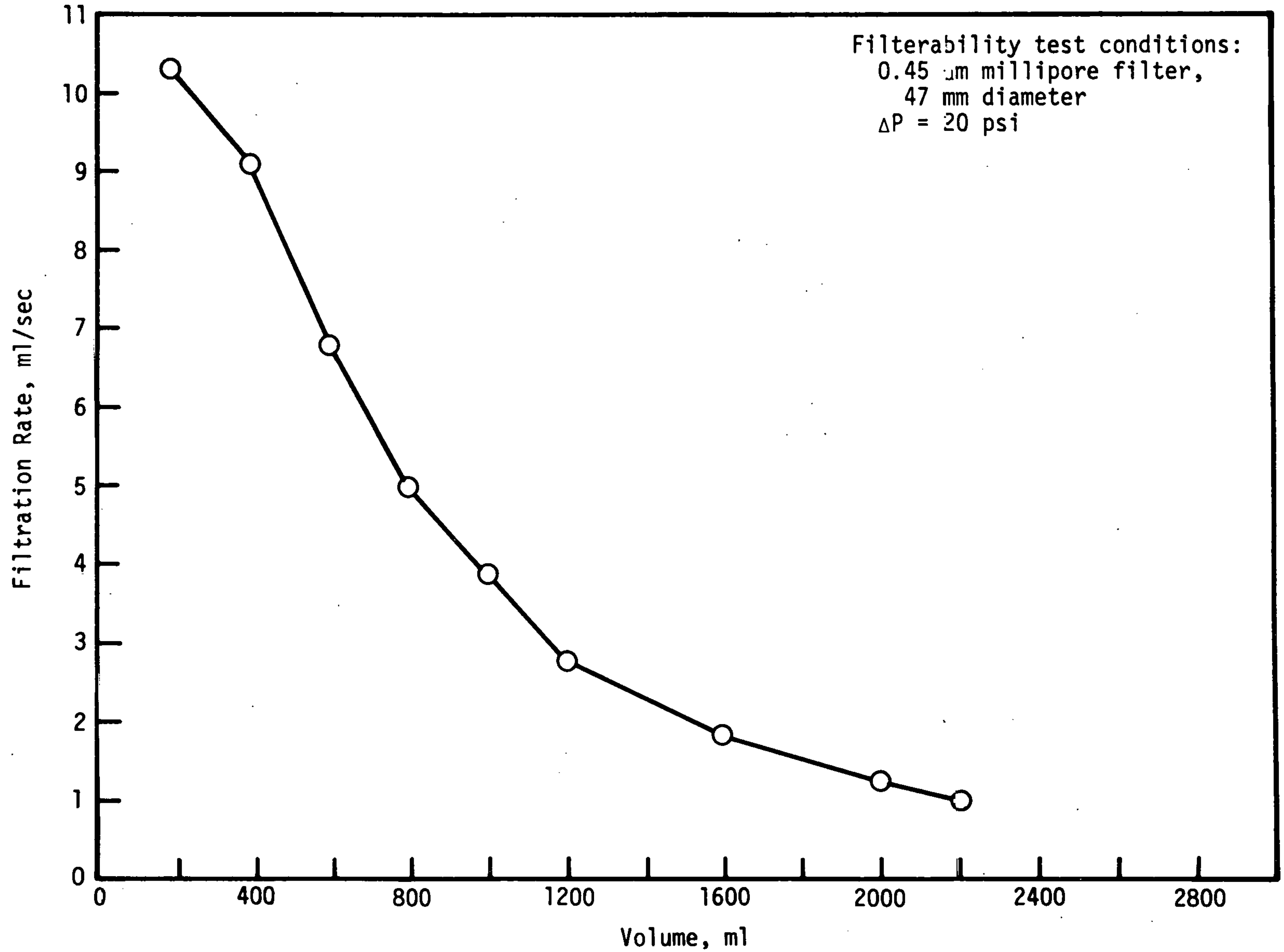


FIGURE F-11

FILTRATION TEST RESULTS FOR PREFLOOD USED TO MAKE 490 PPM PFIZER BIOPOLYMER SOLUTION

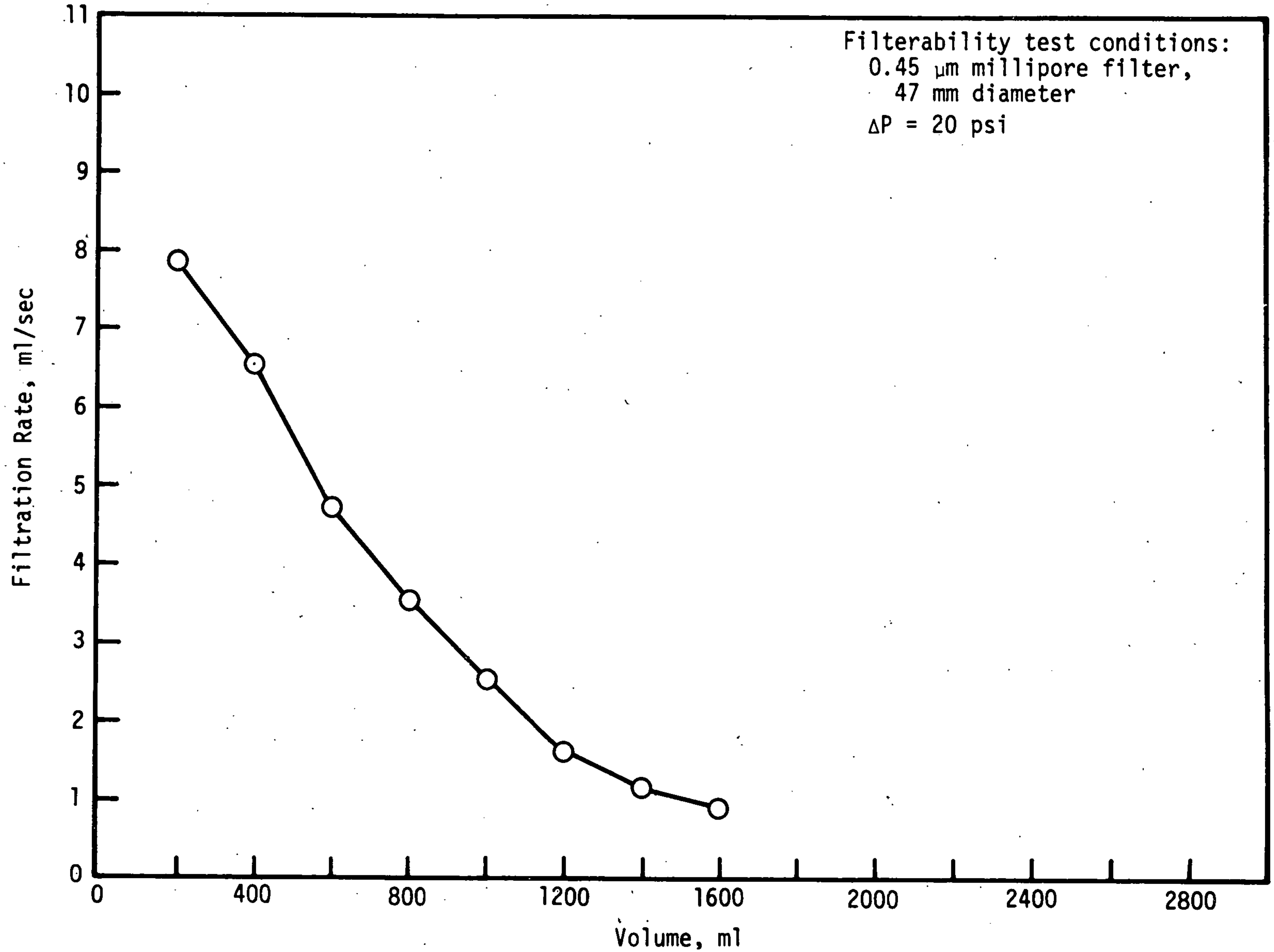


FIGURE F-12

FILTRATION TEST RESULTS FOR PREFLOOD USED TO MAKE 1075 PPM PFIZER BIOPOLYMER SOLUTION

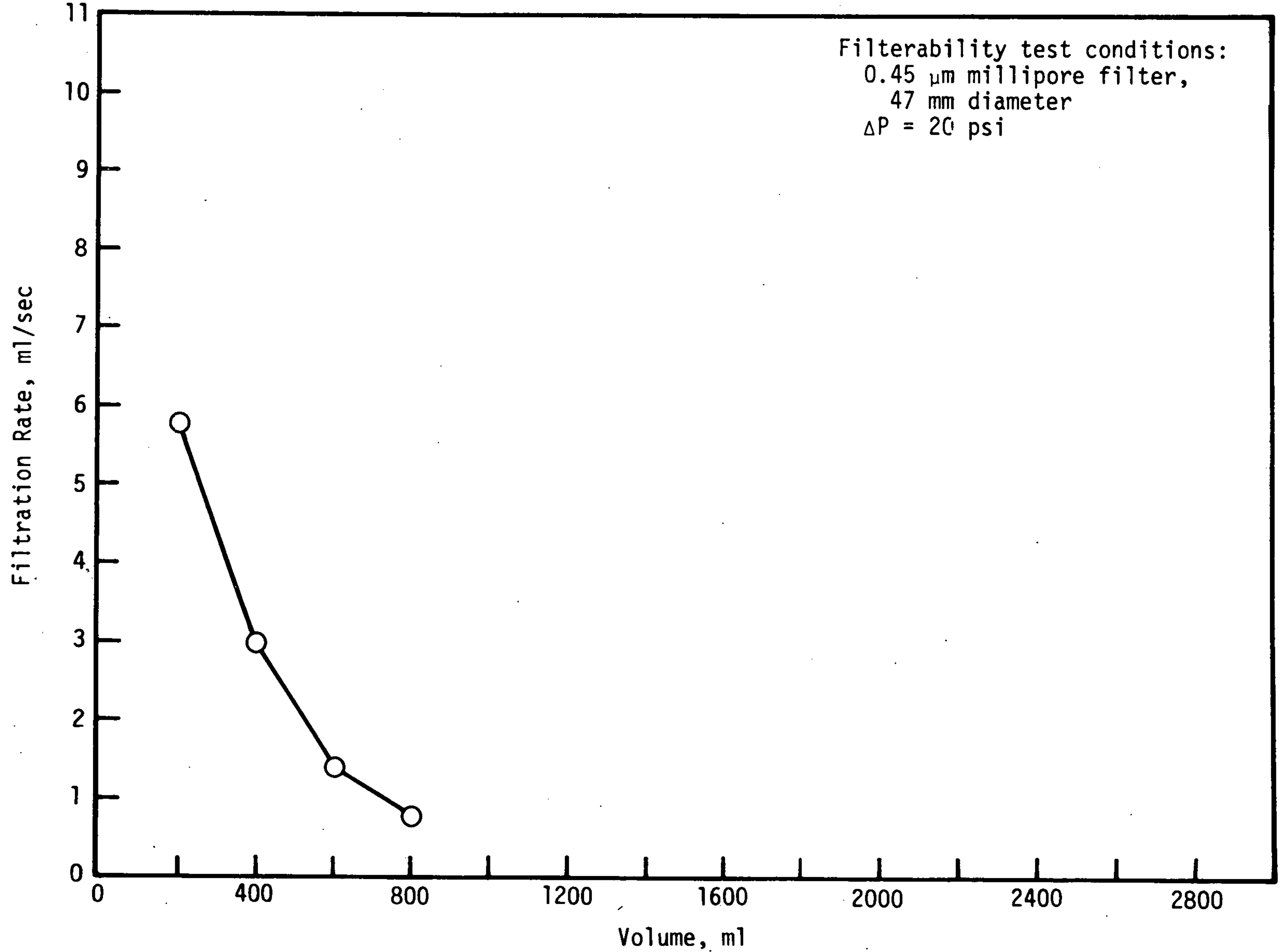


FIGURE F-13

FILTRATION TEST RESULTS FOR PREFLOOD USED TO MAKE 1095 PPM ABBOTT BIOPOLYMER SOLUTION

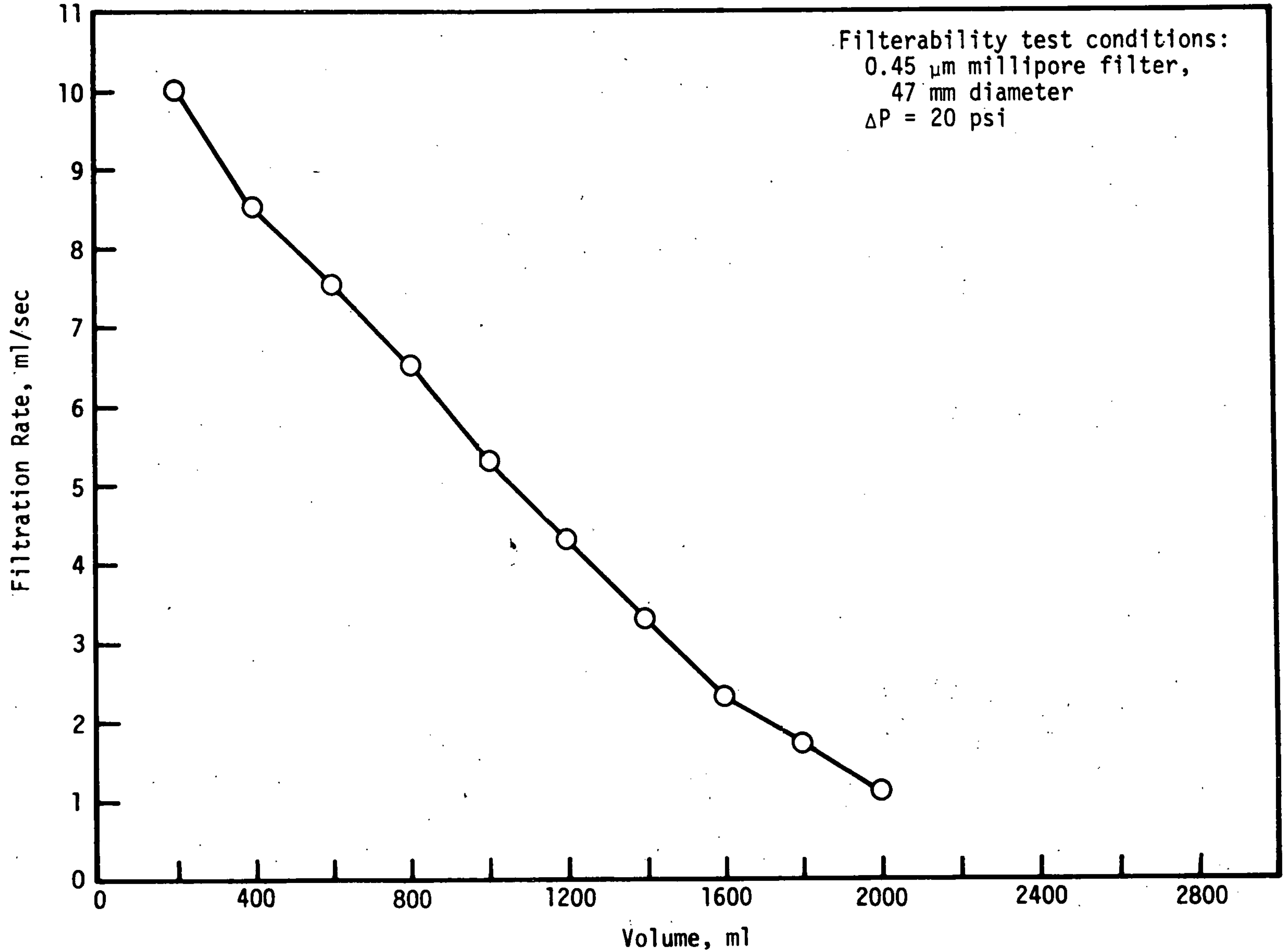


FIGURE F-14

FILTRATION TEST RESULTS FOR PREFLOOD USED TO MAKE 1090 PPM KELZAN SS-4000 BIOPOLYMER SOLUTION

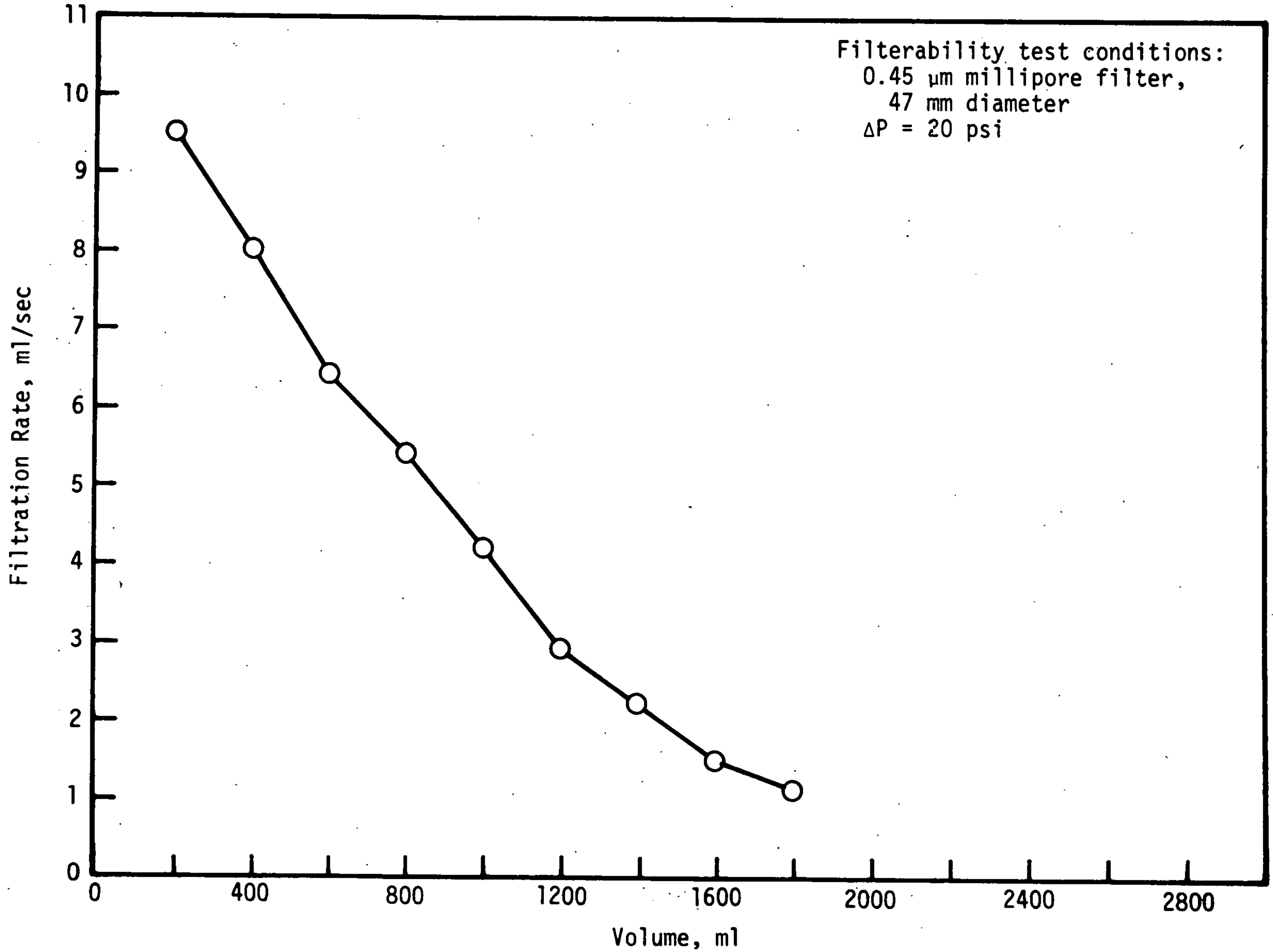
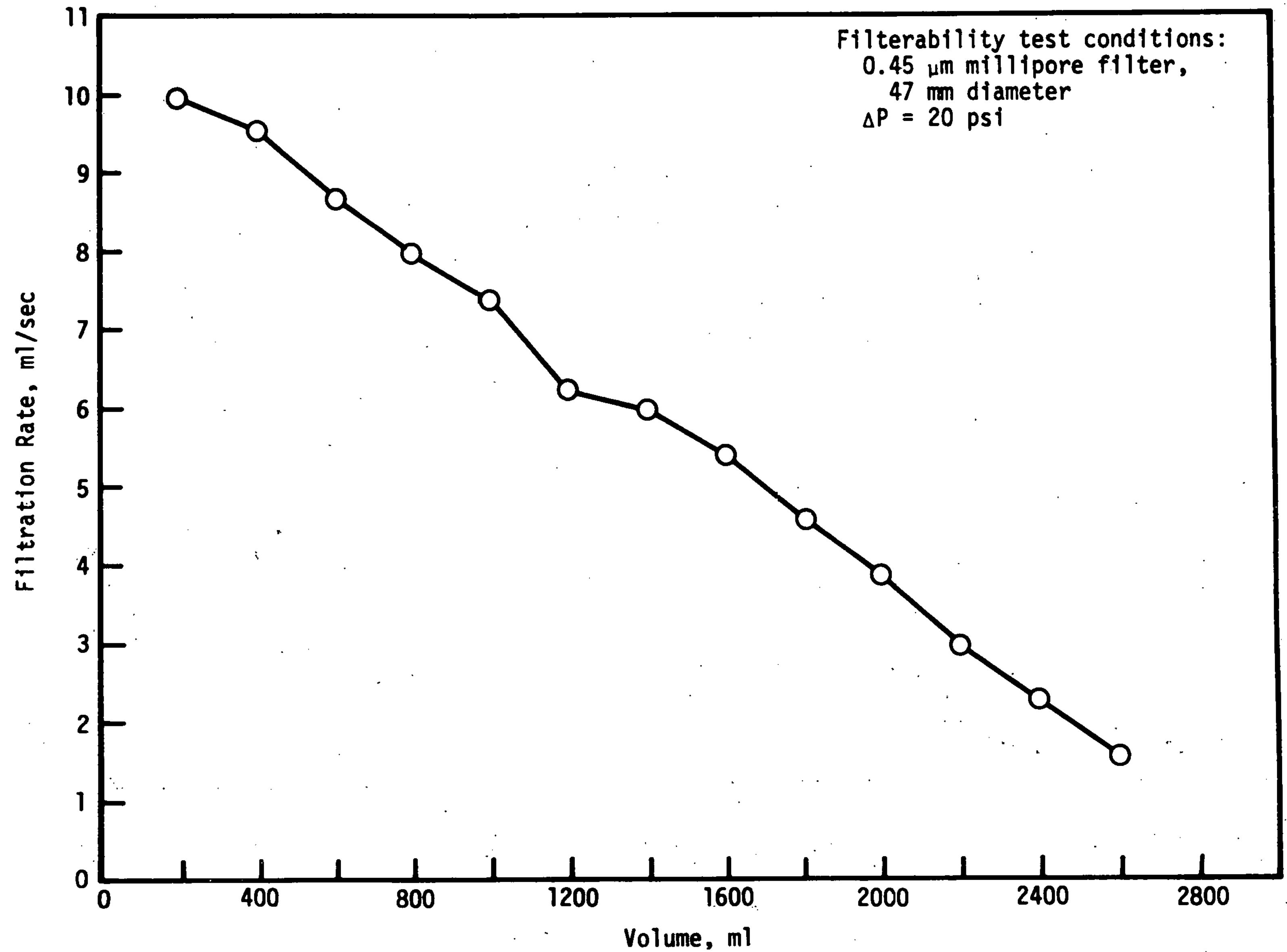


FIGURE F-15

FILTRATION TEST RESULTS FOR PREFLOOD USED TO MAKE MICELLAR SOLUTION CONTAINING KELZAN SS-4000 BIOPOLYMER



APPENDIX G

PATTERN INJECTION AND PRODUCTION

Tables and Figures

TABLE G1

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLUSH INJECTION DATA FOR THE SOUTH (HEGBERG) PATTERN

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
6- 6-76	186	189	192	191	197	198	0	716	604	684	629	616	282	0	192	3531	3531
6-13-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3531
6-20-76	194	197	198	198	198	198	197	690	696	419	374	300	371	653	197	3503	7034
6-27-76	199	202	199	193	198	199	198	472	365	358	561	538	412	369	199	3075	10109
7- 4-76	198	197	198	198	198	196	196	309	279	464	484	490	511	518	197	3055	13164
7-11-76	196	197	200	196	199	202	201	518	306	510	578	563	563	529	199	3567	16731
7-18-76	201	201	201	200	199	201	203	518	512	542	504	534	575	570	201	3755	20486
7-25-76	194	194	194	199	198	198	201	565	550	527	498	499	533	620	197	3792	24278
8- 1-76	201	201	201	199	207	199	196	714	624	489	662	616	684	698	201	4487	28765
8- 8-76	200	211	194	194	193	211	198	659	800	859	689	780	918	802	200	5507	34272
8-15-76	196	205	204	206	196	204	197	982	987	932	900	704	962	801	201	6268	40540
8-22-76	197	198	198	198	193	201	203	761	805	780	680	688	717	794	198	5225	45765
8-29-76	208	203	207	195	200	201	201	696	734	740	650	531	639	623	202	4613	50378
9- 5-76	206	202	199	199	198	201	187	620	599	629	606	611	659	629	199	4353	54731
9-12-76	212	199	206	203	203	201	198	644	616	584	650	597	600	614	203	4305	59036
9-19-76	204	202	207	201	205	203	200	702	546	837	726	639	614	603	203	4667	63703
9-26-76	199	201	203	203	202	201	199	550	561	526	500	491	472	469	201	3569	67272
10- 3-76	200	203	185	199	202	201	208	461	453	477	516	559	511	587	200	3564	70836
10-10-76	198	201	200	199	198	196	198	579	557	562	557	554	593	575	199	3976	74812
10-17-76	181	0	0	200	207	199	201	285	0	0	181	787	665	636	198	2554	77366
10-24-76	203	198	200	0	203	199	208	628	584	533	0	250	764	642	202	3401	80767
10-31-76	198	189	203	199	198	201	214	578	553	561	525	559	506	574	200	3856	84623
11- 7-76	209	199	203	194	189	197	198	508	504	518	536	486	558	539	198	3649	88272
11-14-76	202	203	202	199	198	206	197	537	527	492	412	366	378	398	201	3110	91382
11-21-76	201	202	193	197	204	200	203	432	408	491	484	434	410	374	200	3033	94415
11-28-76	199	200	203	203	200	203	199	326	325	416	430	485	415	338	201	2735	97150
12- 5-76	198	203	202	200	193	191	199	330	431	403	372	337	446	554	198	2873	100023
12-12-76	199	199	199	201	201	192	204	550	550	529	607	303	342	585	199	3466	103489
12-19-76	181	180	180	179	183	181	180	429	452	549	598	443	419	410	181	3300	106789
12-26-76	180	179	149	177	179	181	181	411	153	24	486	459	486	486	175	2505	109294
1- 2-77	178	201	197	193	201	202	193	450	426	438	534	583	550	520	195	3501	112795
1- 9-77	201	200	201	199	201	199	209	520	485	473	480	473	437	409	201	3277	116072
1-16-77	203	203	199	199	200	205	196	401	379	336	427	845	808	754	201	3950	120022
1-23-77	202	210	185	173	145	145	205	666	609	516	381	468	522	502	181	3664	123686
1-30-77	209	210	190	202	200	200	200	512	503	467	418	413	440	532	201	3285	126971
2- 6-77	200	143	155	160	164	186	169	525	375	350	441	485	489	373	168	3038	130009
2-13-77	180	180	172	161	166	166	146	358	419	422	355	410	445	395	167	2804	132813
2-20-77	146	147	147	143	136	136	136	340	320	324	303	298	280	280	142	2145	134958
2-27-77	136	136	144	144	145	153	153	295	296	300	280	201	300	469	144	2141	137099
3- 6-77	153	153	153	0	0	0	0	500	472	136	0	0	0	0	153	1108	138207
3-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	138207
3-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	138207

TABLE G2

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLUSH INJECTION DATA FOR WELL MP-201

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
6- 6-76	190	190	190	190	185	185	0	83	78	79	81	34	2	0	188	357	357
6-13-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	357
6-20-76	190	195	195	195	195	195	190	115	115	69	62	50	62	108	194	581	938
6-27-76	200	200	200	190	195	195	195	78	61	60	93	89	68	62	196	511	1449
7- 4-76	195	195	195	195	195	190	190	51	46	76	80	81	85	86	194	505	1954
7-11-76	190	195	200	195	195	200	200	86	51	85	96	93	93	87	196	591	2545
7-18-76	200	200	200	195	195	195	200	85	85	90	83	88	95	94	198	620	3165
7-25-76	190	190	190	195	195	200	200	91	91	95	82	86	88	104	194	637	3802
8- 1-76	195	200	200	195	205	195	195	91	85	91	93	39	41	62	198	502	4304
8- 8-76	195	210	200	200	195	220	200	56	59	60	92	90	106	104	203	567	4871
8-15-76	195	205	210	200	200	200	200	106	108	106	104	104	101	82	201	711	5582
8-22-76	200	200	200	200	195	195	200	82	88	76	76	76	79	90	199	567	6149
8-29-76	205	200	205	205	195	195	200	88	80	84	75	71	72	70	201	540	6689
9- 5-76	200	200	195	195	195	200	185	70	62	59	48	43	47	39	196	368	7057
9-12-76	210	195	200	200	195	195	195	41	32	32	21	43	45	48	199	262	7319
9-19-76	200	200	200	195	200	200	200	57	46	83	65	58	56	46	199	411	7730
9-26-76	195	200	200	200	205	200	195	38	43	46	44	41	40	37	199	289	8019
10- 3-76	200	200	180	195	200	195	200	37	35	43	65	64	65	73	196	382	8401
10-10-76	190	190	190	195	190	190	195	74	73	112	67	72	86	88	191	572	8973
10-17-76	200	0	0	195	205	195	195	35	0	0	27	132	105	95	198	394	9367
10-24-76	200	195	200	0	200	195	205	92	83	74	0	35	114	106	199	504	9871
10-31-76	195	195	200	190	180	200	220	111	89	110	87	96	87	100	197	680	10551
11- 7-76	210	195	200	190	185	190	195	97	80	79	81	83	101	97	195	618	11169
11-14-76	200	205	200	0	0	200	200	101	89	54	0	0	61	62	201	367	11536
11-21-76	200	200	0	0	0	0	0	67	70	0	0	0	0	0	200	137	11673
11-28-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11673
12- 5-76	0	195	200	195	185	185	195	0	85	80	53	66	72	92	193	448	12121
12-12-76	190	190	190	190	200	0	0	91	91	88	90	43	0	0	192	403	12524
12-19-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12524
12-26-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12524
1- 2-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12524
1- 9-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12524
1-16-77	0	0	0	0	200	205	200	0	0	0	0	80	75	69	202	224	12748
1-23-77	200	250	250	0	0	0	0	45	27	25	0	0	0	0	233	97	12845
1-30-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12845
2- 6-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12845
2-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12845
2-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12845
2-27-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12845
3- 6-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12845
3-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12845
3-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12845

TABLE G3

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLUSH INJECTION DATA FOR WELL MP-203

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
6- 6-76	190	190	190	190	195	195	0	102	98	98	87	86	44	0	192	515	515
6-13-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	515
6-20-76	195	195	195	195	195	195	195	55	55	31	29	23	28	52	195	273	788
6-27-76	200	200	200	195	195	200	195	36	28	27	44	42	32	28	198	237	1025
7- 4-76	195	190	190	190	195	195	195	25	23	37	37	37	39	40	193	238	1263
7-11-76	195	195	200	195	200	200	200	40	24	39	45	44	46	41	198	279	1542
7-18-76	200	200	200	200	200	200	205	42	41	44	40	43	47	46	201	303	1845
7-25-76	190	190	190	195	195	195	200	54	49	48	38	47	47	56	194	339	2184
8- 1-76	200	200	200	195	205	200	195	90	45	67	107	109	103	102	199	623	2807
8- 8-76	200	210	200	200	200	225	200	96	105	97	68	66	79	86	205	597	3404
8-15-76	200	210	210	210	210	205	200	94	96	80	77	59	75	70	206	551	3955
8-22-76	200	205	205	200	200	200	200	67	79	70	55	55	55	55	201	436	4391
8-29-76	205	200	210	210	200	200	200	55	55	55	55	18	52	51	204	341	4732
9- 5-76	205	200	200	200	195	200	185	52	39	40	41	43	45	43	198	303	5035
9-12-76	215	200	205	200	200	200	195	45	39	39	40	40	42	50	202	295	5330
9-19-76	205	200	205	200	205	200	200	54	45	70	59	52	51	46	202	377	5707
9-26-76	200	200	200	205	200	200	200	43	46	46	48	43	40	40	201	306	6013
10- 3-76	200	200	180	200	200	200	205	40	39	49	67	65	55	59	198	374	6387
10-10-76	195	200	200	205	205	190	195	60	52	49	55	61	72	72	199	421	6808
10-17-76	200	0	0	200	205	195	200	28	0	0	21	92	71	63	200	275	7083
10-24-76	200	195	200	0	200	200	210	60	55	49	0	23	71	63	201	321	7404
10-31-76	195	200	210	200	200	200	220	64	64	59	55	55	50	58	204	405	7809
11- 7-76	215	200	205	185	185	195	200	60	54	57	56	46	58	56	198	387	8196
11-14-76	200	205	200	200	195	210	200	55	52	51	45	42	30	33	201	308	8504
11-21-76	205	205	190	200	210	205	200	33	29	57	55	49	45	42	202	310	8814
11-28-76	200	200	200	200	200	205	200	37	37	47	49	55	46	39	201	310	9124
12- 5-76	200	200	200	200	200	190	200	38	40	37	37	30	42	57	199	281	9405
12-12-76	200	200	200	200	200	190	205	56	56	54	54	23	33	61	199	337	9742
12-19-76	200	200	200	200	205	200	200	49	52	63	47	35	34	32	201	312	10054
12-26-76	200	200	140	190	195	200	200	33	12	2	38	34	38	38	189	195	10249
1- 2-77	200	200	195	190	200	205	190	38	34	36	44	45	41	36	197	274	10523
1- 9-77	200	200	202	200	200	200	250	36	31	30	31	30	25	22	207	205	10728
1-16-77	205	205	200	200	200	205	208	20	17	12	24	50	46	40	203	209	10937
1-23-77	200	205	200	200	145	145	205	32	31	23	23	23	31	26	186	189	11126
1-30-77	200	210	190	0	0	0	200	26	25	15	0	0	0	87	200	153	11279
2- 6-77	200	200	200	200	200	200	200	105	100	100	100	100	115	105	200	725	12004
2-13-77	200	200	200	200	200	200	200	93	109	110	110	100	100	100	200	722	12726
2-20-77	200	200	200	200	200	200	200	100	95	96	90	88	85	85	200	639	13365
2-27-77	200	200	200	200	0	200	200	89	89	90	70	0	90	145	200	573	13938
3- 6-77	200	200	200	0	0	0	0	180	133	39	0	0	0	0	200	352	14290
3-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14290
3-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]

TABLE G4

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLUSH INJECTION DATA FOR WELL MP-205

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary		Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S	Pressure, psig	Injection, bbl	
6- 6-76	160	165	165	175	195	195	0	151	149	151	123	121	70	0	176	765	765
6-13-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	765
6-20-76	190	195	195	195	195	195	190	112	112	68	60	48	60	107	194	567	1332
6-27-76	195	195	195	190	190	195	195	76	59	58	91	87	66	59	194	496	1828
7- 4-76	195	195	195	195	195	190	190	49	44	74	78	79	83	84	194	491	2319
7-11-76	190	190	200	190	195	200	200	84	50	82	94	91	92	86	195	579	2898
7-18-76	200	200	200	200	190	200	205	84	82	87	81	86	93	92	199	605	3503
7-25-76	190	190	190	195	195	195	200	88	85	90	84	86	86	88	194	607	4110
8- 1-76	200	200	200	200	205	200	195	81	93	100	83	42	88	88	200	575	4685
8- 8-76	200	210	200	200	195	220	200	81	88	88	52	51	60	42	204	462	5147
8-15-76	200	205	210	210	205	200	200	60	61	70	80	46	73	55	204	445	5592
8-22-76	200	200	200	200	195	200	200	52	63	57	55	55	55	61	199	398	5990
8-29-76	205	200	200	200	200	200	200	41	47	46	41	39	39	39	201	292	6282
9- 5-76	205	200	195	195	195	200	185	39	30	30	30	10	26	29	196	194	6476
9-12-76	210	195	200	200	200	195	195	25	25	14	41	42	42	57	199	246	6722
9-19-76	200	200	200	195	200	200	200	55	48	48	43	55	51	43	199	343	7065
9-26-76	195	195	200	200	200	200	195	37	41	39	39	34	30	30	198	250	7315
10- 3-76	200	200	180	195	200	200	205	29	29	38	29	84	65	67	197	341	7656
10-10-76	195	195	200	195	195	195	195	64	64	53	57	61	74	72	196	445	8101
10-17-76	200	0	0	200	205	195	200	29	0	0	21	90	71	62	200	273	8374
10-24-76	200	195	200	0	200	195	205	58	52	45	0	24	73	61	199	313	8687
10-31-76	195	200	205	200	200	200	220	60	45	58	55	53	48	53	203	372	9059
11- 7-76	210	200	200	190	180	190	195	53	41	47	45	35	52	45	195	318	9377
11-14-76	200	205	200	195	195	205	195	45	45	45	45	45	34	35	199	294	9671
11-21-76	200	205	190	200	205	200	200	38	40	57	55	49	45	42	200	326	9997
11-28-76	194	195	200	200	195	200	190	37	37	47	49	55	46	39	196	310	10307
12- 5-76	190	200	200	195	185	185	195	38	40	37	37	30	42	57	193	281	10588
12-12-76	195	200	200	200	200	190	200	56	56	54	54	23	33	61	198	337	10925
12-19-76	200	200	200	200	200	200	200	49	52	63	73	54	51	50	200	392	11317
12-26-76	200	200	150	200	200	200	200	50	19	3	59	55	59	59	193	304	11621
1- 2-77	200	200	195	190	200	200	190	59	55	57	65	65	61	56	196	418	12039
1- 9-77	200	200	200	200	200	200	205	56	51	50	51	50	45	41	201	344	12383
1-16-77	205	205	200	200	200	205	200	40	37	30	40	75	71	65	202	358	12741
1-23-77	210	205	200	200	145	145	205	57	56	45	45	52	30	40	187	325	13066
1-30-77	210	210	190	200	200	200	200	50	49	48	48	48	60	60	201	363	13429
2- 6-77	200	200	200	200	200	200	200	60	55	50	50	50	34	41	200	340	13769
2-13-77	200	200	200	200	200	200	200	38	44	45	45	45	45	45	200	307	14076
2-20-77	200	200	200	200	200	200	200	45	40	41	36	35	30	30	200	257	14333
2-27-77	200	200	200	200	200	200	200	34	34	35	35	32	35	89	200	294	14627
3- 6-77	200	200	200	0	0	0	0	80	57	17	0	0	0	0	200	154	14781
3-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14781
3-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14781

TABLE G5
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLUSH INJECTION DATA FOR WELL MP-211

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
6- 6-76	190	195	195	195	195	0	0	104	94	90	49	34	0	0	194	371	371
6-13-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	371
6-20-76	195	200	200	200	200	200	195	121	121	73	65	52	65	114	199	611	982
6-27-76	200	200	200	185	200	200	200	82	63	62	98	94	72	64	198	535	1517
7- 4-76	200	195	200	200	200	195	195	54	48	81	85	86	89	90	198	533	2050
7-11-76	195	195	195	195	195	200	200	90	53	89	101	98	98	92	196	621	2671
7-18-76	200	200	200	200	200	200	205	90	89	94	88	93	100	99	201	653	3324
7-25-76	195	195	195	200	200	195	200	94	97	94	93	89	93	76	197	636	3960
8- 1-76	200	200	200	200	210	200	195	87	82	54	95	92	87	85	201	582	4542
8- 8-76	200	215	200	200	200	220	200	82	92	87	62	85	88	70	205	566	5108
8-15-76	200	210	210	210	205	205	205	93	89	87	86	79	57	60	206	551	5659
8-22-76	205	205	205	205	200	200	205	52	67	58	43	44	35	35	204	334	5993
8-29-76	205	200	205	205	200	200	200	35	35	36	31	23	35	20	202	215	6208
9- 5-76	205	200	200	200	195	200	190	35	30	30	5	22	22	21	199	165	6373
9-12-76	210	195	205	205	200	200	200	22	22	22	95	28	18	23	202	230	6603
9-19-76	205	205	210	200	210	205	200	32	26	41	50	30	20	30	205	229	6832
9-26-76	200	200	205	205	205	200	200	40	30	7	7	7	5	5	202	101	6933
10- 3-76	200	200	190	200	205	200	210	5	5	5	9	37	46	49	201	156	7089
10-10-76	200	200	200	200	195	195	200	45	32	19	19	19	19	25	199	178	7267
10-17-76	200	0	0	200	200	200	200	19	0	0	4	21	21	34	200	99	7366
10-24-76	200	200	200	0	200	200	200	44	49	55	0	30	76	78	200	332	7698
10-31-76	200	200	200	200	200	200	200	77	60	75	74	69	64	79	200	498	8196
11- 7-76	200	200	200	200	200	200	200	71	55	60	61	56	56	45	200	404	8600
11-14-76	200	200	200	200	200	200	200	48	55	58	44	47	38	55	200	345	8945
11-21-76	200	200	200	200	200	200	200	54	55	87	87	80	74	69	200	506	9451
11-28-76	200	200	200	200	200	200	200	60	60	77	79	86	69	59	200	490	9941
12- 5-76	200	200	200	200	200	200	200	58	60	57	57	50	69	90	200	441	10382
12-12-76	200	200	200	200	200	190	200	90	90	87	86	42	53	95	199	543	10925
12-19-76	200	200	200	200	200	200	200	74	78	95	199	146	138	136	200	866	11791
12-26-76	200	200	160	200	200	200	200	136	51	9	161	157	161	161	194	836	12627
1- 2-77	200	200	195	190	200	200	190	161	157	159	165	165	161	155	196	1123	13750
1- 9-77	200	200	200	200	200	200	205	155	150	148	149	148	140	135	201	1025	14775
1-16-77	205	205	200	200	200	205	143	134	130	121	130	160	156	150	194	981	15756
1-23-77	185	205	195	0	145	145	205	142	141	110	0	110	140	135	180	778	16534
1-30-77	210	210	190	200	200	200	200	135	133	133	133	133	140	140	201	947	17481
2- 6-77	200	30	80	75	75	135	130	115	30	25	25	25	25	19	104	264	17745
2-13-77	130	130	80	75	75	75	75	17	20	20	20	20	20	20	91	137	17882
2-20-77	75	75	75	75	50	50	50	15	15	15	15	15	15	15	64	105	17987
2-27-77	50	50	70	70	90	90	90	15	15	15	15	15	15	15	73	105	18092
3- 6-77	90	90	90	0	0	0	0	20	30	8	0	0	0	0	90	58	18150
3-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18150
3-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18150

TABLE G6

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLUSH INJECTION DATA FOR TWIN WELLS MP-213/226

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary		Cumulative
	S	M	T	W	T	F	S	S	M	T	W	T	F	S	Pressure, psig	Injection, bbl	Injection, bbl
6- 6-76	195	200	200	195	200	200	0	80	81	83	74	63	31	0	198	412	412
6-13-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	412
6-20-76	195	200	200	200	200	200	200	100	100	61	54	43	54	95	199	507	919
6-27-76	200	200	200	195	200	200	200	69	53	52	82	79	61	54	199	450	1369
7- 4-76	200	200	200	200	200	200	200	44	41	68	71	72	75	76	200	447	1816
7-11-76	200	200	200	195	200	200	200	76	44	75	85	83	82	78	199	523	2339
7-18-76	200	200	200	200	200	200	205	76	75	79	74	78	84	84	201	550	2889
7-25-76	205	205	205	205	200	200	200	84	80	79	81	44	73	92	203	533	3422
8- 1-76	200	200	200	200	210	200	200	105	96	100	106	106	100	102	201	715	4137
8- 8-76	200	215	200	200	200	225	200	98	105	90	66	95	60	110	206	624	4761
8-15-76	200	210	215	215	210	210	210	100	100	100	100	69	107	75	210	651	5412
8-22-76	210	210	210	210	200	200	205	74	92	81	79	79	58	92	206	555	5967
8-29-76	210	210	210	210	200	205	200	89	86	86	86	28	85	87	206	547	6514
9- 5-76	210	205	200	200	200	200	185	86	88	94	96	97	103	98	200	662	7176
9-12-76	215	200	210	205	210	210	200	101	94	94	95	94	95	86	207	659	7835
9-19-76	205	205	210	205	205	205	200	102	81	110	94	87	92	90	205	656	8491
9-26-76	200	205	205	205	200	200	200	87	89	82	58	83	82	83	202	564	9055
10- 3-76	200	205	190	200	200	200	210	82	81	80	85	82	76	85	201	571	9626
10-10-76	200	210	200	200	200	200	200	83	85	79	84	79	78	82	201	570	10196
10-17-76	200	0	0	200	210	205	200	33	0	0	18	86	86	86	203	309	10505
10-24-76	205	200	200	0	205	200	210	86	82	82	0	33	91	83	203	457	10962
10-31-76	200	200	210	205	200	200	200	83	68	32	69	76	65	71	202	464	11426
11- 7-76	0	200	205	205	190	200	200	0	64	64	80	70	82	81	200	441	11867
11-14-76	205	210	205	200	200	210	200	80	80	81	78	74	55	56	204	504	12371
11-21-76	210	210	195	205	210	205	205	58	36	87	87	80	74	69	206	491	12862
11-28-76	200	200	205	205	205	210	200	60	60	77	79	86	69	59	204	490	13352
12- 5-76	200	210	205	200	185	190	210	58	60	57	57	50	69	90	200	441	13793
12-12-76	200	200	200	205	200	190	200	90	90	87	86	42	53	57	199	505	14298
12-19-76	35	35	35	35	35	35	35	10	10	10	10	10	10	10	35	70	14368
12-26-76	35	35	0	35	35	35	35	10	3	0	10	10	10	10	35	53	14421
1- 2-77	35	200	195	190	190	190	190	10	10	10	10	10	10	10	170	70	14491
1- 9-77	190	190	190	190	190	190	190	10	10	10	10	10	10	10	190	70	14561
1-16-77	190	190	190	190	200	205	200	10	10	10	30	100	96	90	195	346	14907
1-23-77	200	205	10	10	0	0	0	82	51	50	50	0	0	0	106	233	15140
1-30-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15140
2- 6-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15140
2-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15140
2-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15140
2-27-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15140
3- 6-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15140
3-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15140
3-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15140

TABLE G7
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLUSH INJECTION DATA FOR WELL MP-215

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
6- 6-76	190	0	190	190	195	195	0	53	0	2	29	41	4	0	192	129	129
6-13-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	129
6-20-76	195	195	195	200	195	195	195	50	56	30	26	21	26	47	196	256	385
6-27-76	200	200	200	195	195	195	195	34	26	25	40	38	30	26	197	219	604
7- 4-76	195	195	195	195	195	190	195	22	20	34	34	35	36	37	194	218	822
7-11-76	195	195	200	195	195	200	200	37	21	36	41	40	40	38	197	253	1075
7-18-76	200	200	200	200	200	200	200	37	36	39	36	38	41	41	200	268	1343
7-25-76	190	190	190	195	195	195	200	40	37	39	39	41	42	43	194	281	1624
8- 1-76	200	200	0	0	0	0	0	40	37	0	0	0	0	0	200	77	1701
8- 8-76	0	210	150	150	155	170	170	0	146	204	146	149	149	68	168	862	2563
8-15-76	155	165	165	200	200	200	165	131	133	132	130	140	125	132	179	923	3486
8-22-76	165	160	165	170	165	200	200	121	130	127	125	115	120	126	175	864	4350
8-29-76	205	200	205	100	195	200	200	120	116	111	102	95	97	97	186	738	5088
9- 5-76	205	200	195	195	195	200	185	95	105	111	115	122	126	119	196	793	5881
9-12-76	200	195	200	200	200	195	190	122	122	122	95	91	94	92	197	738	6619
9-19-76	200	195	200	200	200	200	200	90	54	134	116	104	103	95	199	696	7315
9-26-76	195	195	200	200	200	200	195	89	91	89	87	81	77	77	198	591	7906
10- 3-76	200	200	180	195	200	200	205	76	76	76	71	52	50	54	197	455	8361
10-10-76	195	200	200	195	195	195	195	54	54	75	79	76	80	85	196	503	8864
10-17-76	200	0	0	200	204	195	200	35	0	0	27	110	90	84	200	346	9210
10-24-76	200	195	200	0	200	195	205	83	78	70	0	30	92	52	199	405	9615
10-31-76	195	195	170	180	185	190	210	52	60	75	65	59	51	56	189	418	10033
11- 7-76	205	190	195	185	175	190	190	63	61	60	62	64	62	62	190	434	10467
11-14-76	195	200	195	190	190	200	190	55	55	50	50	30	47	47	194	334	10801
11-21-76	195	200	180	190	205	200	200	51	54	60	59	53	49	46	196	372	11173
11-28-76	195	195	200	200	195	200	195	40	39	50	52	59	49	41	197	330	11503
12- 5-76	190	200	200	195	185	185	195	40	42	39	38	30	46	60	193	295	11798
12-12-76	195	195	195	195	200	190	200	60	60	57	57	26	35	65	196	360	12158
12-19-76	200	200	200	200	200	200	200	52	55	67	52	38	36	35	200	335	12493
12-26-76	200	200	160	200	200	200	200	35	13	2	42	38	42	42	194	214	12707
1- 2-77	200	200	195	190	200	200	195	42	38	40	48	50	45	40	197	303	13010
1- 9-77	200	200	200	200	200	200	205	40	35	33	34	33	30	26	201	231	13241
1-16-77	205	205	200	200	200	205	200	25	22	17	30	60	56	50	202	260	13501
1-23-77	200	205	200	200	145	145	205	42	41	33	33	38	48	43	186	278	13779
1-30-77	210	210	190	200	200	200	200	43	42	20	24	44	45	30	201	248	14027
2- 6-77	0	0	0	200	200	200	200	0	0	0	91	135	140	96	200	462	14489
2-13-77	200	200	200	200	200	200	200	93	109	110	100	85	90	90	200	677	15166
2-20-77	200	200	200	200	200	200	200	90	85	86	81	80	75	75	200	572	15738
2-27-77	200	200	200	200	200	200	200	79	79	60	50	47	40	50	200	405	16143
3- 6-77	200	200	200	0	0	0	0	50	41	12	0	0	0	0	200	103	16246
3-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16246
3-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16246

TABLE G8
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLUSH INJECTION DATA FOR WELL MP-221

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
6- 6-76	190	195	195	195	200	200	0	98	96	96	109	132	75	0	196	606	606
6-13-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	606
6-20-76	195	195	195	195	200	200	200	61	61	37	33	27	32	58	197	309	915
6-27-76	200	205	200	195	200	200	200	42	32	31	50	48	36	32	200	271	1186
7- 4-76	195	200	200	200	195	195	195	27	25	41	43	43	45	46	197	270	1456
7-11-76	195	195	195	195	200	200	200	46	27	45	51	50	50	47	197	316	1772
7-18-76	200	200	200	200	200	200	205	46	45	48	44	47	51	50	201	331	2103
7-25-76	195	195	195	195	195	195	200	51	50	18	24	46	45	91	196	325	2428
8- 1-76	200	200	200	195	205	200	195	173	174	65	166	174	157	148	199	1057	3485
8- 8-76	200	210	200	200	200	220	200	136	145	144	108	148	184	120	204	985	4470
8-15-76	200	210	210	210	205	205	200	183	191	150	118	120	195	123	206	1080	5550
8-22-76	200	205	205	205	200	200	205	117	120	112	105	90	104	109	203	757	6307
8-29-76	205	200	205	200	200	200	200	89	88	86	79	74	77	75	201	568	6875
9- 5-76	205	200	200	200	200	200	185	73	49	45	45	45	49	48	199	354	7229
9-12-76	210	200	205	205	200	200	195	48	44	41	43	44	45	46	202	311	7540
9-19-76	205	200	210	200	205	200	200	56	48	80	69	42	21	44	203	360	7900
9-26-76	195	200	200	200	200	200	200	43	47	45	45	41	39	37	199	297	8197
10- 3-76	200	200	180	200	200	200	210	37	36	36	36	32	37	43	199	257	8454
10-10-76	195	200	200	200	195	195	195	43	44	40	41	35	35	35	197	273	8727
10-17-76	200	0	0	200	205	195	200	16	0	0	9	51	44	41	200	161	8888
10-24-76	200	195	200	0	205	200	210	38	34	29	0	13	78	45	202	237	9125
10-31-76	195	200	205	200	200	200	225	42	34	33	28	31	27	29	204	224	9349
11- 7-76	215	200	200	190	185	195	195	33	32	32	32	28	32	30	197	219	9568
11-14-76	200	200	200	195	195	210	175	30	30	30	30	20	24	25	196	189	9757
11-21-76	180	180	180	170	180	175	200	27	28	38	35	30	27	25	181	210	9967
11-28-76	195	200	200	200	195	205	195	22	22	28	29	36	36	26	199	199	10166
12- 5-76	195	205	200	205	185	185	0	25	27	25	24	18	25	0	196	144	10310
12-12-76	0	0	0	205	200	190	210	0	0	0	76	60	73	130	201	339	10649
12-19-76	200	205	195	200	205	200	195	100	105	129	92	68	64	63	200	621	11270
12-26-76	195	200	140	190	195	200	200	63	24	2	75	71	75	75	189	385	11655
1- 2-77	200	200	195	190	200	200	190	75	71	73	81	81	75	70	196	526	12181
1- 9-77	200	200	200	200	200	200	205	70	65	62	63	62	57	53	201	432	12613
1-16-77	205	205	200	200	200	205	200	52	50	45	53	100	96	90	202	486	13099
1-23-77	200	205	200	200	145	145	205	82	81	70	70	75	85	80	186	543	13642
1-30-77	210	210	190	200	200	200	200	80	79	78	78	78	55	40	201	488	14130
2- 6-77	200	200	200	75	200	200	200	80	75	70	70	70	70	53	182	488	14618
2-13-77	200	200	200	0	200	200	75	47	55	55	0	80	110	60	179	407	15025
2-20-77	75	65	65	75	50	50	50	15	15	15	15	15	15	15	61	105	15130
2-27-77	50	50	70	70	90	90	90	15	15	15	15	15	15	15	73	105	15235
3- 6-77	90	90	90	0	0	0	0	20	30	8	0	0	0	0	90	58	15293
3-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15293
3-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15293

TABLE G9

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLUSH INJECTION DATA FOR WELL MP-223

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
6- 6-76	185	185	200	190	200	200	0	45	8	12	13	41	15	0	193	134	134
6-13-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	134
6-20-76	190	195	200	200	200	200	200	64	64	38	35	28	34	60	198	323	457
6-27-76	200	200	200	185	200	200	195	43	33	33	51	49	37	34	197	280	737
7- 4-76	195	195	200	200	200	200	195	29	26	43	44	45	47	47	198	281	1018
7-11-76	195	200	200	195	200	200	195	47	28	47	53	52	52	48	198	327	1345
7-18-76	195	200	200	195	200	200	205	48	47	49	46	49	52	52	199	343	1688
7-25-76	195	195	195	200	200	200	200	51	49	52	45	48	47	58	198	350	2038
8- 1-76	200	0	0	0	210	200	195	35	0	0	0	54	108	111	201	308	2346
8- 8-76	205	210	200	200	200	200	200	110	60	89	95	96	62	76	202	588	2934
8-15-76	200	210	210	200	210	205	205	86	89	87	85	75	71	71	206	564	3498
8-22-76	205	205	205	205	200	200	205	70	83	73	70	84	83	88	204	551	4049
8-29-76	210	205	210	205	200	200	200	90	88	88	66	63	65	66	204	526	4575
9- 5-76	205	200	200	200	200	200	185	66	67	70	69	68	70	67	199	477	5052
9-12-76	215	200	205	205	200	200	200	69	67	68	68	66	66	60	204	464	5516
9-19-76	205	205	210	205	205	205	200	73	57	78	67	62	67	66	205	470	5986
9-26-76	200	200	205	205	200	200	200	63	64	62	62	58	56	56	201	421	6407
10- 3-76	200	205	180	200	200	200	210	56	56	56	56	56	28	53	199	361	6768
10-10-76	200	200	200	200	195	195	200	53	33	28	44	52	51	51	199	312	7080
10-17-76	23	0	0	200	210	200	200	51	0	0	12	56	60	60	167	239	7319
10-24-76	205	200	200	0	205	200	210	60	50	40	0	20	60	55	203	285	7604
10-31-76	200	100	210	210	205	205	230	50	50	50	46	50	39	43	194	328	7932
11- 7-76	215	200	205	200	200	200	200	48	47	46	47	47	34	47	203	316	8248
11-14-76	200	200	200	200	200	200	200	47	47	47	47	40	36	36	200	300	8548
11-21-76	200	200	200	200	200	200	200	39	41	45	42	36	34	31	200	268	8816
11-28-76	200	200	200	200	200	200	200	27	27	35	36	44	42	31	200	242	9058
12- 5-76	200	200	200	200	200	200	200	30	32	29	29	22	31	43	200	216	9274
12-12-76	200	200	200	200	200	190	200	42	42	40	40	16	24	46	199	250	9524
12-19-76	200	200	200	200	200	200	200	39	41	50	45	33	31	30	200	269	9793
12-26-76	200	200	140	200	200	200	200	30	11	2	36	32	36	36	191	183	9976
1- 2-77	0	0	0	190	200	200	190	0	0	0	50	95	89	88	195	322	10298
1- 9-77	200	200	200	200	200	200	205	88	83	80	81	80	75	71	201	558	10856
1-16-77	205	205	200	200	200	205	200	70	66	60	70	120	116	110	202	612	11468
1-23-77	200	205	200	200	145	145	205	102	100	90	90	95	103	98	186	678	12146
1-30-77	210	210	190	200	200	200	200	98	96	95	95	55	60	95	201	594	12740
2- 6-77	200	200	80	200	200	200	200	95	85	80	80	80	80	40	183	540	13280
2-13-77	200	200	200	200	200	200	200	53	62	62	60	60	60	60	200	417	13697
2-20-77	200	200	200	200	200	200	200	60	55	56	51	50	45	45	200	362	14059
2-27-77	200	200	200	200	200	200	200	48	49	70	80	77	90	140	200	554	14613
3- 6-77	200	200	200	0	0	0	0	130	151	44	0	0	0	0	200	325	14938
3-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14938
3-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14938

TABLE G10
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLUSH INJECTION DATA FOR WELL MP-225

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary		Cumulative
	S	M	T	W	T	F	S	S	M	T	W	T	F	S	Pressure, psig	Injection, bbl	Injection, bbl
6- 6-76	0	0	200	200	210	210	0	0	0	73	64	64	41	0	205	242	242
6-13-76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	242
6-20-76	205	205	205	205	205	205	205	12	12	12	10	8	10	12	205	76	318
6-27-76	200	215	200	210	210	210	210	12	10	10	12	12	10	10	208	76	394
7- 4-76	210	210	210	210	210	210	210	8	6	10	12	12	12	12	210	72	466
7-11-76	210	210	210	210	210	215	210	12	8	12	12	12	10	12	211	78	544
7-18-76	210	210	210	210	210	210	200	10	12	12	12	12	12	12	209	82	626
7-25-76	200	200	200	210	210	210	210	12	12	12	12	12	12	12	206	84	710
8- 1-76	215	210	210	210	0	0	0	12	12	12	12	0	0	0	211	48	758
8- 8-76	0	0	0	0	0	200	210	0	0	0	0	0	130	126	205	256	1014
8-15-76	210	220	200	200	120	210	190	129	120	120	120	12	158	133	193	792	1806
8-22-76	190	190	190	190	180	210	210	126	83	126	72	90	128	138	194	763	2569
8-29-76	220	215	215	220	210	210	210	89	139	148	115	120	117	118	214	846	3415
9- 5-76	215	215	210	205	210	205	200	104	129	150	157	161	171	165	209	1037	4452
9-12-76	220	210	220	210	220	210	210	171	171	152	152	149	153	152	214	1100	5552
9-19-76	215	210	220	205	215	215	200	183	141	193	163	149	153	143	211	1125	6677
9-26-76	210	210	215	210	210	210	210	110	110	110	110	103	103	104	211	750	7427
10- 3-76	200	215	205	205	215	210	220	99	96	94	98	87	89	104	210	667	8094
10-10-76	210	210	210	205	210	210	210	103	120	107	111	99	97	65	209	702	8796
10-17-76	210	0	0	205	220	210	215	39	0	0	42	149	117	111	212	458	9254
10-24-76	215	210	200	0	215	210	220	107	101	89	0	42	109	99	212	547	9801
10-31-76	210	210	220	205	215	215	200	39	83	69	46	70	75	85	211	467	10268
11- 7-76	200	210	220	200	200	210	210	83	70	73	72	57	81	76	207	512	10780
11-14-76	215	200	215	210	210	220	210	76	74	76	73	68	53	49	211	469	11249
11-21-76	220	220	210	210	220	215	215	65	55	60	64	57	62	50	216	413	11662
11-28-76	210	210	215	220	210	200	210	43	43	55	57	64	58	44	211	364	12026
12- 5-76	210	215	215	210	210	200	200	43	45	42	40	41	50	65	209	326	12352
12-12-76	210	210	210	210	210	205	220	65	65	62	64	28	38	70	211	392	12744
12-19-76	210	200	210	200	220	215	210	56	59	72	80	59	55	54	209	435	13179
12-26-76	210	200	150	200	210	215	210	54	20	4	65	62	65	65	199	335	13514
1- 2-77	210	210	210	210	220	220	210	65	61	63	71	72	68	65	213	465	13979
1- 9-77	220	212	219	200	220	200	205	65	60	60	61	60	55	51	211	412	14391
1-16-77	205	205	200	200	200	205	212	50	47	41	50	100	96	90	204	474	14865
1-23-77	220	205	210	200	145	145	205	82	81	70	70	75	85	80	190	543	15408
1-30-77	210	210	190	210	200	200	200	80	79	78	40	55	80	80	203	492	15900
2- 6-77	200	30	170	170	75	165	50	70	30	25	25	25	25	19	123	219	16119
2-13-77	130	130	125	90	90	90	75	17	20	20	20	20	20	20	104	137	16256
2-20-77	75	90	90	50	50	50	50	15	15	15	15	15	15	15	65	105	16361
2-27-77	50	50	70	70	90	90	90	15	15	15	15	15	15	15	73	105	16466
3- 6-77	90	90	90	0	0	0	0	20	30	8	0	0	0	0	90	58	16524
3-13-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16524
3-20-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16524

TABLE G11

EL DORADO MICELLAR-POLYMER PROJECT WELL STIMULATION SUMMARY

(May, 1976-August, 1977)

Well	Date	Workover Description	Before Workover		After Workover		One Month After Workover	
			Rate, bbl/day	Wellhead Pressure, psig	Rate, bbl/day	Wellhead Pressure, psig	Rate, bbl/day	Wellhead Pressure, psig
MP-106	5/27/76	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	30	190	153	180	128	190
MP-108	5/28/76	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	50	180	139	185	149	180
	4/22/77	Acidized with 750 gal 15 percent HCl	117	190	190	190	189	185
MP-110	4/22/77	Acidized with 750 gal 15 percent HCl	174	190	65	190	194	195
MP-112 Producer		No work to date						
MP-116	4/07/76	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	37	185	150	90	141	140
MP-118	5/26/76	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	19	190	151	135	134	195
MP-120	5/25/76	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	35	190	159	185	142	195

TABLE G11

EL DORADO MICELLAR-POLYMER PROJECT WELL STIMULATION SUMMARY

(continued)

Well	Date	Workover Description	Before Workover		After Workover		One Month After Workover	
			Rate, bbl/day	Wellhead Pressure, psig	Rate, bbl/day	Wellhead Pressure, psig	Rate, bbl/day	Wellhead Pressure, psig
MP-122 Producer		No work to date						
MP-124 Producer		No work to date						
MP-126	5/20/76	Acidized with 250 gal HCl, 1700 gal HF, and 650 gal HCl	17	200	150	120	142	200
MP-128	5/22/76	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	41	195	165	180	126	180
MP-130	5/21/76	Acidized with 250 gal HCl, 1700 gal HF, and 650 gal HCl	51	185	140	75	107	165
MP-201	4/14/76	Acidized with 250 gal HCl, 1700 gal HF, and 650 gal HCl	14	200	159	170	116	190
MP-203	4/15/76	Acidized with 250 gal HCl, 1700 gal HF, and 650 gal HCl	33	200	126	195	138	190
	5/21/76	Treated with 200 gal xylene, 250 gal HCl, 500 gal HF, and 250 gal HCl	6.4	220	5	200	--	--

TABLE G11

EL DORADO MICELLAR-POLYMER PROJECT WELL STIMULATION SUMMARY

(continued)

Well	Date	Workover Description	Before Workover Rate, bbl/day	Before Workover Wellhead Pressure, psig	After Workover Rate, bbl/day	After Workover Wellhead Pressure, psig	One Month After Workover Rate, bbl/day	One Month After Workover Wellhead Pressure, psig
	7/13/76	Acidized with 250 gal HCl, 750 gal HF, and 250 gal HCl	3.7	260	34.2	265	--	--
MP-203	2/04/77	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	25	210	87	200	90	200
	6/12/77	Treated with 200 gal xylene, 250 gal HCl, 500 gal HF, and 250 gal HCl	6.4	200	10	200	--	--
MP-205	5/30/77	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	36	195	120	190	91	190
	7/15/77	Acidized with 250 gal HCl, 750 gal HF, and 250 gal HCl	10.8	260	--	--	--	--
MP-207 Producer		No work to date						
MP-209 Producer		No work to date						
MP-211	4/13/76	Acidized with 850 gal HCl, 2700 gal HF, and 850 gal HCl	2	180	100	200	89	200

TABLE G11

EL DORADO MICELLAR-POLYMER PROJECT WELL STIMULATION SUMMARY

(continued)

Well	Date	Workover Description	Before Workover		After Workover		One Month After Workover	
			Rate, bbl/day	Wellhead Pressure, psig	Rate, bbl/day	Wellhead Pressure, psig	Rate, bbl/day	Wellhead Pressure, psig
MP-213	5/29/76	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	75	195	102	190	52	200
MP-215	8/08/76	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	28	200	146	210	115	195
MP-215	2/08/77	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	45	200	135	200	41	200
	4/21/77	Acidized with 750 gal HCl	4.8	220	1.5	200	4.7	210
MP-217 Producer		No work to date						
MP-219 Producer		No work to date						
MP-221	12/14/76	Acidized with 850 gal HCl, 1700 gal HF, and 850 gal HCl	25	200	60	200	57	200
	6/10/77	Acidized with 500 gal HCl, 1700 gal HF, and 750 gal HCl	1.8	290	19.2	290	5.1	265

TABLE G11

EL DORADO MICELLAR-POLYMER PROJECT WELL STIMULATION SUMMARY

(continued)

Well	Date	Workover Description	Before Workover		After Workover		One Month After Workover	
			Rate, bbl/day	Wellhead Pressure, psig	Rate, bbl/day	Wellhead Pressure, psig	Rate, bbl/day	Wellhead Pressure, psig
	7/13/77	Acidized with 150 gal HCl, 750 gal HF, and 250 gal HCl	3.6	260	49.6	265	--	--
MP-223	1/04/77	Acidized with 750 gal HCl, 1500 gal HF, and 750 gal HCl	36	200	95	200	95	200
	5/4/77	Acidized with 500 gal HCl, 740 gal HF, and 250 gal HCl	4.1	205	65.2	205	--	--
MP-223	5/7/77	Acidized with 250 gal HCl, 750 gal HF, and 250 gal HCl	4.1	205	65.2	205	6.7	255
MP-225	8/12/77	Acidized with 850 gal HCl, 750 gal HF, and 250 gal HCl	12	210	126	210	69	115
	4/20/77	Acidized with 750 gal HCl	4.1	220	11.2	220	3.0	220
	6/22/77	Acidized with 250 gal HCl, 500 gal HF, and 250 gal HCl	10.8	255	78.7	10	--	--
MP-227 Observation Well	5/6/77	Acidized with 200 gal HCl	--	--	--	--	--	--

TABLE G12

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLOOD INJECTION DATA FOR THE NORTH (CHESNEY) PATTERN

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
6- 6-76	174	174	174	179	179	174	179	1189	1172	1195	1064	1196	1139	1189	176	8144	8144
6-13-76	175	177	178	177	177	179	173	1186	1179	1112	946	1291	1175	1223	177	8112	16256
6-20-76	183	178	181	186	188	191	194	1139	960	1019	1257	1044	1168	1088	186	7675	23931
6-27-76	191	187	185	187	185	183	193	1251	1228	1257	1133	1210	1296	1299	187	8674	32605
7- 4-76	194	193	192	187	190	174	191	1168	691	1064	967	650	1158	1259	189	6957	39562
7-11-76	187	181	184	191	193	197	183	1161	1162	1133	1153	1118	1174	1050	188	7951	47513
7-18-76	173	191	189	183	191	181	195	1075	1208	1224	1116	1213	1332	1359	186	8527	56040
7-25-76	196	196	192	186	182	193	187	1213	1204	984	1146	1378	1344	1244	190	8513	64553
8- 1-76	191	188	190	189	189	189	187	1151	1193	1323	1260	1335	1203	1061	189	8526	73079
8- 8-76	191	186	188	183	194	184	188	1140	1263	1316	1276	1323	1149	1141	188	8608	81687
8-15-76	183	177	176	176	174	186	189	1101	1137	1315	1277	1239	1336	1454	180	8859	90546
8-22-76	191	177	178	188	182	177	186	1425	1195	1394	1151	1095	1149	1367	183	8776	99322
8-29-76	163	193	177	181	190	189	178	1257	1497	1474	1540	1507	1507	1064	182	9846	109168
9- 5-76	176	183	187	187	191	191	186	1330	1397	1527	1373	1343	1358	1297	186	9625	118793
9-12-76	193	187	187	188	194	184	201	1347	1245	1311	1258	1329	1339	1416	191	9245	128038
9-19-76	173	181	185	184	184	189	192	1251	1372	1454	1371	1274	1295	1287	184	9304	137342
9-26-76	193	191	190	191	189	183	191	1264	1271	1357	1304	1446	1351	1491	190	9484	146826
10- 3-76	189	191	185	189	186	187	192	1559	1529	1641	1691	1586	1724	1670	189	11400	158226
10-10-76	187	192	192	190	0	129	158	1687	1714	1724	873	0	1897	1783	175	9678	167904
10-17-76	181	189	190	99	143	154	162	1877	1836	852	300	1620	1677	1666	160	9828	177732
10-24-76	167	172	106	101	93	88	82	1664	1637	1374	1068	984	963	935	115	8625	186357
10-31-76	85	81	73	83	82	79	90	1078	1029	947	1016	954	969	1016	82	7009	193366
11- 7-76	86	87	86	84	87	77	89	986	974	962	989	903	831	860	85	6505	199871
11-14-76	87	84	80	78	87	81	86	871	822	813	837	811	974	983	83	6111	205982
11-21-76	86	87	84	83	83	85	84	1008	955	991	959	972	963	974	85	6822	212804
11-28-76	83	86	87	86	78	82	80	908	931	938	905	920	926	1004	83	6532	219336
12- 5-76	81	84	84	83	84	82	82	889	910	897	876	882	846	899	83	6199	225535
12-12-76	84	86	87	77	83	77	78	877	900	856	772	876	848	820	82	5949	231484
12-19-76	81	87	87	83	83	85	86	798	855	909	900	760	909	868	85	5999	237483
12-26-76	86	85	49	83	83	84	85	841	260	42	958	921	805	834	79	4661	242144
1- 2-77	85	84	84	101	104	107	112	782	766	793	874	983	921	834	97	5953	248097
1- 9-77	124	128	133	125	136	140	140	914	939	929	904	909	897	872	132	6364	254461
1-16-77	140	140	139	135	145	150	152	892	897	898	886	888	876	913	143	6250	260711
1-23-77	145	140	138	142	205	210	145	935	975	896	869	875	922	882	161	6354	267065
1-30-77	145	150	146	146	150	144	145	884	873	877	882	853	859	847	147	6075	273140
2- 6-77	150	150	149	145	150	146	150	889	871	880	884	860	891	852	149	6127	279267
2-13-77	160	160	159	158	150	155	160	882	884	881	885	895	937	926	157	6290	285557
2-20-77	160	155	158	161	165	160	170	897	858	890	875	843	912	897	161	6172	291729
2-27-77	170	170	170	0	0	0	50	909	924	451	0	0	0	210	140	2494	294223
3- 6-77	80	115	120	102	170	190	195	793	883	899	976	825	1236	1156	139	6768	300991
3-13-77	190	185	190	184	200	195	200	1093	1101	1128	1101	1269	1266	1189	192	8147	309138
3-20-77	195	195	190	190	195	195	190	1138	1090	1075	1130	1124	1016	1042	193	7615	316753
3-27-77	195	195	180	192	190	190	190	1249	1217	879	1206	1280	1148	1179	190	8158	324911
4- 3-77	190	190	218	190	190	190	190	1180	1175	1209	1196	1272	1116	1527	194	8675	333586
4-10-77	190	190	190	190	190	190	190	1401	1379	1285	1288	1345	1248	1488	190	9434	343020
4-17-77	190	190	190	190	190	190	190	1430	1376	1330	1303	1392	1265	1725	190	9821	352841
4-24-77	190	190	190	190	190	181	187	1630	1504	1518	1454	1480	1417	1670	188	10673	363514
5- 1-77	191	190	186	189	189	188	192	1572	1495	1485	1540	1541	1491	1587	189	10711	374225
5- 8-77	193	192	193	190	186	187	187	1597	1588	1493	1449	1481	1561	1649	190	10818	385043
5-15-77	189	191	191	190	190	176	193	1653	1658	1569	1627	1644	1384	1623	188	11158	396201
5-22-77	193	192	193	188	188	178	189	1570	1570	1547	1489	1506	1474	1620	189	10776	406977
5-29-77	190	188	194	184	181	186	180	1563	1354	1682	1600	1482	1690	1648	186	11019	417996
6- 5-77	184	187	182	183	188	188	189	1592	1563	1547	1454	1433	1505	1540	186	10634	428630
6-12-77	185	185	189	194	197	189	188	1420	1387	1463	1478	1462	1605	1547	190	10362	438992
6-19-77	189	194	199	192	192	189	191	1532	1553	1416	1569	1407	1425	1433	192	10335	449327
6-26-77	191	187	196	202	194	189	199	1437	1469	1541	1487	1396	1494	1538	194	10362	459689
7- 3-77	194	199	196	194	193	194	195	1541	1622	1584	1536	1535	1555	1543	195	10916	470605
7-10-77	195	196	194	194	169	193	200	1549	1564	1557	1420	1303	1652	1685	192	10730	481335
7-17-77	189	187	190	193	192	193	192	1527	1556	1519	1551	1528	1555	1554	191	10790	492125
7-24-77	194	172	190	197	185	187	187	1556	1336	1466	1654	1604	1495	1525	187	10636	502761
7-31-77	192	190	190	189	177	189	188	1560	1528	1581	1497	1516	1335	1249	188	10266	513027
8- 7-77	184	178	186	188	167	156	156	1379	1421	1429	1548	1430	1272	1188	174	9667	522694
8-14-77	155	150	143	143	149	149	167	1166	1250	1252	1283	1373	1345	1457	151	9126	531820
8-21-77	158	158	157	161	163	156	159	1393	1392	1385	1397	1387	1358	1385	159	9697	541517
8-28-77	161	144	154	157	154	156	153	1421	1418	1412	1329	1381	1292	1396	154	9649	551166

TABLE G13
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLOOD INJECTION DATA FOR WELL MP-106

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S		M	T	W	T	F	S			
6- 6-76	185	185	185	190	190	185	190	118	118	119	112	121	114	112	187	814	814
6-13-76	185	185	185	190	185	190	195	116	114	115	94	126	113	118	186	796	1610
6-20-76	190	185	185	185	190	190	195	114	97	106	128	107	135	120	189	807	2417
6-27-76	190	185	185	185	185	185	190	128	125	128	115	126	133	134	186	889	3306
7- 4-76	195	195	190	180	190	175	190	127	72	110	95	70	118	124	188	716	4022
7-11-76	185	180	185	190	195	195	190	116	117	122	120	113	124	114	187	826	4848
7-18-76	170	190	190	185	190	180	195	115	128	130	119	122	121	134	186	869	5717
7-25-76	195	195	190	175	180	195	185	119	117	102	112	135	129	119	188	833	6550
8- 1-76	190	185	190	190	190	185	185	106	111	120	120	126	114	104	188	801	7351
8- 8-76	190	190	190	175	180	175	190	98	84	110	100	100	100	102	184	694	8045
8-15-76	180	175	175	175	175	185	185	101	102	113	112	110	121	134	179	793	8838
8-22-76	190	175	190	190	180	175	185	135	110	128	107	94	97	122	184	793	9631
8-29-76	165	195	175	185	190	190	175	113	109	129	135	132	132	92	182	842	10473
9- 5-76	170	180	190	190	190	190	185	117	126	133	118	115	113	108	185	830	11303
9-12-76	195	185	185	190	195	185	205	113	104	110	119	125	125	131	191	827	12130
9-19-76	170	180	185	185	185	190	190	125	127	127	123	112	113	126	184	853	12983
9-26-76	190	190	190	190	190	185	190	127	127	127	114	130	121	130	189	876	13859
10- 3-76	190	190	170	190	185	185	190	133	124	155	136	127	133	132	186	940	14799
10-10-76	185	190	190	190	0	130	160	133	133	138	69	0	151	147	174	771	15570
10-17-76	185	190	190	100	145	155	160	164	162	75	19	136	142	139	161	837	16407
10-24-76	165	170	105	100	90	90	85	139	139	108	78	75	80	79	115	698	17105
10-31-76	85	80	70	85	80	80	85	89	89	84	89	84	85	90	81	610	17715
11- 7-76	85	85	85	85	85	75	90	92	93	92	95	89	80	84	84	625	18340
11-14-76	85	80	80	80	85	80	85	86	82	77	87	85	91	82	82	590	18930
11-21-76	85	85	85	80	80	85	85	95	95	96	91	93	95	97	84	662	19592
11-28-76	80	85	85	85	80	80	80	95	95	96	104	93	93	93	82	669	20261
12- 5-76	80	85	80	80	80	80	80	91	95	95	95	95	88	98	81	657	20918
12-12-76	80	85	85	75	75	75	75	96	98	94	80	89	85	81	79	623	21541
12-19-76	80	85	85	85	80	85	85	86	96	101	97	90	95	96	84	661	22202
12-26-76	85	85	50	85	80	80	85	92	25	6	112	108	97	99	79	539	22741
1- 2-77	85	80	80	100	105	105	110	98	97	99	108	118	110	103	95	733	23474
1- 9-77	125	127	136	125	135	140	140	115	118	126	117	112	109	103	133	800	24274
1-16-77	140	140	140	135	145	150	153	106	108	107	106	111	115	118	143	771	25045
1-23-77	145	140	140	145	205	210	145	120	116	108	108	108	113	110	161	783	25828
1-30-77	145	150	145	145	150	145	145	110	111	112	113	109	111	110	146	776	26604
2- 6-77	150	150	190	140	150	150	150	110	113	112	113	112	117	111	154	788	27392
2-13-77	160	160	155	160	150	155	160	113	115	117	118	112	117	112	157	804	28196
2-20-77	160	155	160	160	165	160	170	119	106	110	110	110	116	117	161	788	28984
2-27-77	170	170	170	0	0	0	50	118	119	54	0	0	0	26	140	317	29301
3- 6-77	80	115	120	100	170	190	195	100	111	112	120	105	151	140	139	839	30140
3-13-77	190	185	190	190	200	195	200	128	118	122	120	130	135	140	193	893	31033
3-20-77	195	195	190	190	195	195	190	130	129	128	134	133	54	80	193	788	31821
3-27-77	195	195	180	190	190	190	190	145	141	101	140	148	135	145	190	955	32776
4- 3-77	190	190	220	190	190	190	190	145	143	142	140	146	64	151	194	931	33707
4-10-77	190	190	190	190	190	190	190	140	149	145	149	150	121	155	190	1009	34716
4-17-77	190	190	190	190	190	190	190	149	143	140	136	140	125	163	190	996	35712
4-24-77	190	190	190	190	190	180	100	151	135	136	131	128	121	147	176	949	36661
5- 1-77	185	190	185	185	190	190	190	138	130	126	126	122	117	127	188	886	37547
5- 8-77	190	190	190	190	190	190	190	129	127	115	112	122	130	140	190	875	38422
5-15-77	190	190	190	195	185	170	190	138	139	132	137	136	111	146	187	939	39361
5-22-77	190	190	190	185	185	175	185	154	157	158	152	154	148	164	186	1087	40448
5-29-77	190	185	190	180	180	185	175	162	139	174	158	127	142	133	184	1035	41483
6- 5-77	180	180	180	180	185	185	185	125	122	119	111	119	127	131	182	854	42337
6-12-77	180	180	190	190	195	185	185	123	121	132	133	128	139	132	186	908	43245
6-19-77	185	190	195	190	185	185	185	127	128	120	132	120	127	129	188	883	44128
6-26-77	185	180	190	195	190	185	195	125	124	135	144	123	131	133	189	915	45043
7- 3-77	190	195	190	190	190	190	190	132	141	138	133	132	134	133	191	943	45986
7-10-77	190	190	190	190	165	190	195	134	136	135	138	123	138	137	187	941	46927
7-17-77	190	185	190	190	190	190	195	114	123	124	114	110	106	121	190	812	47739
7-24-77	195	170	180	195	185	185	185	125	106	117	132	126	116	119	185	841	48580
7-31-77	190	190	190	190	175	190	185	124	121	125	119	121	113	115	187	838	49418
8- 7-77	180	180	185	185	180	180	185	119	115	114	125	120	121	124	182	838	50256
8-14-77	185	180	180	180	180	175	205	138	141	147	110	168	164	182	184	1050	51306
8-21-77	195	195	195	195	200	195	200	172	168	171	177	180	172	173	196	1213	52519
8-28-77	200	190	190	200	190	195	195	182	180	178	167	174	172	180	194	1233	53752

TABLE G14
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLOOD INJECTION DATA FOR WELL MP-108

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day						Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	M	T	W	T	F	S			
6- 6-76	130	130	130	130	135	135	140	153	150	149	133	147	140	142	133	1014	1014
6-13-76	135	150	150	150	150	150	150	139	145	141	109	147	135	146	148	962	1976
6-20-76	175	165	165	180	180	185	190	136	115	126	147	129	147	144	177	944	2920
6-27-76	190	180	185	180	180	180	190	156	149	147	136	151	160	156	184	1055	3975
7- 4-76	190	190	190	185	185	170	185	130	66	102	101	88	135	154	185	776	4751
7-11-76	180	175	180	185	190	195	180	142	143	144	139	134	142	129	184	973	5724
7-18-76	170	185	185	175	185	175	190	131	144	147	135	148	152	166	181	1023	6747
7-25-76	190	190	190	190	175	190	185	145	144	128	150	178	173	159	187	1077	7824
8- 1-76	185	180	190	190	185	185	180	144	146	160	159	172	155	136	185	1072	8896
8- 8-76	185	180	180	180	190	180	185	145	170	170	164	158	135	130	183	1072	9968
8-15-76	180	175	170	170	170	180	185	118	125	165	163	160	172	182	176	1089	11057
8-22-76	185	170	180	185	175	170	180	170	140	165	144	132	151	174	178	1076	12133
8-29-76	160	190	175	180	180	185	175	159	191	191	196	192	192	132	178	1253	13386
9- 5-76	170	180	190	180	185	185	180	162	168	181	168	163	163	155	181	1160	14546
9-12-76	190	180	180	185	190	180	200	162	154	161	166	172	173	186	186	1174	15720
9-19-76	170	175	180	180	180	185	185	171	177	182	177	164	165	180	179	1216	16936
9-26-76	195	185	190	185	185	180	185	180	181	181	165	189	174	183	186	1253	18189
10- 3-76	185	185	160	190	180	180	185	184	186	211	184	209	201	189	181	1364	19553
10-10-76	180	185	185	190	0	130	155	189	192	139	98	0	220	207	171	1045	20598
10-17-76	175	185	190	90	135	150	155	219	209	94	34	182	193	189	154	1120	21718
10-24-76	160	165	105	100	90	85	85	188	184	155	123	114	114	113	113	991	22709
10-31-76	80	80	60	80	80	75	85	127	125	117	123	115	116	120	77	843	23552
11- 7-76	80	85	85	80	80	75	85	115	113	113	118	110	100	103	81	772	24324
11-14-76	85	75	75	75	80	75	80	103	97	90	105	96	107	111	78	709	25033
11-21-76	80	80	80	80	80	80	80	112	108	110	107	110	110	110	80	767	25800
11-28-76	80	80	80	80	75	80	75	104	103	101	96	94	96	96	79	690	26490
12- 5-76	75	80	80	80	80	80	80	95	95	94	93	91	88	94	79	650	27140
12-12-76	80	80	80	75	80	75	75	91	94	89	79	88	87	83	78	611	27751
12-19-76	75	85	80	80	80	80	80	82	89	96	96	89	98	97	80	647	28398
12-26-76	80	85	45	80	80	80	80	94	28	5	100	99	86	87	76	499	28897
1- 2-77	80	80	80	100	100	105	110	80	79	82	92	104	96	88	94	621	29518
1- 9-77	124	125	127	125	130	140	140	96	98	96	92	94	92	88	130	656	30174
1-16-77	140	140	135	130	145	150	150	91	92	92	88	97	103	111	141	674	30848
1-23-77	140	140	130	140	205	210	145	113	109	102	96	95	100	97	159	712	31560
1-30-77	145	150	140	140	150	145	145	96	96	95	97	92	94	91	145	661	32221
2- 6-77	150	150	140	140	150	140	150	97	98	98	98	97	99	92	146	679	32900
2-13-77	160	160	155	155	150	155	160	96	96	95	96	95	98	98	156	674	33574
2-20-77	160	155	155	155	165	160	170	95	91	96	95	85	95	96	160	653	34227
2-27-77	170	170	170	0	0	0	50	97	101	48	0	0	0	22	140	268	34495
3- 6-77	80	115	120	100	170	190	195	94	101	102	110	96	129	114	139	746	35241
3-13-77	190	185	190	175	200	195	200	105	111	115	120	136	138	130	191	855	36096
3-20-77	155	195	190	185	195	195	190	115	110	105	112	112	108	108	192	770	36866
3-27-77	195	195	180	190	190	190	190	126	122	88	121	129	80	70	190	736	37602
4- 3-77	190	190	220	190	190	190	190	112	108	107	100	120	111	125	194	783	38385
4-10-77	190	190	190	190	190	190	190	119	117	113	121	121	113	131	190	835	39220
4-17-77	190	190	190	190	190	190	190	124	122	119	102	117	109	190	190	883	40103
4-24-77	190	190	190	190	190	180	195	180	172	177	178	174	170	209	189	1260	41363
5- 1-77	185	185	185	185	185	185	190	196	186	183	180	179	173	186	186	1283	42646
5- 8-77	190	185	190	190	180	180	180	186	184	168	170	180	186	191	185	1265	43911
5-15-77	185	185	185	185	185	175	190	188	187	178	187	189	155	55	184	1139	45050
5-22-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45050
5-29-77	0	0	0	180	175	185	175	0	0	0	124	185	195	187	179	691	45741
6- 5-77	180	185	175	180	185	185	185	181	181	181	176	178	183	193	182	1273	47014
6-12-77	180	185	195	190	195	185	185	185	186	200	203	200	215	203	188	1392	48406
6-19-77	185	190	195	190	190	185	185	199	199	181	195	179	186	188	189	1327	49733
6-26-77	185	180	195	200	190	185	195	182	185	194	199	180	191	194	190	1325	51058
7- 3-77	190	195	190	190	190	190	190	194	203	193	186	187	191	190	191	1344	52402
7-10-77	190	190	190	190	165	190	195	192	195	193	177	164	209	212	187	1342	53744
7-17-77	185	185	190	190	190	190	190	194	197	194	193	194	198	197	189	1367	55111
7-24-77	190	170	180	195	185	185	185	199	170	191	213	206	194	197	184	1370	56481
7-31-77	185	185	185	190	175	185	185	200	196	200	189	191	165	156	184	1297	57778
8- 7-77	180	175	185	185	180	180	185	176	178	179	193	185	189	197	181	1297	59075
8-14-77	185	180	175	175	175	180	205	181	195	200	198	201	194	207	182	1376	60451
8-21-77	195	195	195	195	195	190	195	194	192	192	196	190	186	189	194	1339	61790
8-28-77	195	190	190	195	190	195	190	193	193	190	183	191	181	189	192	1320	63110

TABLE G15
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLOOD INJECTION DATA FOR WELL MP-110

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S		M	T	W	T	F	S			
6- 6-76	190	190	190	190	195	185	195	110	111	110	103	109	103	111	191	757	757
6-13-76	190	185	190	190	190	195	185	108	105	34	84	114	107	115	189	667	1424
6-20-76	195	190	190	185	195	195	195	109	93	94	123	106	116	116	192	757	2181
6-27-76	195	190	185	185	185	190	195	124	120	123	120	120	120	120	189	847	3028
7- 4-76	195	190	190	190	190	175	190	120	60	120	120	70	117	119	189	726	3754
7-11-76	190	180	185	195	195	200	185	108	97	57	105	105	93	63	190	628	4382
7-18-76	175	195	190	185	195	185	200	98	113	116	104	114	116	121	189	782	5164
7-25-76	200	200	195	190	185	200	185	111	113	83	94	117	117	109	194	744	5908
8- 1-76	195	190	190	190	195	195	190	101	102	110	106	116	105	85	192	725	6633
8- 8-76	195	185	190	185	200	185	190	89	104	122	123	124	106	91	190	759	7392
8-15-76	190	175	180	180	175	190	195	71	95	122	123	121	129	140	184	801	8193
8-22-76	195	180	190	190	185	180	185	130	104	122	104	109	108	132	186	809	9002
8-29-76	165	195	180	180	190	195	180	125	155	161	168	163	163	110	184	1045	10047
9- 5-76	180	185	190	190	195	195	190	136	146	158	151	148	151	143	189	1033	11080
9-12-76	195	190	190	190	200	190	205	149	139	140	140	143	144	153	194	1008	12088
9-19-76	175	185	190	185	185	195	195	142	148	159	153	142	175	150	187	1069	13157
9-26-76	195	195	190	195	190	185	195	150	151	154	147	167	152	159	192	1080	14237
10- 3-76	190	195	190	190	190	190	195	162	166	174	184	104	172	164	191	1126	15363
10-10-76	190	195	195	190	0	130	160	167	169	175	86	0	154	157	177	908	16271
10-17-76	185	190	190	100	145	155	165	172	162	72	23	132	153	152	161	866	17137
10-24-76	170	175	105	100	95	85	85	151	146	124	91	80	75	73	116	740	17877
10-31-76	90	85	80	85	80	80	95	82	83	73	86	80	80	83	85	567	18444
11- 7-76	90	90	90	85	85	75	95	75	76	76	81	75	67	70	87	520	18964
11-14-76	90	85	85	80	90	80	85	69	65	64	73	69	76	77	85	493	19457
11-21-76	85	90	85	85	85	85	85	82	78	79	77	74	73	72	86	535	19992
11-28-76	80	85	90	90	80	80	80	68	71	69	65	64	61	58	84	456	20448
12- 5-76	85	85	85	85	90	85	80	58	59	57	55	56	53	56	85	394	20842
12-12-76	85	90	90	80	85	80	80	57	59	57	51	55	54	52	84	385	21227
12-19-76	80	90	90	85	85	90	90	49	52	55	52	47	59	60	87	374	21601
12-26-76	90	85	45	85	85	90	90	56	17	4	66	64	55	55	81	317	21918
1- 2-77	90	90	90	100	110	110	115	52	48	50	56	66	64	58	101	394	22312
1- 9-77	110	130	135	125	140	140	140	64	64	63	62	62	61	59	131	435	22747
1-16-77	140	140	140	135	145	150	155	61	62	60	60	63	51	64	144	421	23168
1-23-77	150	140	145	145	205	210	145	60	60	56	58	57	57	55	163	403	23571
1-30-77	145	150	150	150	150	145	145	60	60	60	61	62	60	58	148	421	23992
2- 6-77	150	150	150	150	150	150	150	58	56	58	58	55	57	55	150	397	24389
2-13-77	160	160	160	160	150	155	160	56	56	56	57	56	58	58	158	397	24786
2-20-77	160	155	160	165	165	160	170	56	55	56	55	51	56	56	162	385	25171
2-27-77	170	170	170	0	0	0	50	57	57	29	0	0	0	13	140	156	25327
3- 6-77	80	115	120	105	0	0	0	54	63	65	21	0	0	0	105	203	25530
3-13-77	0	0	0	0	200	195	200	0	0	0	0	51	86	88	198	225	25755
3-20-77	195	195	190	190	195	195	190	79	75	74	80	80	77	77	193	542	26297
3-27-77	195	195	180	190	190	190	190	95	91	66	90	98	95	52	190	587	26884
4- 3-77	190	190	220	190	190	190	190	55	95	95	90	100	95	102	194	632	27516
4-10-77	190	190	190	190	190	190	190	90	79	67	85	85	75	61	190	542	28058
4-17-77	190	190	190	190	190	190	190	57	56	55	56	65	96	174	190	559	28617
4-24-77	190	190	190	190	190	180	200	167	163	172	136	160	150	173	190	1121	29738
5- 1-77	195	195	190	195	195	190	190	164	154	152	153	159	157	157	193	1096	30834
5- 8-77	200	195	195	190	190	190	190	166	172	155	151	160	169	177	193	1150	31984
5-15-77	190	185	195	195	195	180	200	179	179	167	170	174	146	191	191	1206	33190
5-22-77	195	195	195	190	190	175	195	194	197	197	190	189	184	199	191	1350	34540
5-29-77	190	190	195	190	185	190	185	190	163	201	183	147	168	156	189	1208	35748
6- 5-77	190	195	185	190	195	195	195	150	144	140	127	134	134	136	192	965	36713
6-12-77	190	190	205	200	200	195	190	122	118	127	127	120	138	135	196	887	37600
6-19-77	195	200	200	190	195	195	195	135	140	130	179	138	138	139	196	999	38599
6-26-77	195	195	205	210	200	195	205	137	136	143	149	133	140	143	201	981	39580
7- 3-77	200	205	200	200	200	200	200	140	147	144	141	142	144	143	201	1001	40581
7-10-77	200	200	200	200	170	200	205	143	145	145	127	118	151	157	196	986	41567
7-17-77	195	195	190	200	200	200	190	142	145	143	147	146	149	149	196	1021	42588
7-24-77	200	180	200	205	175	195	196	148	129	139	158	154	143	144	193	1015	43603
7-31-77	200	200	200	190	180	200	195	147	142	149	142	143	127	118	195	968	44571
8- 7-77	190	180	200	195	190	190	195	131	133	132	143	137	140	147	191	963	45534
8-14-77	195	190	190	190	190	190	205	137	150	155	158	162	155	167	193	1084	46618
8-21-77	195	195	195	195	200	190	195	162	162	157	162	158	156	162	195	1119	47737
8-28-77	195	190	190	195	190	195	190	166	165	163	154	162	153	160	192	1123	48860

TABLE G16
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLOOD INJECTION DATA FOR WELL MP-116

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S		M	T	W	T	F	S			
6- 6-76	185	185	185	185	190	180	185	79	78	77	82	96	88	95	185	595	595
6-13-76	185	185	185	190	185	185	180	93	95	96	80	113	103	109	185	689	1284
6-20-76	185	185	185	185	180	185	190	109	94	92	112	92	93	91	185	683	1967
6-27-76	190	185	185	185	185	180	190	109	109	112	100	105	115	115	186	765	2732
7- 4-76	190	190	190	175	185	170	185	108	73	112	97	69	112	118	184	689	3421
7-11-76	185	180	180	185	190	195	180	108	112	117	114	108	116	108	185	783	4204
7-18-76	170	185	190	180	190	180	190	103	117	119	107	109	190	123	184	868	5072
7-25-76	195	195	195	175	180	190	185	113	110	96	106	129	125	114	188	793	5865
8- 1-76	185	185	190	185	180	185	185	103	105	113	105	100	97	92	185	715	6580
8- 8-76	185	180	190	180	195	180	185	98	115	130	125	129	111	113	185	821	7401
8-15-76	180	175	175	175	170	180	185	113	110	123	117	113	124	137	177	837	8238
8-22-76	185	175	195	190	180	175	180	137	112	130	108	108	105	128	183	828	9066
8-29-76	160	190	175	180	185	175	175	116	148	131	141	137	137	105	177	915	9981
9- 5-76	175	180	180	185	185	190	185	120	130	142	125	121	124	118	183	880	10861
9-12-76	190	185	185	190	195	185	205	125	114	121	115	127	130	138	191	870	11731
9-19-76	170	180	185	185	185	190	190	127	136	142	134	123	119	118	184	899	12630
9-26-76	190	185	190	185	185	180	190	114	115	127	123	136	128	136	186	879	13509
10- 3-76	185	185	185	190	185	185	190	137	139	174	160	145	169	169	186	1093	14602
10-10-76	185	185	185	190	0	130	155	166	165	174	87	0	192	185	172	969	15571
10-17-76	175	185	190	100	140	150	160	199	194	91	29	175	178	173	157	1039	16610
10-24-76	165	170	105	100	90	85	85	178	181	146	111	107	111	108	114	942	17552
10-31-76	85	80	90	85	80	75	85	120	120	112	121	112	111	118	83	814	18366
11- 7-76	85	85	80	80	85	75	85	118	114	121	122	114	105	103	82	797	19163
11-14-76	85	80	80	80	85	80	85	109	105	105	112	109	118	120	82	778	19941
11-21-76	85	85	80	80	80	85	80	122	120	122	118	120	120	122	82	84-	20785
11-28-76	80	85	85	85	75	80	80	120	118	118	114	115	113	112	81	810	21595
12- 5-76	80	80	80	80	80	80	80	111	115	114	112	112	107	117	80	788	22383
12-12-76	80	85	85	75	80	75	75	113	117	110	97	108	103	100	79	748	23131
12-19-76	75	85	85	80	80	80	85	103	112	118	113	106	114	113	81	779	23910
12-26-76	85	85	50	80	80	80	85	111	42	7	125	120	108	109	78	622	24532
1- 2-77	85	85	80	100	100	105	110	105	102	107	115	128	120	112	95	785	25321
1- 9-77	125	130	130	125	135	140	140	124	126	124	120	122	121	116	132	853	26174
1-16-77	140	140	140	135	145	150	150	119	122	120	118	122	130	130	143	861	27035
1-23-77	145	140	135	140	205	210	145	133	124	116	114	116	122	118	160	843	27878
1-30-77	145	150	145	145	150	145	145	118	119	120	121	117	119	118	146	832	28710
2- 6-77	150	150	140	145	150	145	150	118	120	122	123	121	126	120	147	850	29560
2-13-77	160	160	155	150	150	155	160	123	124	125	125	126	138	140	156	901	30461
2-20-77	160	155	155	155	165	160	170	134	129	133	131	131	138	139	160	935	31396
2-27-77	170	170	170	0	0	0	50	135	135	64	0	0	0	27	140	361	31757
3- 6-77	80	115	120	100	170	190	195	109	120	121	134	119	173	161	139	937	32694
3-13-77	190	185	190	180	200	195	200	150	145	147	146	155	113	110	191	966	33660
3-20-77	195	195	190	185	195	195	190	141	138	136	142	141	137	137	192	972	34632
3-27-77	195	195	180	190	190	190	190	155	155	112	152	160	138	147	190	1019	35651
4- 3-77	190	190	220	190	190	190	190	148	151	150	101	72	149	204	194	975	36626
4-10-77	190	190	190	190	190	190	190	189	187	183	190	185	171	197	190	1302	37928
4-17-77	190	190	190	190	190	190	190	191	185	179	176	188	167	211	190	1297	39225
4-24-77	190	190	190	190	190	180	195	198	182	182	177	178	173	210	189	1300	40525
5- 1-77	195	185	180	180	190	185	190	196	189	185	184	177	173	190	186	1294	41819
5- 8-77	190	195	190	190	180	185	185	190	187	168	167	174	181	190	188	1257	43076
5-15-77	185	190	190	185	185	170	190	188	189	177	182	190	160	196	185	1282	44358
5-22-77	190	190	190	185	185	175	185	195	194	193	185	188	181	201	186	1337	45695
5-29-77	190	185	195	180	175	185	180	186	159	196	181	150	176	173	184	1221	46916
6- 5-77	180	185	180	185	190	185	185	167	166	165	153	161	164	173	184	1149	48065
6-12-77	180	180	195	190	195	185	185	161	159	173	175	166	183	175	187	1192	49257
6-19-77	185	190	195	190	190	190	190	170	172	155	173	158	163	164	190	1155	50412
6-26-77	190	190	190	200	190	185	195	158	160	169	166	152	164	168	191	1137	51549
7- 3-77	190	195	195	190	190	195	195	168	178	175	171	170	172	171	193	1205	52754
7-10-77	195	195	190	190	165	190	200	171	173	172	151	129	177	181	189	1154	53908
7-17-77	185	185	190	195	190	190	190	163	162	162	167	168	169	168	189	1159	55067
7-24-77	195	175	195	195	185	190	190	168	143	158	182	172	163	167	189	1153	56220
7-31-77	190	190	190	190	175	190	190	171	164	175	168	169	149	148	188	1144	57364
8- 7-77	185	180	190	190	185	185	185	162	161	162	174	167	169	176	186	1171	58535
8-14-77	185	185	180	180	180	180	205	157	173	178	177	183	174	188	185	1230	59765
8-21-77	195	195	195	195	200	190	195	177	174	173	177	172	166	170	195	1209	60974
8-28-77	200	190	190	195	190	195	190	175	175	173	164	173	158	178	193	1196	62170

TABLE G17

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLOOD INJECTION DATA FOR WELL MP-118

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary		Cumulative Injection, bbl
	S	M	T	W	T	F	S		M	T	W	T	F	S	Pressure, psig	Injection, bbl	
6- 6-76	165	165	170	170	155	160	160	143	142	149	97	141	144	147	164	963	963
6-13-76	160	160	160	155	160	160	155	147	145	142	104	152	140	148	159	978	1941
6-20-76	175	170	175	185	190	190	195	139	111	122	158	127	147	134	183	938	2879
6-27-76	190	185	185	185	185	185	190	156	153	158	133	146	169	162	186	1077	3956
7- 4-76	195	195	195	190	190	175	190	137	77	112	103	77	133	148	190	787	4743
7-11-76	185	180	180	190	195	195	185	136	142	140	135	131	139	126	187	949	5692
7-18-76	175	190	190	185	190	180	195	126	141	144	133	146	152	164	186	1006	6698
7-25-76	195	195	190	190	180	195	185	140	141	112	134	161	157	145	190	990	7688
8- 1-76	190	185	190	190	190	190	185	137	144	161	152	165	148	132	189	1039	8727
8- 8-76	190	185	190	180	195	185	185	146	165	161	157	166	141	141	187	1077	9804
8-15-76	180	175	175	175	175	185	150	140	143	165	159	154	165	179	179	1105	10909
8-22-76	190	175	190	190	180	175	185	179	153	178	147	134	146	172	184	1109	12018
8-29-76	160	195	175	185	190	190	175	160	185	182	192	186	186	130	181	1221	13239
9- 5-76	175	180	190	190	190	190	185	167	171	187	163	159	170	165	186	1182	14421
9-12-76	195	185	185	190	200	185	205	159	149	159	133	141	134	131	192	1006	15427
9-19-76	175	180	190	185	185	190	190	106	114	122	112	104	99	92	185	749	16176
9-26-76	190	190	190	190	190	185	190	91	90	109	106	107	100	138	189	741	16917
10- 3-76	190	190	190	190	185	190	195	177	176	180	145	142	150	142	190	1112	18029
10-10-76	190	195	195	190	0	130	160	144	148	155	68	0	239	205	177	959	18988
10-17-76	180	190	190	100	140	155	160	208	202	96	42	191	188	184	159	1111	20099
10-24-76	165	170	105	100	90	85	85	185	182	159	135	129	130	124	114	1044	21143
10-31-76	85	80	70	85	80	75	90	137	134	123	129	122	124	129	81	898	22041
11- 7-76	85	85	85	85	85	75	85	131	130	128	131	120	111	110	84	861	22902
11-14-76	85	80	80	65	85	80	85	117	113	113	66	63	130	127	80	729	23631
11-21-76	85	85	80	80	80	85	85	130	126	130	123	125	124	127	83	885	24516
11-28-76	80	85	85	85	75	80	80	129	139	137	131	149	153	151	81	989	25505
12- 5-76	80	85	85	80	80	75	80	148	151	150	146	145	140	145	81	1025	26530
12-12-76	85	85	85	75	85	75	75	144	147	140	128	139	134	132	81	964	27494
12-19-76	80	85	85	80	80	80	85	131	139	143	170	95	143	121	82	942	28436
12-26-76	85	85	50	80	80	80	80	121	37	6	139	129	118	119	77	669	29105
1- 2-77	80	80	80	100	100	100	110	114	112	116	123	133	123	113	93	834	29939
1- 9-77	124	125	129	125	130	140	140	122	122	118	119	119	117	114	130	831	30770
1-16-77	140	140	135	130	145	150	153	118	118	119	119	121	126	84	142	805	31575
1-23-77	145	140	135	140	205	210	145	52	131	116	112	111	118	114	150	754	32329
1-30-77	145	150	145	145	150	145	145	112	109	112	112	107	108	107	146	767	33096
2- 6-77	150	150	140	140	150	140	150	112	110	108	107	107	111	107	146	762	33858
2-13-77	160	160	155	155	150	155	160	111	110	111	113	109	111	113	156	778	34636
2-20-77	160	155	155	155	165	160	170	111	108	113	112	103	116	105	150	768	35404
2-27-77	170	170	170	0	0	0	50	112	114	57	0	0	0	27	140	310	35714
3- 6-77	80	115	120	100	170	190	195	107	111	111	125	111	146	132	139	843	36557
3-13-77	190	185	190	180	200	195	200	128	138	144	138	153	156	150	191	1007	37564
3-20-77	195	195	190	190	195	195	190	132	127	127	133	132	128	128	193	907	38471
3-27-77	195	195	180	190	190	190	190	146	141	101	140	148	100	145	190	921	39392
4- 3-77	190	190	220	190	190	190	190	148	146	145	165	164	138	191	194	1097	40489
4-10-77	190	190	190	190	190	190	190	177	174	169	171	182	166	185	190	1224	41713
4-17-77	190	190	190	190	190	190	190	174	163	157	154	160	144	183	190	1135	42848
4-24-77	190	190	190	190	190	190	195	166	152	156	152	148	140	163	191	1077	43925
5- 1-77	195	185	185	190	185	185	190	150	141	143	155	164	160	170	188	1083	45008
5- 8-77	190	190	190	190	180	180	185	174	173	222	192	165	174	181	186	1281	46289
5-15-77	185	190	190	185	190	175	190	180	181	172	176	177	153	198	186	1237	47526
5-22-77	190	190	190	185	185	175	185	199	199	193	188	190	188	205	186	1362	48888
5-29-77	190	185	195	180	180	180	175	194	172	217	195	164	187	182	184	1311	50199
6- 5-77	180	185	180	180	185	185	185	171	165	159	150	157	161	167	183	1130	51329
6-12-77	180	185	135	195	195	185	185	154	152	141	145	168	184	177	180	1121	52450
6-19-77	185	190	200	190	190	190	190	185	177	157	168	153	155	158	191	1153	53603
6-26-77	190	185	195	200	190	185	195	164	170	175	160	159	170	177	191	1175	54778
7- 3-77	190	195	195	190	190	190	190	180	187	183	177	178	180	179	191	1264	56042
7-10-77	190	195	190	190	165	195	200	180	181	180	164	153	195	199	189	1252	57294
7-17-77	185	180	190	185	185	185	185	181	182	174	178	175	181	178	185	1249	58543
7-24-77	185	160	175	185	175	175	175	177	152	164	182	178	167	169	176	1189	59732
7-31-77	190	180	180	180	175	185	180	173	171	176	166	169	139	123	181	1117	60849
8- 7-77	175	170	155	175	175	175	165	146	157	159	169	166	165	99	170	1061	61910
8-14-77	170	180	175	175	175	180	205	154	160	125	249	256	260	287	180	1491	63401
8-21-77	195	195	195	195	200	190	195	269	277	280	271	285	285	288	195	1955	65356
8-28-77	200	190	190	195	190	195	190	291	292	295	278	286	263	290	193	1995	67351

TABLE G18
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLOOD INJECTION DA¯A
FOR WELL MP-120

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S		M	T	W	T	F	S			
6- 6-76	175	175	175	190	190	185	185	147	141	148	134	143	136	138	182	987	987
6-13-76	185	185	185	185	185	190	185	133	128	131	106	140	125	131	186	894	1881
6-20-76	185	180	185	185	180	190	195	120	120	120	152	105	131	142	186	890	2771
6-27-76	190	185	185	190	185	170	195	154	149	152	149	157	154	158	186	1073	3844
7- 4-76	195	190	190	190	190	175	190	132	84	124	115	31	148	158	189	792	4636
7-11-76	190	180	190	190	190	195	185	146	146	146	146	145	155	144	189	1028	5664
7-18-76	175	190	190	185	190	180	195	145	165	163	151	168	174	188	186	1154	6818
7-25-76	195	195	190	190	185	195	185	160	163	128	152	181	176	162	191	1122	7940
8- 1-76	190	190	190	190	190	185	185	152	162	181	169	185	170	152	189	1171	9111
8- 8-76	190	185	190	185	195	185	185	169	181	180	177	189	164	163	188	1223	10334
8-15-76	180	175	175	175	175	185	185	160	162	184	180	175	185	199	179	1245	11579
8-22-76	190	175	185	185	180	175	185	198	170	197	160	151	162	187	182	1225	12804
8-29-76	165	190	175	185	190	190	175	174	203	195	204	201	201	143	181	1321	14125
9- 5-76	175	180	180	185	190	190	185	181	187	203	182	177	177	166	184	1273	15398
9-12-76	195	190	190	190	195	185	205	174	160	166	165	169	169	175	193	1178	16576
9-19-76	175	180	185	185	185	190	190	151	174	187	176	165	165	173	184	1191	17767
9-26-76	190	190	190	185	190	180	190	171	171	175	169	192	172	181	188	1231	18998
10- 3-76	190	185	190	185	185	185	190	183	149	171	240	238	245	238	187	1464	20462
10-10-76	185	190	190	190	0	130	160	243	251	259	128	0	261	237	174	1379	21841
10-17-76	180	190	190	100	140	155	160	239	234	109	44	212	217	219	159	1274	23115
10-24-76	165	175	105	100	95	85	85	223	222	194	157	134	129	127	116	1186	24301
10-31-76	85	80	70	80	80	80	90	154	138	128	136	132	136	142	81	966	25267
11- 7-76	85	85	90	85	85	75	90	141	138	130	127	115	109	124	85	884	26151
11-14-76	85	90	80	80	90	80	85	116	109	109	117	112	136	139	84	838	26989
11-21-76	85	85	85	85	85	85	85	139	129	141	134	139	135	137	85	954	27943
11-28-76	85	85	85	85	80	85	80	132	129	127	122	125	123	118	84	876	28819
12- 5-76	80	85	85	80	85	85	80	115	118	117	114	117	112	119	83	812	29631
12-12-76	85	85	90	75	85	75	80	117	120	115	107	123	119	115	82	816	30447
12-19-76	80	85	85	85	85	85	85	107	111	118	108	96	112	103	84	755	31202
12-26-76	85	85	50	80	85	85	85	101	31	4	118	109	102	101	79	566	31768
1- 2-77	85	85	85	100	105	110	112	96	95	97	109	123	116	105	97	741	32509
1- 9-77	127	129	133	125	135	140	140	112	118	113	112	112	111	111	133	789	33298
1-16-77	140	140	140	135	145	150	153	113	111	113	113	116	120	123	143	809	34107
1-23-77	140	140	140	140	205	210	145	130	123	115	111	111	117	111	160	818	34925
1-30-77	145	150	145	145	150	145	145	113	112	113	113	107	108	108	146	774	35699
2- 6-77	150	150	145	150	150	150	150	124	120	110	118	113	117	111	149	813	36512
2-13-77	160	160	160	155	150	155	160	116	116	115	117	120	129	127	157	840	37352
2-20-77	160	155	155	160	165	160	170	121	116	119	117	107	120	120	161	820	38172
2-27-77	170	170	170	0	0	0	50	122	127	62	0	0	0	23	140	334	38506
3- 6-77	80	115	120	100	170	190	195	94	105	108	121	99	134	122	139	783	39289
3-13-77	190	185	190	185	200	195	200	120	139	141	133	158	151	146	192	988	40277
3-20-77	195	195	190	190	195	195	190	129	128	128	134	133	129	129	193	910	41187
3-27-77	195	195	180	200	190	190	190	147	143	103	142	150	154	164	191	1003	42190
4- 3-77	190	190	220	190	190	190	190	164	163	162	160	150	125	165	194	1089	43279
4-10-77	190	190	190	190	190	190	190	150	147	145	149	114	76	173	190	954	44233
4-17-77	190	190	190	190	190	190	190	171	165	156	164	172	149	188	190	1165	45398
4-24-77	190	190	190	190	190	180	195	185	171	171	165	174	167	184	189	1217	46615
5- 1-77	190	190	185	190	185	185	190	171	168	169	186	192	187	197	188	1270	47885
5- 8-77	195	190	195	190	185	185	185	194	190	170	169	176	188	199	189	1286	49171
5-15-77	190	190	190	190	190	175	190	196	196	186	195	193	167	207	188	1340	50511
5-22-77	190	190	190	185	185	175	190	207	208	205	198	201	200	219	186	1438	51949
5-29-77	190	185	195	185	180	185	180	211	188	235	219	185	210	208	186	1456	53405
6- 5-77	185	185	180	185	185	190	190	203	199	198	187	190	189	191	186	1357	54762
6-12-77	185	185	195	195	200	190	190	176	172	185	188	182	198	192	191	1293	56055
6-19-77	190	195	200	195	190	190	190	190	196	179	192	175	176	176	193	1284	57339
6-26-77	190	185	195	200	190	190	200	182	188	196	193	182	193	198	193	1332	58671
7- 3-77	195	200	195	195	190	190	195	198	206	202	198	196	198	196	194	1394	60065
7-10-77	195	195	195	195	170	190	200	197	197	196	179	168	210	216	191	1363	61428
7-17-77	190	190	190	195	195	195	195	198	203	200	205	198	208	204	193	1416	62844
7-24-77	195	175	195	200	190	185	185	204	177	196	217	212	190	200	189	1396	64240
7-31-77	190	190	190	190	180	180	190	204	201	208	197	199	175	155	187	1339	65579
8- 7-77	185	180	190	190	185	115	110	175	187	187	202	196	150	125	165	1222	66801
8-14-77	105	105	55	55	90	90	95	114	123	128	102	103	101	105	85	776	67577
8-21-77	95	95	95	105	105	95	95	101	101	100	98	98	97	99	98	694	68271
8-28-77	95	95	95	90	90	90	90	99	100	101	93	93	88	93	92	667	68938

TABLE G19
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLOOD INJECTION DATA FOR WELL MP-126

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S		M	T	W	T	F	S			
6- 6-76	190	190	190	200	200	190	200	145	143	148	134	142	134	142	194	988	988
6-13-76	190	195	195	190	195	200	195	142	140	144	117	161	143	151	194	998	1986
6-20-76	200	190	190	195	200	200	200	142	113	103	130	119	99	103	196	809	2795
6-27-76	190	195	185	200	190	190	200	125	126	130	107	116	137	136	193	877	3672
7- 4-76	200	200	200	190	195	180	200	123	74	109	96	74	116	131	195	723	4395
7-11-76	195	190	190	200	200	200	190	117	119	121	116	110	115	104	195	802	5197
7-18-76	180	200	190	190	200	190	200	103	119	120	106	112	117	125	193	802	5999
7-25-76	200	200	195	185	190	190	195	131	119	96	112	137	132	119	194	846	6845
8- 1-76	200	200	190	185	195	195	195	107	114	125	123	134	112	94	194	809	7654
8- 8-76	200	195	195	195	200	195	200	102	120	127	124	132	109	114	197	828	8482
8-15-76	190	190	175	180	180	195	200	114	110	127	121	115	125	141	187	853	9335
8-22-76	200	190	100	190	190	185	195	143	116	134	105	100	104	130	179	832	10167
8-29-76	170	195	185	190	200	190	190	115	150	143	152	149	149	101	189	959	11126
9- 5-76	185	195	200	190	200	200	195	126	136	152	136	135	136	130	195	951	12077
9-12-76	200	195	200	200	205	195	210	138	124	134	124	133	136	149	201	938	13015
9-19-76	180	190	195	195	195	200	200	135	147	159	150	135	134	127	194	987	14002
9-26-76	200	200	190	200	200	190	200	121	124	139	140	152	157	210	197	1043	15045
10- 3-76	200	200	200	195	195	195	200	209	208	149	222	212	220	213	198	1433	16478
10-10-76	195	200	200	190	0	120	160	215	218	226	112	0	208	206	178	1185	17663
10-17-76	190	200	190	100	155	160	170	228	230	108	32	192	201	208	166	1199	18862
10-24-76	180	180	110	105	100	100	95	197	192	156	114	110	105	100	124	974	19836
10-31-76	100	95	90	90	90	90	100	113	109	98	103	95	96	101	94	715	20551
11- 7-76	90	95	90	90	100	85	95	94	93	92	99	89	80	76	92	623	21174
11-14-76	100	90	80	85	95	90	95	83	77	78	89	88	95	98	91	608	21782
11-21-76	95	95	95	90	90	95	90	99	93	95	93	94	93	93	93	660	22442
11-28-76	95	95	96	90	85	90	90	89	87	85	80	79	78	174	92	672	23114
12- 5-76	90	95	95	95	95	95	90	72	73	68	65	66	64	69	94	477	23591
12-12-76	95	95	95	85	90	85	90	65	66	62	54	61	61	61	91	430	24021
12-19-76	90	95	95	90	90	95	95	59	67	75	73	64	78	76	93	492	24513
12-26-76	95	85	55	90	95	95	90	73	25	4	91	88	73	85	86	439	24952
1- 2-77	90	90	90	100	110	115	120	67	65	68	79	94	87	75	102	535	25487
1- 9-77	130	130	140	125	140	140	140	82	86	84	81	81	80	77	135	571	26058
1-16-77	140	140	145	145	145	150	160	77	75	77	79	48	66	101	146	523	26581
1-23-77	150	140	140	150	205	210	145	92	86	74	70	74	77	74	163	547	27128
1-30-77	145	150	150	150	150	145	145	72	68	68	68	64	64	62	148	466	27594
2- 6-77	150	150	150	150	150	180	150	72	65	75	73	67	68	64	150	484	28078
2-13-77	160	160	170	170	150	155	160	69	69	67	67	76	85	80	161	513	28591
2-20-77	160	155	170	170	165	160	170	70	66	68	66	64	72	68	164	474	29065
2-27-77	170	170	170	0	0	0	50	69	70	34	0	0	0	14	140	187	29252
3- 6-77	80	115	120	110	170	190	195	62	76	81	105	85	157	151	140	717	29969
3-13-77	190	185	190	195	200	195	200	136	130	130	127	140	135	130	194	928	30897
3-20-77	195	195	190	200	195	195	190	117	100	105	112	112	110	110	194	766	31663
3-27-77	195	195	180	195	190	190	190	128	124	90	123	132	117	124	191	838	32501
4- 3-77	190	190	220	190	190	190	190	71	35	130	143	155	128	169	194	831	33332
4-10-77	190	190	190	190	190	190	190	156	152	107	106	186	168	194	190	1069	34401
4-17-77	190	190	190	190	190	190	190	189	180	172	163	169	142	185	190	1200	35601
4-24-77	190	190	190	190	190	180	205	168	147	143	140	143	134	166	191	1041	36642
5- 1-77	200	200	190	195	200	200	200	162	147	144	155	148	140	152	198	1048	37690
5- 8-77	200	200	200	190	200	200	200	149	149	131	126	131	135	147	199	968	38658
5-15-77	200	200	200	200	200	185	200	162	166	156	162	163	135	175	198	1119	39777
5-22-77	200	200	200	200	200	190	200	174	173	168	159	161	156	174	199	1165	40942
5-29-77	190	200	200	195	190	195	190	170	150	187	104	142	170	166	194	1089	42031
6- 5-77	195	200	190	190	195	195	200	159	158	156	143	146	141	143	195	1046	43077
6-12-77	200	190	195	200	195	200	200	132	124	131	135	132	149	143	197	946	44023
6-19-77	200	200	210	200	200	190	200	140	143	134	149	135	135	135	200	971	44994
6-26-77	200	200	195	205	205	200	210	131	132	140	126	117	127	134	202	907	45901
7- 3-77	205	210	205	200	205	205	205	135	144	140	134	134	135	134	205	956	46857
7-10-77	205	205	205	205	190	195	200	132	133	134	118	110	148	151	201	926	47783
7-17-77	190	190	190	190	190	195	195	136	139	128	143	140	132	133	191	951	48734
7-24-77	195	175	195	200	190	190	190	130	111	124	144	139	129	132	191	909	49643
7-31-77	195	190	190	190	180	190	190	133	131	136	127	132	119	118	189	896	50539
8- 7-77	190	180	190	190	185	185	190	127	124	125	136	133	132	135	187	912	51451
8-14-77	190	185	180	180	185	180	205	124	135	140	107	118	115	131	186	870	52321
8-21-77	195	195	195	195	200	190	200	136	137	139	149	140	133	138	196	972	53293
8-28-77	200	100	190	195	195	195	190	145	144	141	132	141	134	148	181	985	54278

TABLE G20
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLOOD INJECTION DATA FOR WELL MP-128

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S		M	T	W	T	F	S			
6- 6-76	175	175	175	175	175	170	175	150	147	146	133	147	138	147	174	1008	1008
6-13-76	170	175	175	170	170	170	170	149	150	151	123	165	151	159	171	1048	2056
6-20-76	175	175	180	190	195	195	200	137	110	126	150	127	143	128	187	921	2977
6-27-76	195	190	185	190	190	190	195	149	148	150	125	133	154	152	191	1011	3988
7- 4-76	195	200	195	195	195	180	195	141	94	140	123	82	138	152	194	870	4858
7-11-76	190	[illegible]	185	195	195	200	185	142	142	142	138	134	142	128	191	968	5826
7-18-76	175	195	190	185	195	185	200	122	139	141	129	145	152	165	189	993	6819
7-25-76	200	200	190	185	185	195	195	142	144	118	141	166	162	153	193	1026	7845
8- 1-76	195	190	190	190	195	195	190	147	153	176	162	166	146	130	192	1080	8925
8- 8-76	195	190	190	185	200	190	190	145	157	156	151	158	134	142	191	1043	9968
8-15-76	185	180	180	180	175	190	195	139	143	158	149	143	155	168	184	1055	11023
8-22-76	195	180	190	190	185	180	190	164	143	165	135	130	134	160	187	1031	12054
8-29-76	165	195	180	190	195	195	180	147	176	170	175	172	172	123	186	1135	13189
9- 5-76	180	185	180	190	190	185	185	160	164	185	156	154	155	149	185	1123	14312
9-12-76	185	190	185	175	175	175	175	157	143	154	135	153	158	171	180	1071	15383
9-19-76	175	175	170	175	175	175	195	139	169	184	164	157	153	141	177	1107	16490
9-26-76	195	195	190	195	190	185	195	133	136	164	165	173	168	177	192	1116	17606
10- 3-76	185	195	190	190	190	190	195	180	184	207	211	207	220	214	191	1423	19029
10-10-76	190	195	195	190	0	135	160	219	223	233	114	0	252	230	178	1271	20300
10-17-76	185	190	190	100	145	155	165	237	231	108	42	213	214	209	161	1254	21554
10-24-76	170	175	105	100	95	90	50	209	201	172	138	132	127	121	112	1100	22654
10-31-76	70	65	70	80	85	80	95	138	132	121	129	118	119	123	78	880	23534
11- 7-76	90	90	85	85	90	80	90	117	114	114	120	106	99	95	87	765	24299
11-14-76	85	85	85	80	90	85	90	103	95	98	107	104	115	118	86	740	25039
11-21-76	90	90	90	85	85	85	85	119	109	113	111	110	105	105	87	772	25811
11-28-76	85	90	90	85	80	85	80	102	100	99	93	100	108	103	85	705	26516
12- 5-76	80	85	85	85	85	85	85	100	102	100	96	98	96	100	84	692	27208
12-12-76	85	85	90	80	85	80	80	97	99	93	87	105	100	97	84	678	27886
12-19-76	85	90	90	85	85	85	85	89	94	102	93	84	105	100	86	667	28553
12-26-76	85	85	50	85	85	85	85	95	26	3	102	100	80	87	80	493	29046
1- 2-77	85	85	85	105	105	110	115	83	81	85	94	107	102	88	99	640	29686
1- 9-77	130	130	135	125	140	140	140	97	102	100	98	99	99	98	134	693	30379
1-16-77	140	140	145	140	145	150	155	99	100	101	99	103	58	77	145	637	31016
1-23-77	150	140	145	145	205	210	145	130	121	110	102	102	110	103	163	778	31794
1-30-77	145	150	150	150	150	145	145	103	98	97	97	90	90	87	148	662	32456
2- 6-77	150	150	150	150	150	150	150	94	89	92	89	88	91	87	150	630	33086
2-13-77	160	160	165	160	150	155	160	93	93	90	90	96	101	98	159	661	33747
2-20-77	160	155	160	165	165	160	170	91	87	90	89	87	94	91	162	629	34376
2-27-77	170	170	170	0	0	0	50	94	96	47	0	0	0	26	140	263	34639
3- 6-77	80	115	120	105	170	190	195	83	91	94	123	106	166	156	139	819	35458
3-13-77	190	185	190	185	200	195	200	146	145	149	142	156	162	154	192	1054	36512
3-20-77	195	195	190	190	195	195	190	130	133	122	128	127	123	123	193	886	37398
3-27-77	195	195	180	190	190	190	190	141	137	99	136	144	164	165	190	986	38384
4- 3-77	190	190	220	190	190	190	190	168	169	114	129	207	173	240	194	1200	39584
4-10-77	190	190	190	190	190	190	190	218	216	206	218	220	193	210	190	1481	41065
4-17-77	190	190	190	190	190	190	190	202	196	191	191	206	180	231	190	1397	42462
4-24-77	190	190	190	190	190	180	200	218	198	198	195	197	190	223	190	1419	43881
5- 1-77	190	195	190	190	190	190	195	211	200	201	211	206	197	210	191	1436	45317
5- 8-77	195	195	195	190	190	190	190	212	213	189	186	192	206	220	192	1418	46735
5-15-77	190	195	195	190	195	175	195	219	218	207	215	217	186	236	191	1498	48233
5-22-77	195	195	195	190	190	180	190	229	227	221	212	217	213	234	191	1553	49786
5-29-77	190	190	195	190	185	190	180	228	195	243	221	194	224	223	189	1528	51314
6- 5-77	185	190	190	185	190	190	190	218	214	213	202	138	200	199	189	1384	52698
6-12-77	190	190	200	200	200	190	190	178	174	185	185	184	202	197	194	1305	54003
6-19-77	190	200	200	195	195	195	195	194	200	180	190	173	172	172	196	1281	55284
6-26-77	195	190	200	205	200	195	200	179	187	193	172	176	191	198	198	1296	56580
7- 3-77	200	200	200	200	195	200	200	201	211	208	201	202	205	202	199	1430	58010
7-10-77	200	200	200	200	170	200	205	204	206	205	187	174	218	223	196	1417	59427
7-17-77	195	190	190	200	200	200	200	205	211	206	211	208	215	211	196	1467	60894
7-24-77	200	175	195	200	195	190	195	211	181	194	218	213	200	202	193	1419	62313
7-31-77	195	195	195	195	175	195	195	207	203	209	198	199	173	154	192	1343	63656
8- 7-77	190	185	195	195	185	150	155	174	185	188	205	196	167	144	179	1259	64915
8-14-77	155	125	125	125	145	145	145	126	138	143	144	146	143	151	138	991	65906
8-21-77	130	130	130	140	140	135	135	146	146	146	143	140	138	141	134	1000	66906
8-28-77	135	135	135	135	140	135	135	144	144	146	137	143	130	143	136	987	67893

TABLE G21

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE PREFLOOD INJECTION DATA FOR WELL MP-130

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S		M	T	W	T	F	S			
6- 6-76	170	170	170	180	185	175	180	144	142	149	136	150	142	155	176	1018	1018
6-13-76	175	170	180	175	175	175	150	159	157	158	129	173	158	146	171	1080	2098
6-20-76	170	165	170	185	185	185	190	133	107	130	157	132	157	110	179	926	3024
6-27-76	190	185	185	185	180	175	190	150	149	157	148	156	154	166	184	1080	4104
7- 4-76	190	190	190	190	190	170	190	150	91	135	117	89	141	155	187	878	4982
7-11-76	185	180	180	190	190	195	180	146	144	144	140	138	143	134	186	994	5976
7-18-76	170	190	190	180	180	175	190	132	142	144	132	149	158	173	182	1030	7006
7-25-76	195	195	195	190	180	190	185	152	153	121	145	174	173	164	190	1082	8088
8- 1-76	190	185	190	190	185	185	185	154	156	177	164	171	156	136	187	1114	9202
8- 8-76	185	180	180	180	195	180	185	148	167	160	155	167	149	145	184	1091	10293
8-15-76	180	175	175	175	175	180	185	145	143	158	153	148	160	174	178	1081	11374
8-22-76	190	175	185	185	180	175	185	169	147	175	141	137	142	162	182	1073	12447
8-29-76	160	190	175	155	190	190	175	148	180	172	177	175	175	128	176	1155	13602
9- 5-76	175	180	180	185	190	190	185	161	169	186	174	171	169	163	184	1193	14795
9-12-76	195	185	185	185	190	180	200	170	158	166	161	166	170	182	189	1173	15968
9-19-76	170	180	185	180	180	190	190	155	180	192	182	172	172	180	182	1233	17201
9-26-76	190	185	190	190	185	180	185	177	176	181	175	200	179	177	186	1265	18466
10- 3-76	190	190	190	185	180	185	190	194	197	220	209	202	214	209	187	1445	19911
10-10-76	180	190	190	190	0	130	155	211	215	225	111	0	220	209	173	1191	21102
10-17-76	175	185	190	100	140	155	160	211	212	99	35	187	191	193	158	1128	22230
10-24-76	165	170	105	100	90	85	80	194	190	160	121	103	92	90	114	950	23180
10-31-76	85	80	60	80	80	75	85	118	99	91	100	96	102	110	78	716	23896
11- 7-76	80	80	80	80	85	75	85	103	103	96	96	85	80	95	81	658	24554
11-14-76	85	90	75	75	85	75	80	85	79	79	81	85	106	111	81	626	25180
11-21-76	80	85	80	85	80	80	80	110	97	105	105	107	108	111	81	743	25923
11-28-76	80	80	85	85	75	80	75	69	89	106	100	101	101	99	80	665	26588
12- 5-76	80	80	80	80	80	75	80	99	102	102	100	102	98	101	79	704	27292
12-12-76	80	85	85	75	80	75	75	97	100	96	89	108	105	99	79	694	27986
12-19-76	80	85	85	80	80	85	85	92	95	101	98	89	135	102	83	682	28668
12-26-76	85	85	45	80	80	80	85	98	29	3	105	104	86	92	77	517	29185
1- 2-77	85	85	85	100	105	105	110	87	87	89	98	110	103	92	96	666	29851
1- 9-77	125	127	130	125	135	140	140	102	105	105	103	108	107	106	132	736	30587
1-16-77	140	140	135	130	145	150	140	108	109	109	104	107	107	108	140	749	31236
1-23-77	140	140	130	130	205	210	145	105	105	99	98	101	108	100	157	716	32052
1-30-77	145	150	140	140	180	140	145	100	100	100	100	105	105	106	144	716	32768
2- 6-77	150	150	140	140	150	140	150	104	100	105	105	100	105	105	146	724	33492
2-13-77	160	160	160	155	180	155	160	105	105	105	102	105	100	100	157	722	34214
2-20-77	160	155	165	160	165	160	170	100	100	105	100	105	105	105	161	720	34934
2-27-77	170	170	170	0	0	0	50	105	105	56	0	0	0	32	140	298	35232
3- 6-77	80	115	120	100	170	190	195	90	105	105	117	104	180	180	139	881	36113
3-13-77	190	185	190	180	200	195	200	180	175	180	175	190	190	141	191	1231	37344
3-20-77	195	195	190	190	195	195	190	165	150	150	155	154	150	150	193	1074	38418
3-27-77	195	195	180	190	190	190	190	166	163	119	162	171	165	167	190	1113	39531
4- 3-77	190	190	200	190	190	190	190	169	165	164	168	188	132	180	191	1137	40668
4-10-77	190	190	190	190	190	190	190	162	158	150	99	102	165	182	190	1018	41686
4-17-77	190	190	190	190	190	190	190	173	166	161	161	175	183	200	190	1189	42875
4-24-77	190	190	190	190	190	180	195	197	184	183	180	178	172	198	189	1289	44164
5- 1-77	185	185	180	195	185	185	190	184	180	182	190	194	187	198	186	1315	45479
5- 8-77	190	185	190	190	180	180	180	197	193	175	176	181	192	204	185	1318	46797
5-15-77	185	190	185	185	185	175	190	203	203	194	203	205	171	219	188	1398	48195
5-22-77	190	185	190	185	185	175	185	218	215	212	208	206	204	224	185	1484	49679
5-29-77	190	185	190	180	175	180	180	222	188	229	215	188	218	220	183	1480	51159
6- 5-77	180	180	175	175	180	185	185	218	214	216	205	210	206	207	180	1476	52635
6-12-77	180	180	195	190	195	185	185	189	181	189	187	182	197	193	187	1318	53953
6-19-77	185	190	195	190	190	185	185	192	198	180	191	176	173	172	189	1282	55235
6-26-77	185	180	195	200	190	185	195	179	187	196	178	174	187	193	190	1294	56529
7- 3-77	190	195	190	190	190	190	190	193	205	201	195	194	196	195	191	1379	57908
7-10-77	190	190	190	190	165	190	200	196	198	197	179	164	206	209	188	1349	59257
7-17-77	185	185	190	190	190	190	190	194	194	188	193	189	197	193	189	1348	60605
7-24-77	190	170	195	195	185	185	185	194	167	183	208	204	193	195	186	1344	61949
7-31-77	190	190	190	185	180	190	185	201	199	203	191	193	175	162	187	1324	63273
8- 7-77	180	175	188	185	40	45	30	169	181	183	201	130	39	41	120	944	64217
8-14-77	25	20	25	25	25	25	35	35	35	36	38	36	35	39	26	258	64475
8-21-77	30	30	20	30	30	25	20	36	35	27	24	24	25	28	26	196	64671
8-28-77	25	20	20	15	15	10	10	26	25	25	21	18	13	15	16	143	64814

TABLE G22

EL DORADO PROJECT OBSERVATION WELL DATA

Well No.	Surface Casing (8 5/8 in) Depth, feet	Surface Casing (8 5/8 in) Cement, yards	Production Casing* (5 1/2 in) Depth, feet	Production Casing* (5 1/2 in) Cement, No. of Sacks	Location	Completion Date	Top of Sand, ft	Datum,§ feet	Gross Thickness, feet	Total Depth, feet	Perforated Completion Interval, ft
MP-131	27	1	701	175	992' FSL, 2576' FWL Sec. 21-25S-5E	3/22/76	636	761	22	704	644-645
MP-132	29	1	706	175	924' FSL, 2508' FWL Sec. 21-25S-5E	3/26/76	641	752	21	710	645-646
MP-227	29	1	717	175	592' FNL, 2576' FWL Sec. 28-25S-5E	3/19/76	664	737	19	718	668-669 675-676
MP-228	27	1	713	175	660' FNL, 2508' FWL Sec. 28-25S-5E	4/4/76	659	741	19	717	665-666 671-672

*Steel casing run with three joints fiberglass casing on bottom.

§Datum above mean sea level.

TABLE G23

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE MICELLAR FLUID INJECTION DATA FOR THE SOUTH (HEGBERG) PATTERN

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
3-20-77	0	0	0	0	200	205	215	0	0	0	0	403	302	148	207	853	853
3-27-77	204	213	209	197	199	206	204	322	137	284	125	208	180	154	205	1410	2263
4- 3-77	206	215	210	207	218	210	218	243	112	260	133	91	261	119	212	1219	3483
4-10-77	209	214	220	208	203	209	205	118	273	90	96	219	100	90	210	986	4469
4-17-77	203	211	205	205	211	170	170	184	82	67	191	80	86	172	196	863	5332
4-24-77	173	170	193	209	201	210	203	269	274	160	78	56	72	55	194	964	6296
5- 1-77	203	207	201	189	207	202	191	61	51	46	41	43	66	130	200	438	6734
5- 8-77	189	184	209	203	198	206	208	262	286	168	64	51	43	62	200	936	7670
5-15-77	202	206	207	199	212	212	208	53	45	52	57	56	54	49	206	366	8036
5-22-77	198	206	195	194	175	174	164	77	85	48	83	95	103	125	186	616	8651
5-29-77	173	168	190	173	223	251	244	139	136	149	66	37	45	50	203	622	9273
6- 5-77	246	242	243	227	281	283	274	52	46	52	65	50	43	64	257	372	9645
6-12-77	277	273	268	267	257	254	223	94	86	72	58	55	43	71	260	479	10123
6-19-77	235	230	190	165	162	154	214	118	148	145	98	146	193	97	193	945	11068
6-26-77	190	254	261	284	283	269	215	40	56	72	68	58	54	49	251	398	11466
7- 3-77	271	281	281	277	273	246	274	52	64	62	60	43	43	50	272	374	11840
7-10-77	256	258	237	236	209	175	187	43	40	53	103	144	168	153	223	704	12544
7-17-77	187	192	188	191	192	188	246	72	81	79	83	84	87	145	198	631	13175
7-24-77	282	263	258	279	277	287	291	107	60	61	51	53	67	62	277	461	13636
7-31-77	293	293	293	286	289	287	273	59	53	50	49	50	79	56	288	396	14032
8- 7-77	272	271	262	233	232	226	228	41	40	36	62	146	178	179	246	682	14714
8-14-77	227	216	241	294	254	272	241	171	176	151	96	82	48	48	249	772	15486
8-21-77	279	259	276	260	257	260	251	43	41	39	45	44	47	69	263	328	15814
8-28-77	258	260	298	284	281	281	257	60	58	60	60	49	56	67	274	410	16224

TABLE G24
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE MICELLAR FLUID INJECTION DATA FOR WELL MP-201

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
3-20-77	0	0	0	0	203	205	215	0	0	0	0	53	48	31	208	132	132
3-27-77	190	200	210	200	178	190	190	42	29	33	27	22	34	23	194	210	342
4- 3-77	200	215	210	210	220	210	220	35	24	27	28	19	29	25	212	187	529
4-10-77	205	205	220	208	210	200	200	29	75	17	19	41	16	12	207	208	737
4-17-77	200	210	205	205	210	105	105	29	12	12	50	10	17	54	177	185	922
4-24-77	105	95	140	200	210	215	195	53	33	22	16	10	12	9	166	155	1078
5- 1-77	215	215	210	200	200	210	200	10	11	11	9	8	11	36	207	96	1173
5- 8-77	200	195	215	215	200	215	215	47	52	26	13	11	6	11	208	166	1339
5-15-77	210	215	215	215	220	220	215	9	7	10	9	8	10	9	216	62	1401
5-22-77	200	215	200	205	110	105	85	6	10	7	36	29	14	14	160	116	1517
5-29-77	85	70	125	180	180	210	215	13	9	10	5	2	6	8	152	53	1570
6- 5-77	215	195	225	240	220	230	275	9	4	7	17	16	7	11	229	71	1641
6-12-77	230	280	240	210	210	183	125	13	19	11	6	3	1	1	211	54	1696
6-19-77	120	125	100	80	80	75	250	2	1	7	2	2	2	1	119	17	1713
6-26-77	15	250	270	265	265	260	45	1	8	9	8	6	6	2	196	40	1753
7- 3-77	210	250	250	235	225	40	255	2	5	4	4	2	1	4	209	22	1775
7-10-77	245	265	230	100	110	75	80	3	0	3	4	3	2	1	158	16	1791
7-17-77	80	135	130	130	130	125	250	0	5	3	3	3	3	5	140	22	1813
7-24-77	280	265	275	285	285	290	295	18	6	6	3	2	3	2	282	40	1853
7-31-77	300	295	295	290	290	280	300	3	2	2	2	2	14	5	293	30	1883
8- 7-77	300	300	275	250	240	250	245	2	2	2	2	50	37	26	266	121	2004
8-14-77	245	245	238	280	90	150	55	22	26	22	28	16	1	0	186	115	2119
8-21-77	220	195	200	55	50	30	30	1	0	1	3	0	0	0	111	5	2124
8-28-77	30	20	285	215	180	180	195	0	0	2	7	1	1	5	158	16	2139

TABLE G25
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE MICELLAR FLUID INJECTION DATA FOR WELL MP-203

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
3-20-77	0	0	0	0	205	205	215	0	0	0	0	57	34	17	208	108	108
3-27-77	208	220	210	180	208	210	210	38	16	34	14	25	21	18	206	166	274
4- 3-77	208	215	210	210	220	210	220	28	13	31	15	10	31	13	213	141	415
4-10-77	210	218	220	208	160	220	210	14	31	9	9	20	10	8	206	100	515
4-17-77	200	220	210	210	220	200	200	16	8	7	12	8	8	13	209	72	587
4-24-77	210	210	220	220	205	215	220	25	31	17	7	5	6	6	214	97	684
5- 1-77	215	215	215	200	215	213	210	6	5	5	5	5	5	10	212	41	725
5- 8-77	210	205	215	215	200	210	215	18	21	14	5	4	5	7	210	74	799
5-15-77	210	215	215	215	220	220	215	5	5	5	7	7	6	2	216	37	836
5-22-77	205	200	200	210	210	210	205	40	40	10	10	10	4	11	206	125	961
5-29-77	210	210	200	200	265	260	265	17	19	20	11	8	9	8	230	92	1053
6- 5-77	270	270	260	260	295	290	0	8	8	8	7	7	3	0	274	41	1094
6-12-77	0	290	285	295	295	278	255	0	18	17	15	15	11	17	283	93	1187
6-19-77	270	265	85	60	90	110	218	26	36	29	11	12	16	16	157	146	1333
6-26-77	245	270	300	290	285	270	265	11	11	11	10	10	9	9	275	71	1404
7- 3-77	300	295	295	300	300	285	285	9	9	9	9	8	8	8	294	60	1464
7-10-77	265	263	190	270	265	75	75	8	9	5	16	34	24	12	200	108	1572
7-17-77	80	80	80	75	75	55	253	12	13	12	13	12	11	21	100	94	1666
7-24-77	285	270	290	290	285	290	295	15	8	9	8	8	8	9	286	65	1731
7-31-77	300	300	295	255	295	300	295	8	8	8	8	8	10	10	291	60	1791
8- 7-77	290	290	280	250	255	240	250	8	8	8	15	19	22	25	265	105	1896
8-14-77	250	245	248	300	295	295	300	26	27	22	11	11	9	7	276	113	2009
8-21-77	290	290	280	290	285	295	300	8	7	7	7	7	7	8	290	51	2060
8-28-77	290	295	295	295	300	300	298	7	7	7	6	6	5	6	296	44	2104

TABLE G26
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE MICELLAR FLUID INJECTION DATA FOR WELL MP-205

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary		Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S	Pressure, psig	Injection, bbl	
3-20-77	0	0	0	0	198	205	215	0	0	0	0	19	13	4	206	36	36
3-27-77	208	220	210	195	208	210	210	16	4	16	4	12	6	7	209	65	101
4- 3-77	208	215	210	205	220	210	220	12	3	15	4	3	15	4	213	56	157
4-10-77	220	218	220	208	200	200	200	1	2	3	2	2	4	26	209	39	196
4-17-77	200	200	200	200	200	140	140	32	10	9	25	6	7	16	183	104	300
4-24-77	140	150	200	190	195	205	210	27	32	15	5	4	4	4	184	91	391
5- 1-77	200	205	200	185	205	200	200	4	4	4	3	3	3	7	199	28	419
5- 8-77	200	195	195	190	195	205	205	19	22	13	3	2	2	3	198	64	483
5-15-77	200	200	205	190	205	205	205	3	2	3	7	2	1	3	201	21	504
5-22-77	200	205	200	195	190	195	190	2	3	2	2	5	13	15	196	42	545
5-29-77	210	185	195	190	250	245	255	17	18	19	4	5	6	5	219	74	619
6- 5-77	260	250	245	245	280	285	285	5	4	4	3	5	7	7	264	35	654
6-12-77	285	275	275	290	290	273	250	9	7	5	4	5	3	5	277	38	692
6-19-77	265	260	125	90	120	155	153	15	17	13	4	4	6	3	167	62	754
6-26-77	210	260	295	285	285	270	260	3	2	4	2	2	2	2	266	17	771
7- 3-77	295	295	290	290	290	280	280	3	3	3	3	3	2	2	289	19	790
7-10-77	255	258	255	265	260	245	260	2	3	2	3	11	23	64	257	108	898
7-17-77	260	260	260	260	260	260	250	10	10	10	9	9	9	20	259	77	975
7-24-77	290	270	285	285	285	290	295	14	9	10	9	8	8	8	286	66	1041
7-31-77	285	295	295	290	290	295	290	8	8	8	7	7	6	7	291	51	1092
8- 7-77	285	285	275	250	255	245	250	6	6	5	16	21	23	27	264	104	1196
8-14-77	250	145	243	300	295	295	300	31	23	15	5	5	5	5	261	89	1285
8-21-77	290	290	280	285	285	295	300	5	5	4	3	4	4	4	289	29	1314
8-28-77	290	295	300	295	295	295	295	4	4	4	3	3	3	2	295	22	1336

TABLE G27

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE MICELLAR FLUID INJECTION DATA FOR WELL MP-211

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
3-20-77	0	0	0	0	198	205	215	0	0	0	0	70	68	49	206	187	187
3-27-77	190	200	210	195	160	190	190	59	45	44	41	29	52	34	191	304	491
4- 3-77	203	215	210	200	220	210	220	49	37	34	43	30	35	31	211	259	750
4-10-77	205	203	220	208	210	160	183	40	117	25	36	109	27	15	198	368	1118
4-17-77	183	165	183	183	165	85	85	62	13	9	20	10	14	23	150	151	1269
4-24-77	85	70	90	175	180	190	125	29	30	23	21	14	26	13	131	156	1425
5- 1-77	145	155	150	145	165	158	70	5	7	7	6	8	26	25	141	84	1509
5- 8-77	55	50	190	150	150	165	170	29	30	19	18	10	9	17	133	132	1641
5-15-77	160	160	160	160	175	175	170	13	9	10	11	11	13	12	166	79	1720
5-22-77	165	165	165	105	45	25	5	8	9	8	15	15	10	11	96	76	1795
5-29-77	5	25	200	100	10	0	150	9	8	8	3	1	0	5	82	34	1829
6- 5-77	145	160	170	5	290	290	180	6	6	9	13	1	3	5	177	43	1872
6-12-77	230	180	180	165	75	155	125	32	7	5	2	1	6	4	159	57	1928
6-19-77	130	125	105	75	115	140	275	3	3	1	1	1	4	1	138	14	1942
6-26-77	75	0	10	0	0	0	55	1	0	0	0	0	1	1	47	4	1946
7- 3-77	160	215	220	180	180	190	210	1	6	8	5	1	1	5	194	27	1973
7-10-77	205	205	165	145	125	90	130	3	1	5	3	2	14	2	152	30	2003
7-17-77	120	120	120	120	135	130	208	2	2	1	1	1	2	7	136	16	2019
7-24-77	240	205	40	210	205	260	265	9	6	5	3	8	22	17	204	70	2089
7-31-77	275	275	275	270	270	295	260	13	9	8	7	9	7	3	274	56	2145
8- 7-77	260	265	265	240	255	245	245	2	1	1	1	6	27	28	254	66	2211
8-14-77	245	245	230	300	180	0	40	25	26	25	9	7	0	1	207	93	2304
8-21-77	0	135	0	0	0	0	140	0	1	0	0	0	0	10	138	11	2315
8-28-77	0	0	0	0	0	0	213	0	0	0	0	0	0	4	213	4	2319

TABLE G28
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE MICELLAR FLUID INJECTION DATA FOR TWIN WELLS MP-213/226

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
3-20-77	0	0	0	0	200	205	215	0	0	0	0	61	31	16	207	108	108
3-27-77	208	200	200	195	208	210	210	35	14	31	13	22	19	16	204	150	258
4- 3-77	208	215	210	210	220	210	220	26	12	29	14	10	29	13	213	133	391
4-10-77	210	218	220	208	210	220	210	11	15	11	10	15	12	9	214	83	474
4-17-77	210	220	210	210	220	200	200	14	11	9	11	11	9	10	210	74	548
4-24-77	185	185	220	220	205	215	220	22	29	19	8	7	8	7	207	99	648
5- 1-77	210	215	210	195	215	207	210	7	7	7	6	6	7	8	209	48	695
5- 8-77	210	205	215	210	210	210	215	17	20	17	5	5	5	6	211	75	770
5-15-77	210	215	215	195	220	220	215	6	5	6	5	5	5	5	213	37	807
5-22-77	200	215	200	205	200	210	200	5	5	5	5	8	14	17	204	59	867
5-29-77	210	205	200	100	260	255	260	20	21	24	10	5	6	6	213	92	959
6- 5-77	265	260	260	260	290	290	290	6	6	6	6	6	6	6	274	42	1001
6-12-77	290	285	285	290	290	270	255	6	5	6	5	6	4	5	281	37	1038
6-19-77	270	265	265	245	265	260	245	12	14	17	20	22	24	17	259	126	1164
6-26-77	285	295	300	290	290	275	270	4	4	4	5	4	4	4	286	29	1193
7- 3-77	300	300	300	300	300	290	295	4	4	4	5	4	4	4	298	29	1222
7-10-77	275	270	265	275	270	260	265	4	4	2	2	7	8	11	269	38	1260
7-17-77	270	270	250	270	270	270	255	12	14	15	17	18	19	17	265	112	1372
7-24-77	295	280	295	295	295	300	300	4	2	3	3	3	3	3	294	21	1393
7-31-77	300	300	300	300	300	300	300	3	3	3	3	3	3	3	300	21	1414
8- 7-77	295	295	283	250	255	245	250	2	2	2	1	1	2	6	268	16	1430
8-14-77	250	250	250	300	295	295	300	6	7	7	5	2	1	2	277	30	1460
8-21-77	295	290	295	290	290	295	300	1	2	1	2	2	2	2	294	12	1472
8-28-77	290	295	300	295	300	300	298	2	2	2	2	2	2	2	297	14	1485

TABLE G29
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE MICELLAR FLUID INJECTION DATA FOR WELL MP-215

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
3-20-77	0	0	0	0	198	205	215	0	0	0	0	45	30	11	206	86	86
3-27-77	208	220	210	200	208	210	200	37	10	34	9	26	16	16	208	148	234
4- 3-77	208	215	210	205	220	210	220	26	8	33	10	7	31	9	213	124	358
4-10-77	210	218	220	208	210	220	210	7	11	6	6	14	6	5	214	55	413
4-17-77	210	220	210	210	220	200	200	9	6	5	7	6	7	14	210	53	465
4-24-77	205	200	220	220	200	0	0	29	26	13	5	2	0	0	209	75	540
5- 1-77	205	210	205	190	215	208	205	16	4	4	4	5	7	21	205	61	602
5- 8-77	205	200	210	210	205	210	210	41	44	27	7	6	5	6	207	136	738
5-15-77	205	210	210	190	210	210	210	5	5	5	5	5	5	5	206	35	773
5-22-77	200	210	200	200	195	205	195	4	5	4	4	10	14	16	201	57	830
5-29-77	210	200	198	195	255	255	260	17	16	17	7	3	4	4	225	68	898
6- 5-77	265	255	250	255	285	290	290	4	4	4	4	4	5	5	270	30	928
6-12-77	300	300	300	290	290	273	245	4	4	4	4	4	3	4	285	27	955
6-19-77	265	255	255	235	265	115	198	10	12	11	10	3	97	18	227	161	1116
6-26-77	210	240	295	285	285	270	260	7	8	15	18	15	13	13	264	89	1205
7- 3-77	295	295	290	295	290	280	285	15	17	15	14	12	11	10	290	94	1299
7-10-77	265	260	255	265	65	45	50	8	9	26	56	24	8	8	172	139	1438
7-17-77	50	45	45	40	35	35	250	8	8	8	8	8	8	13	71	61	1499
7-24-77	285	270	290	285	285	290	290	11	7	7	6	6	6	6	285	49	1548
7-31-77	295	295	295	290	290	295	205	6	6	5	5	5	17	9	281	53	1601
8- 7-77	205	200	205	215	185	180	175	6	6	5	6	13	25	25	195	86	1687
8-14-77	175	175	238	290	250	260	270	23	25	21	19	20	13	13	237	134	1821
8-21-77	265	265	285	290	275	280	285	11	11	12	14	16	16	18	278	98	1919
8-28-77	280	285	300	280	270	270	215	18	17	18	19	19	20	22	271	133	2052

TABLE G30

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE MICELLAR FLUID INJECTION DATA FOR WELL MP-221

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary		Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S	Pressure, psig	Injection, bbl	
3-20-77	0	0	0	0	200	205	215	0	0	0	0	39	40	9	207	88	88
3-27-77	208	220	210	205	208	210	210	50	8	49	7	39	15	21	210	189	277
4- 3-77	208	215	210	210	220	210	200	35	6	49	8	5	48	7	210	158	435
4-10-77	210	218	220	208	210	220	210	4	5	6	4	5	8	3	214	34	469
4-17-77	210	220	210	210	220	200	200	3	6	4	41	8	9	17	210	87	556
4-24-77	210	210	210	220	210	215	215	33	37	18	6	5	6	6	213	111	666
5- 1-77	215	215	210	200	220	213	210	5	5	4	4	4	4	4	212	30	696
5- 8-77	210	205	215	215	210	215	215	15	14	11	2	2	2	3	212	49	745
5-15-77	210	215	215	215	220	220	215	3	3	4	4	3	4	4	216	25	770
5-22-77	215	215	215	205	190	210	200	3	4	3	3	7	13	15	207	48	818
5-29-77	210	205	200	200	265	265	265	15	15	16	6	3	4	4	230	63	881
6- 5-77	265	265	265	260	290	290	290	4	4	4	6	2	1	19	275	40	921
6-12-77	295	285	285	290	290	270	255	20	17	15	13	12	8	27	281	112	1033
6-19-77	265	260	260	250	250	250	275	39	44	44	6	6	6	10	259	155	1188
6-26-77	205	240	290	285	285	270	265	5	8	11	10	9	8	7	263	58	1246
7- 3-77	295	295	295	300	295	285	290	7	7	7	7	6	6	6	294	46	1292
7-10-77	265	263	260	270	265	290	290	5	5	4	9	50	41	15	272	129	1421
7-17-77	290	290	290	290	290	290	253	6	6	6	6	6	6	22	285	58	1479
7-24-77	290	275	275	290	285	290	295	14	9	9	7	7	6	6	286	58	1537
7-31-77	300	295	295	295	295	295	285	6	5	5	6	5	5	5	294	37	1574
8- 7-77	285	280	270	250	250	240	250	4	4	4	4	13	15	14	261	58	1632
8-14-77	245	245	243	295	295	290	300	12	12	11	3	2	2	2	273	44	1676
8-21-77	250	290	285	290	290	295	300	2	2	2	4	2	2	2	291	16	1692
8-28-77	295	300	300	295	300	300	298	2	2	2	2	2	2	2	298	14	1706

TABLE G31
RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE MICELLAR FLUID INJECTION DATA FOR WELL MP-223

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary Pressure, psig	Weekly Summary Injection, bbl	Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S			
3-20-77	0	0	0	0	198	205	215	0	0	0	0	31	15	4	206	50	50
3-27-77	208	220	210	200	208	210	210	16	4	16	4	12	6	7	209	65	115
4- 3-77	208	215	210	204	200	210	220	12	3	15	4	3	17	10	210	63	178
4-10-77	210	215	220	208	210	220	210	8	9	9	7	9	10	6	213	57	236
4-17-77	210	220	210	210	220	200	200	16	10	8	9	10	7	8	210	67	303
4-24-77	205	200	220	220	200	210	215	16	17	14	5	4	4	4	210	65	368
5- 1-77	215	215	0	0	0	0	205	4	3	0	0	0	0	16	212	23	391
5- 8-77	205	200	210	210	205	210	210	65	68	30	9	7	6	6	207	191	582
5-15-77	205	210	210	210	215	215	210	6	6	6	6	12	7	6	211	49	631
5-22-77	200	210	200	200	195	200	195	6	6	6	6	9	11	14	200	58	689
5-29-77	210	200	198	195	260	255	260	17	16	19	13	8	7	7	225	87	776
6- 5-77	265	260	255	260	290	290	290	7	7	7	6	6	7	7	273	47	823
6-12-77	290	280	280	290	290	273	250	6	6	6	6	6	5	6	279	41	864
6-19-77	265	260	260	240	260	255	245	9	11	12	14	17	20	17	255	100	964
6-26-77	275	285	295	290	285	275	260	8	7	6	6	5	5	5	281	42	1006
7- 3-77	295	295	295	300	290	280	285	5	6	5	6	5	5	5	291	37	1043
7-10-77	265	263	260	270	260	250	260	5	4	4	6	8	9	11	261	47	1090
7-17-77	260	260	250	260	260	260	250	11	13	14	16	17	19	17	257	107	1197
7-24-77	285	265	290	290	285	290	295	7	4	3	4	4	4	3	286	29	1226
7-31-77	295	295	295	290	290	290	285	4	4	4	4	4	4	4	291	28	1254
8- 7-77	280	280	268	250	250	245	250	3	3	3	3	3	6	7	260	28	1282
8-14-77	245	245	243	295	295	295	300	7	8	8	5	3	3	3	274	37	1319
8-21-77	290	290	280	290	290	295	300	3	3	3	3	3	3	3	291	21	1340
8-28-77	295	295	300	300	300	300	298	3	3	3	3	3	3	2	298	20	1360

TABLE G32

RATE, PRESSURE, WEEKLY SUMMARY, AND CUMULATIVE MICELLAR FLUID INJECTION DATA FOR WELL MP-225

Sunday's Date	Wellhead Pressure, psig							Injection Rate, bbl/day							Weekly Summary		Cumulative Injection, bbl
	S	M	T	W	T	F	S	S	M	T	W	T	F	S	Pressure, psig	Injection, bbl	
3-20-77	0	0	0	0	200	205	215	0	0	0	0	28	23	7	207	58	58
3-27-77	208	220	210	205	208	210	210	29	7	27	6	21	11	12	210	113	171
4- 3-77	208	215	210	210	220	210	220	20	6	27	7	4	26	8	213	98	269
4-10-77	210	218	220	208	210	220	210	5	8	6	5	7	7	4	214	41	310
4-17-77	200	220	210	210	220	200	200	5	7	5	16	11	9	17	209	70	380
4-24-77	210	210	220	220	205	215	220	35	39	19	6	5	5	5	214	115	495
5- 1-77	210	215	210	200	220	213	210	5	5	4	4	4	3	3	211	27	523
5- 8-77	210	205	215	215	205	215	215	11	15	11	2	4	3	3	211	49	572
5-15-77	210	215	215	200	220	220	215	3	3	3	3	3	3	3	214	21	593
5-22-77	200	215	200	205	200	210	200	3	3	3	2	2	10	12	204	35	628
5-29-77	210	210	200	200	260	260	265	14	14	16	7	2	3	3	229	59	687
6- 5-77	265	260	260	260	290	295	295	3	3	3	3	3	4	4	275	23	710
6-12-77	295	285	285	285	285	268	245	4	3	3	3	3	2	2	278	20	730
6-19-77	265	255	255	210	10	25	150	2	10	11	30	79	18	14	167	164	894
6-26-77	0	195	290	285	280	265	255	0	8	12	9	7	6	6	262	48	942
7- 3-77	290	290	290	295	290	280	280	6	7	7	7	2	5	6	288	40	982
7-10-77	260	258	255	265	260	245	270	5	5	2	4	5	39	29	259	89	1071
7-17-77	270	270	270	270	270	270	250	11	10	10	10	10	10	23	267	84	1155
7-24-77	285	270	285	285	280	285	290	15	9	9	8	7	7	8	283	63	1218
7-31-77	290	290	290	290	285	235	240	8	8	7	7	7	13	10	274	60	1278
8- 7-77	245	245	243	145	145	145	140	8	8	6	14	20	21	21	187	98	1376
8-14-77	135	145	235	290	295	295	300	19	22	20	11	16	14	15	242	117	1493
8-21-77	290	290	300	290	290	295	300	12	10	9	9	10	13	22	294	85	1578
8-28-77	290	295	300	295	300	300	208	24	23	22	18	13	22	22	284	144	1722

TABLE G33

EL DORADO DEMONSTRATION PROJECT

MONTHLY PRODUCTION DATA

Well Number	June, 1976 Oil, bbl	June, 1976 Water, bbl	July, 1976 Oil, bbl	July, 1976 Water, bbl	August, 1976 Oil, bbl	August, 1976 Water, bbl	September, 1976 Oil, bbl	September, 1976 Water, bbl	October, 1976 Oil, bbl	October, 1976 Water, bbl	November, 1976 Oil, bbl	November, 1976 Water, bbl	December, 1976 Oil, bbl	December, 1976 Water, bbl
MP-112	12	8996	0	7972	25	9800	21	11198	13	6270	31	9849	0	8910
MP-114	89	4070	79	4359	171	3750	257	4673	69	3199	158	2933	130	3381
MP-122	63	6640	90	6538	76	6723	111	7209	41	6953	94	5757	65	6214
MP-124	13	10710	0	11023	26	13162	22	11963	14	12541	32	10574	0	10738
MP-207	63	2142	39	1687	147	3253	66	2083	54	1877	97	1485	65	1142
MP-209	51	7497	0	7192	25	8148	23	7125	14	7379	63	5431	0	6123
MP-217	13	6426	10	6538	25	7578	44	7709	14	7593	32	5757	21	6123
MP-219	50	3641	50	3923	102	7065	67	3792	55	3583	158	1738	66	3381

TABLE G33

EL DORADO DEMONSTRATION PROJECT

MONTHLY PRODUCTION DATA

(continued)

Well Number	January, 1977 Oil, bbl	Water, bbl	February, 1977 Oil, bbl	Water, bbl	March, 1977 Oil, bbl	Water, bbl	April, 1977 Oil, bbl	Water, bbl	May, 1977 Oil, bbl	Water, bbl	June, 1977 Oil, bbl	Water, bbl	July, 1977 Oil, bbl	Water, bbl	August, 1977 Oil, bbl	Water, bbl
MP-112	0	7865	0	8204	0	7068	0	8310	0	11129	0	6270	0	11997	0	10912
MP-114	85	2984	72	2408	56	2759	143	3540	110	3999	57	2640	91	4216	68	3100
MP-122	43	5485	55	5292	45	5983	102	7020	74	7564	95	6480	91	9083	68	8184
MP-124	0	9478	0	8232	0	5301	20	13200	18	13206	0	11130	0	13144	0	11167
MP-207	43	1008	37	952	11	4526	62	930	55	1426	19	3360	55	1829	51	1178
MP-209	0	5404	18	5264	11	3999	20	4920	37	4650	0	4830	0	2883	51	2542
MP-217	14	5404	18	5572	12	4402	21	4020	18	4774	58	4230	0	2914	17	2542
MP-219	43	2984	37	3052	34	2666	41	2640	93	4774	153	3360	55	2263	35	1736

FIGURE G-1

INJECTION RATE AND CUMULATIVE PREFLUSH VOLUME INJECTED VERSUS TIME FOR THE SOUTH PATTERN

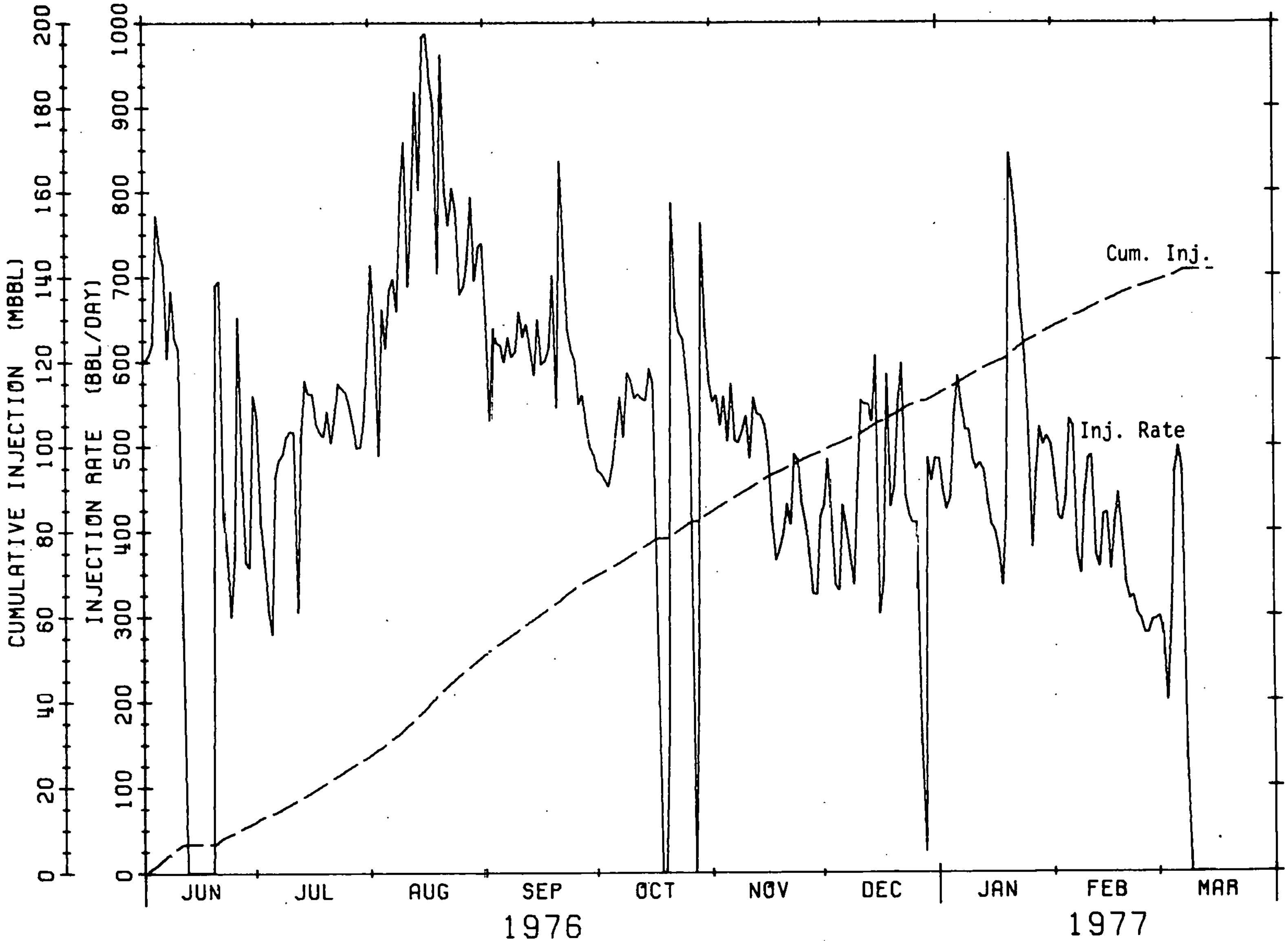


FIGURE G-2

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLUSH VOLUME INJECTED VERSUS TIME FOR WELL MP-201

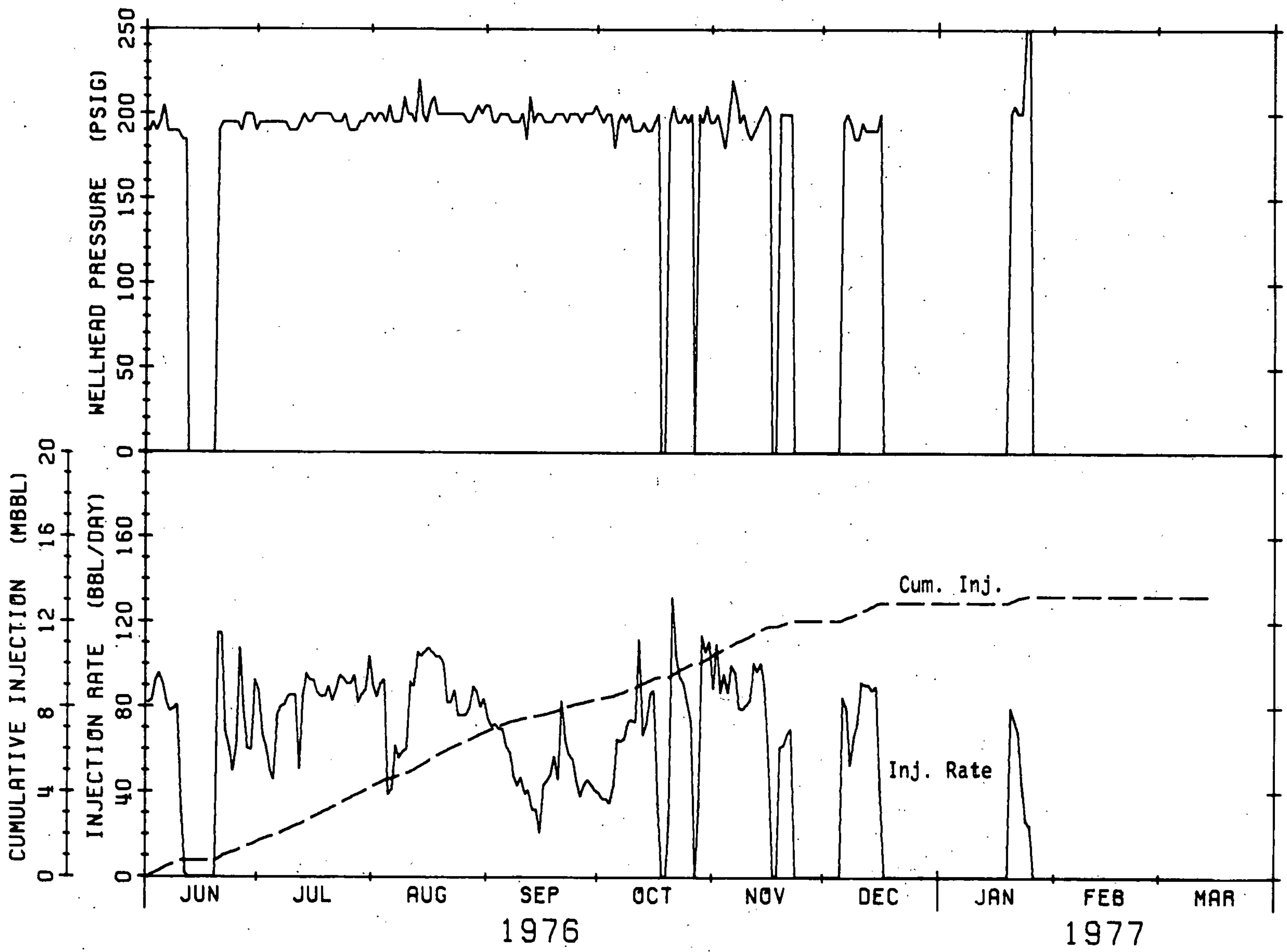


FIGURE G-3

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLUSH VOLUME INJECTED VERSUS TIME FOR WELL MP-203

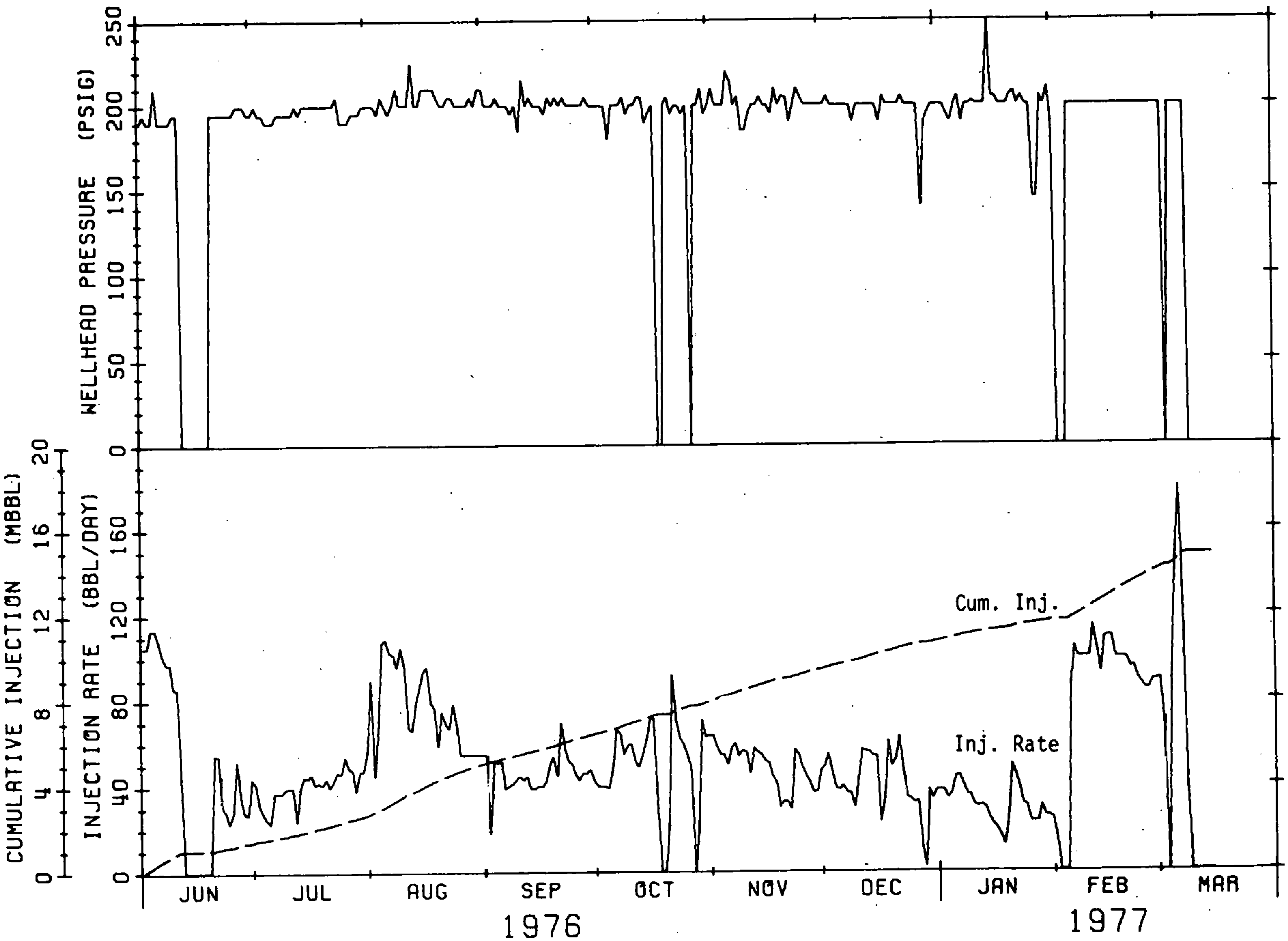


FIGURE G-4

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLUSH VOLUME INJECTED VERSUS TIME FOR WELL MP-205

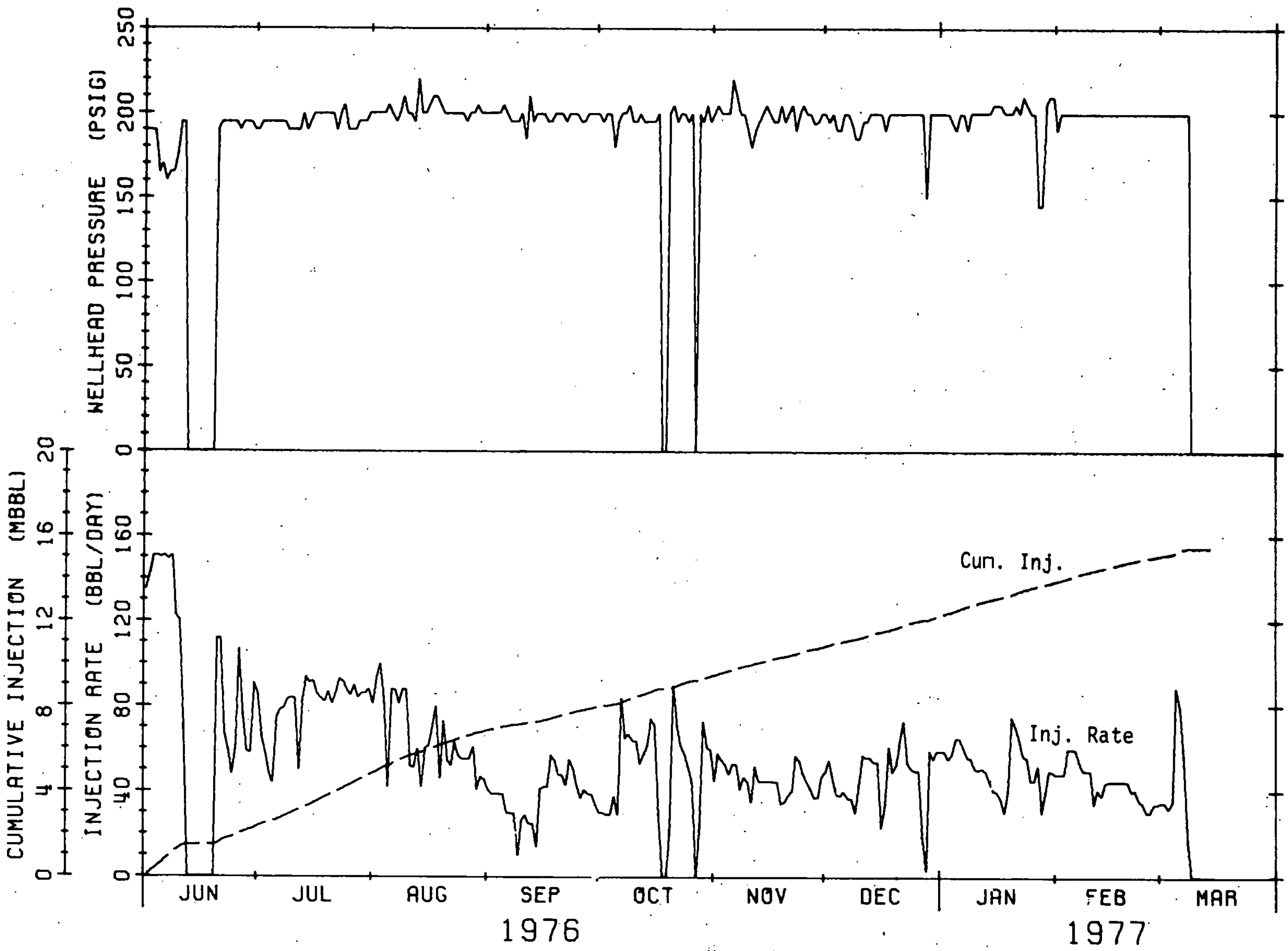


FIGURE G-5

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLUSH VOLUME INJECTED VERSUS TIME FOR WELL MP-211

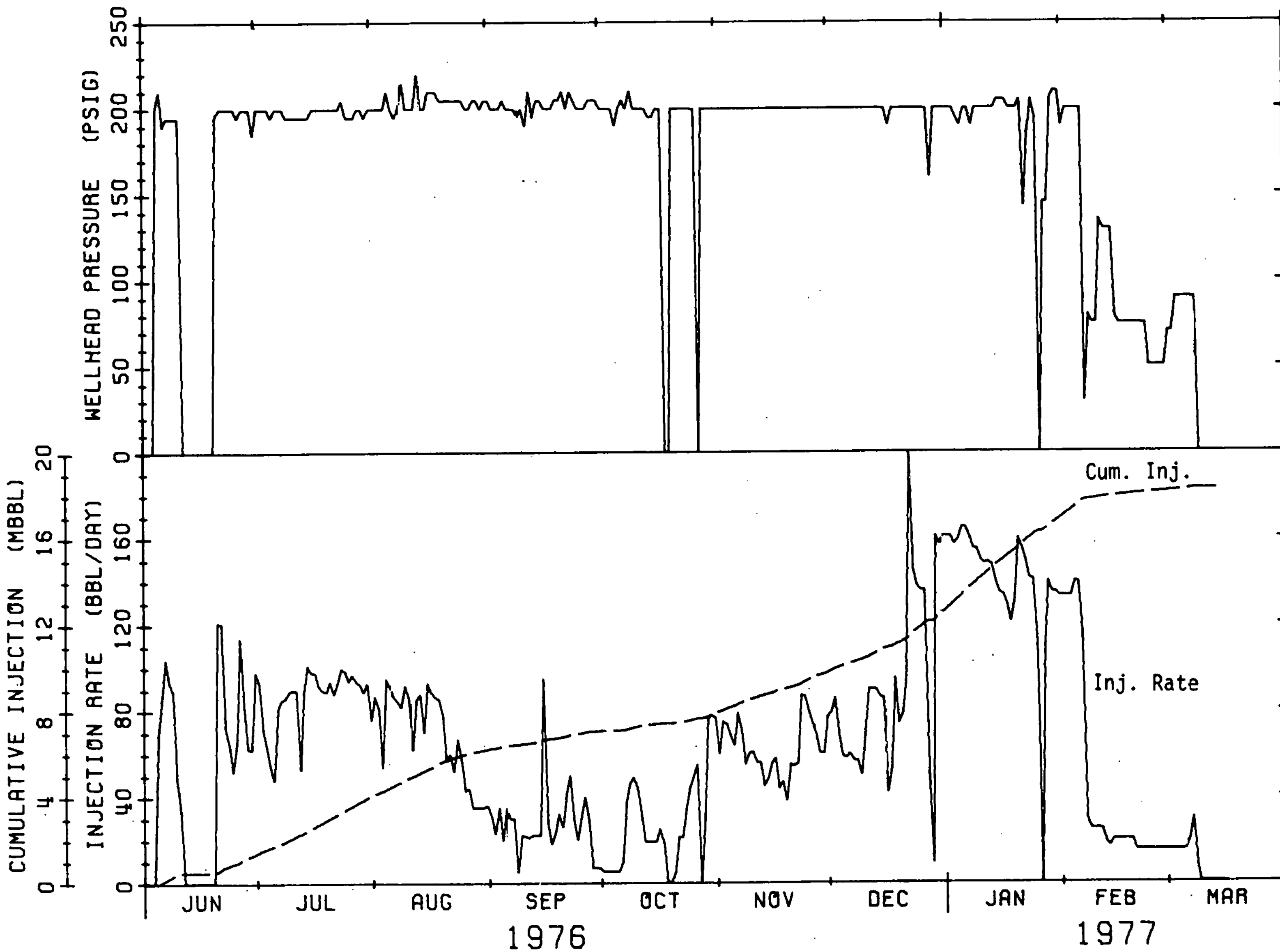


FIGURE G-6

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLUSH VOLUME INJECTED VERSUS TIME FOR TWIN WELLS MP-213/226

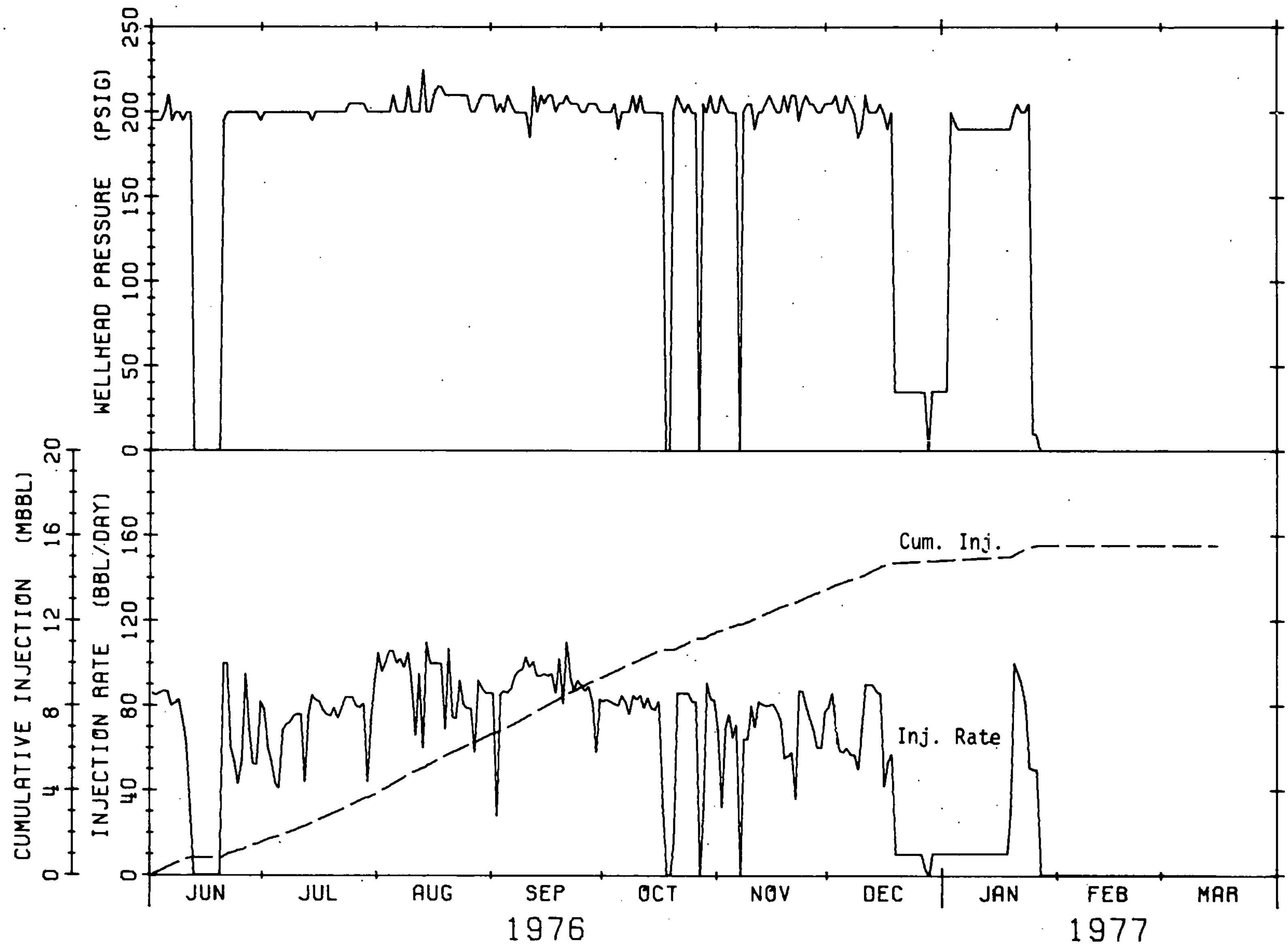


FIGURE G-7

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLUSH VOLUME INJECTED VERSUS TIME FOR WELL MP-215

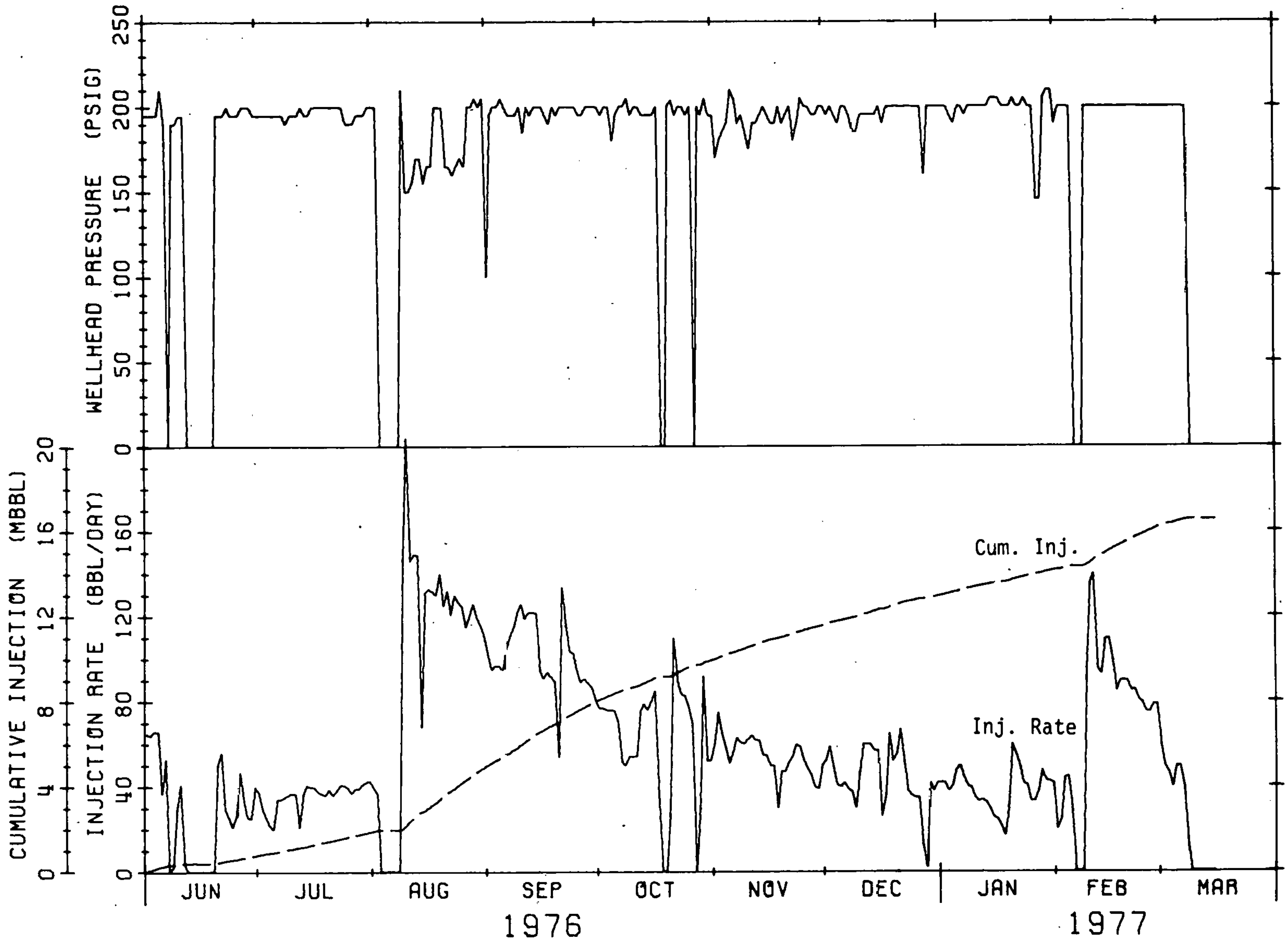


FIGURE G-8

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLUSH VOLUME INJECTED VERSUS TIME FOR WELL MP-221

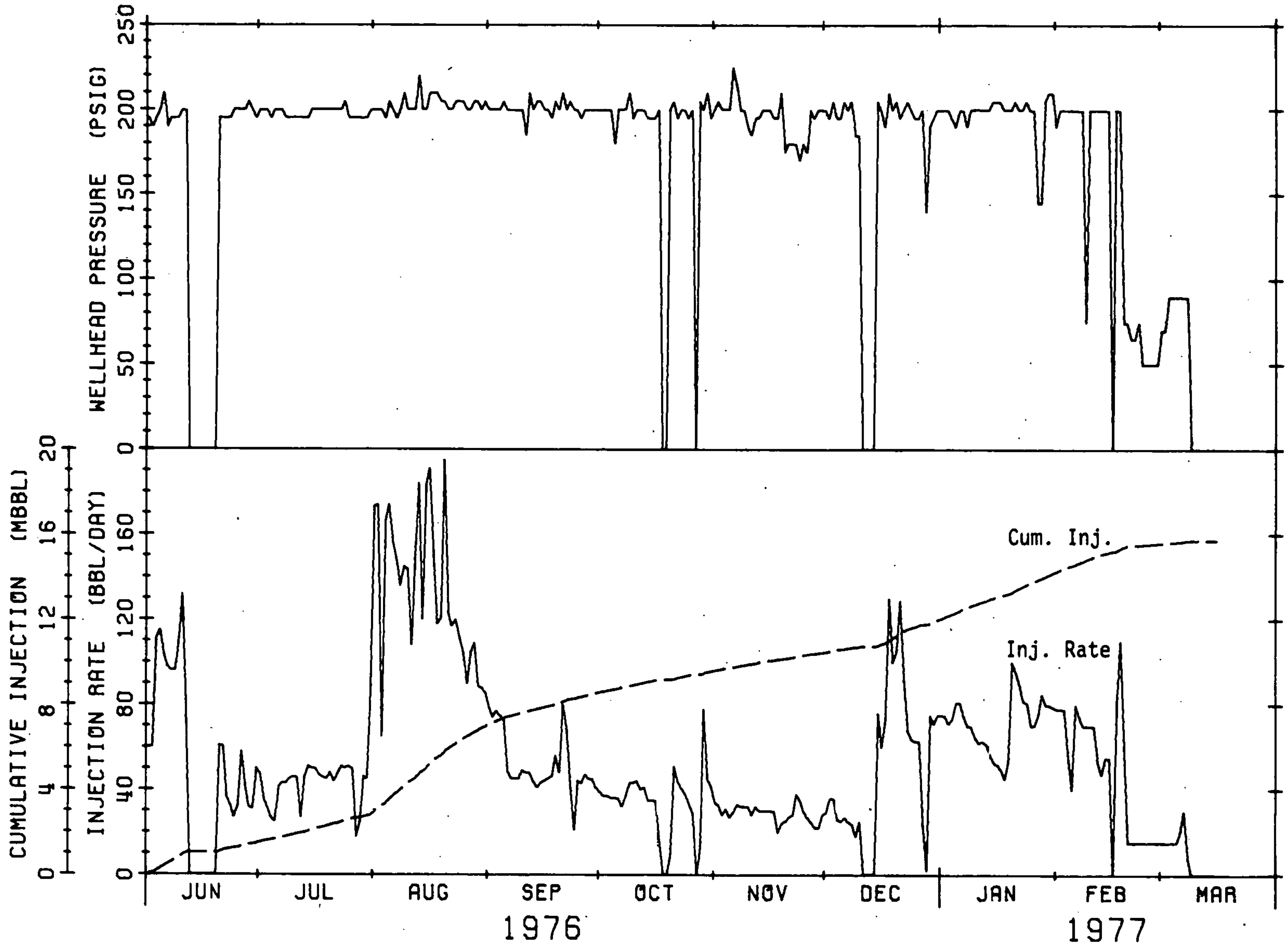


FIGURE G-9

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLUSH VOLUME INJECTED VERSUS TIME FOR WELL MP-223

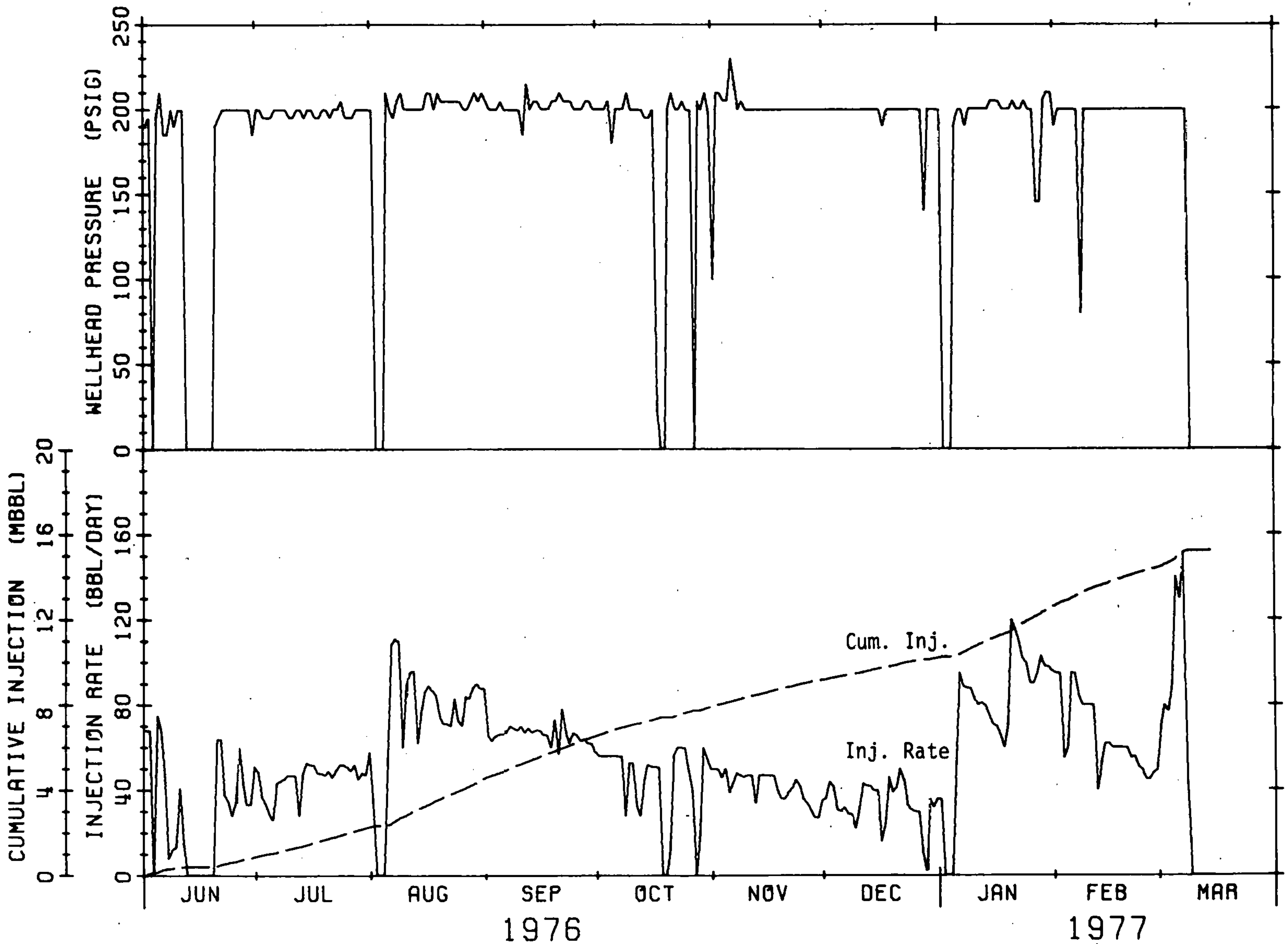


FIGURE G-10

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLUSH VOLUME INJECTED VERSUS TIME FOR WELL MP-225

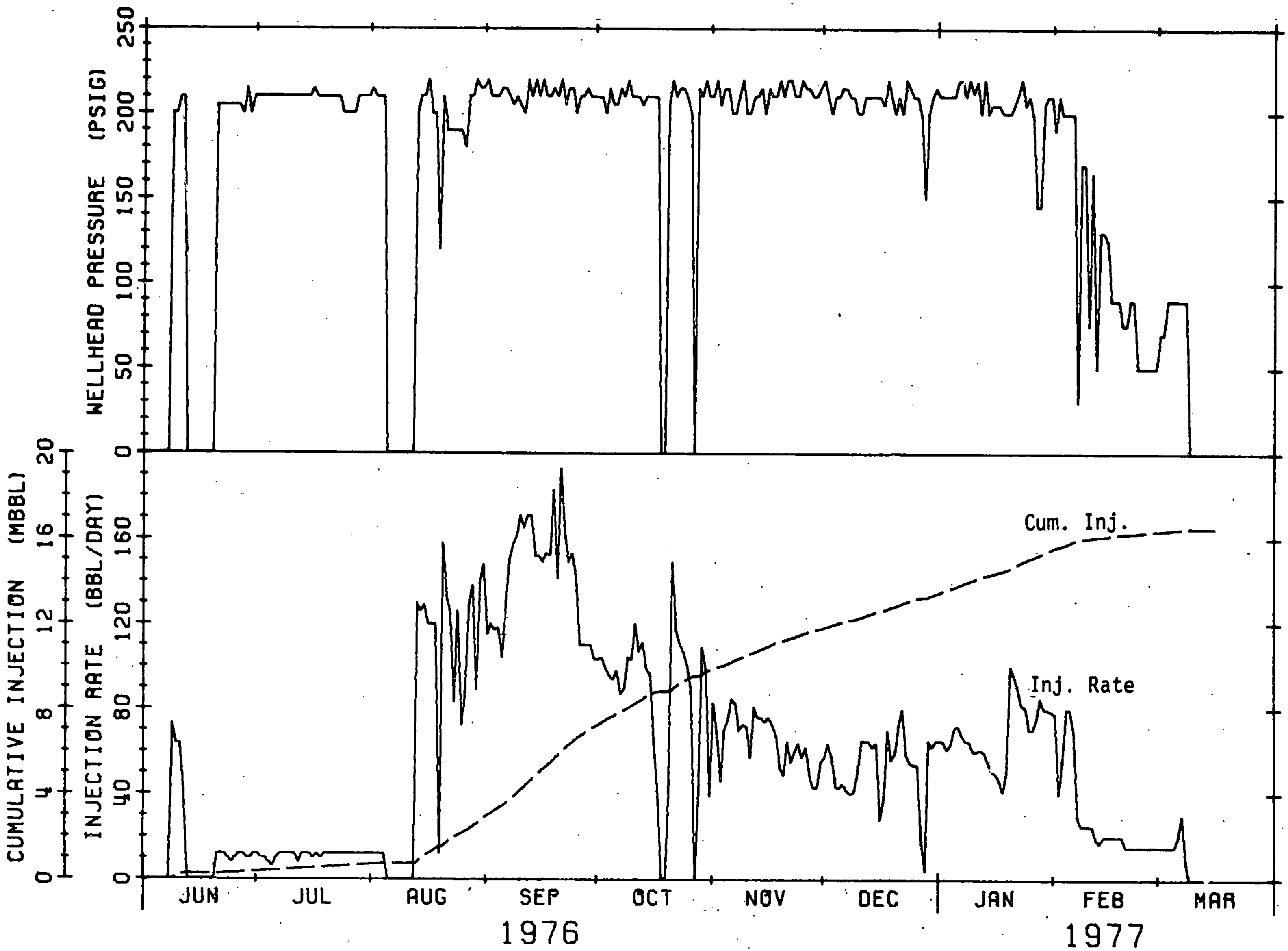


FIGURE G-11

INJECTION RATE AND CUMULATIVE PREFLOOD VOLUME INJECTED VERSUS TIME FOR THE NORTH PATTERN

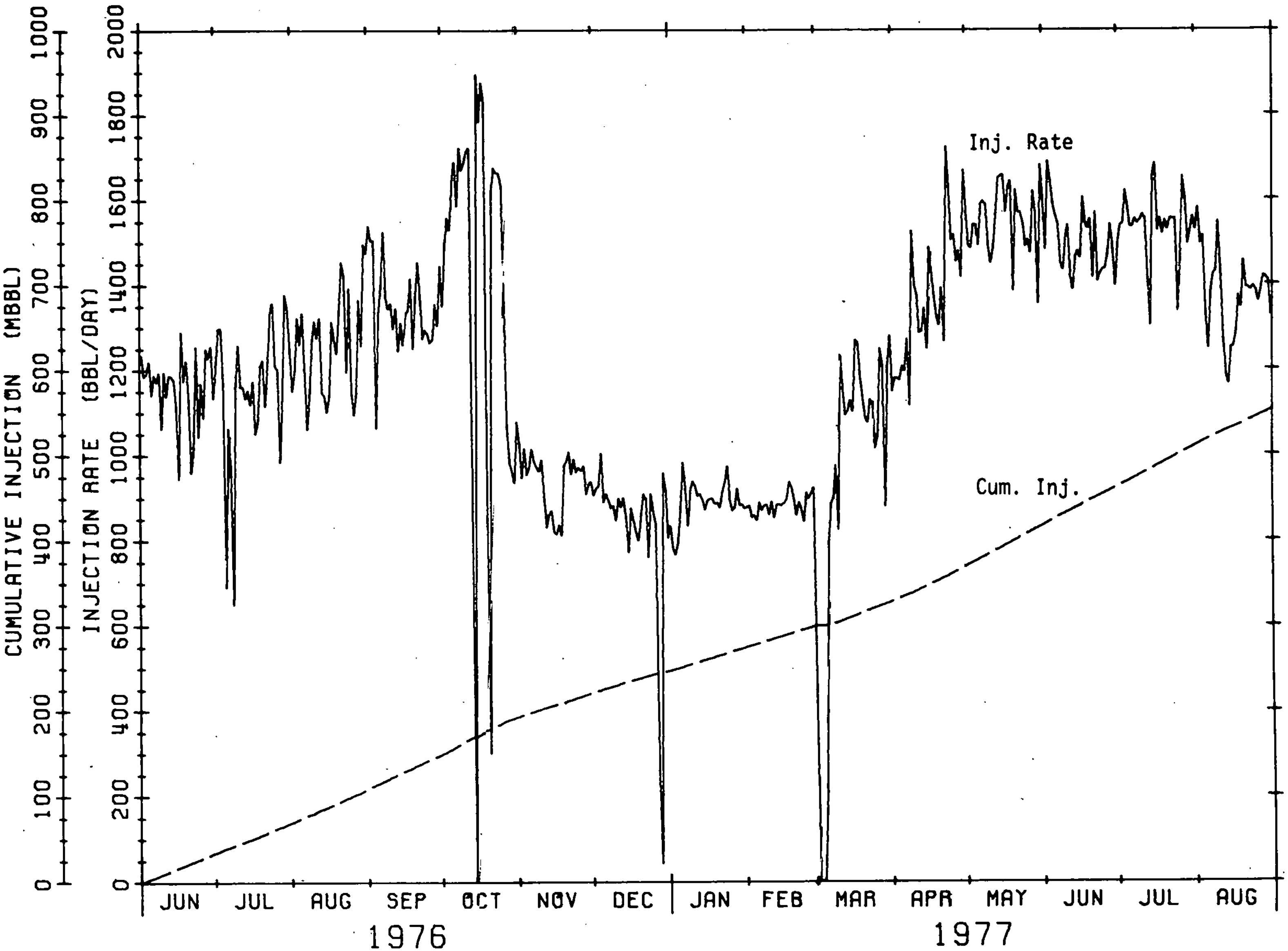


FIGURE G-12

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLOOD VOLUME INJECTED VERSUS TIME FOR WELL MP-106

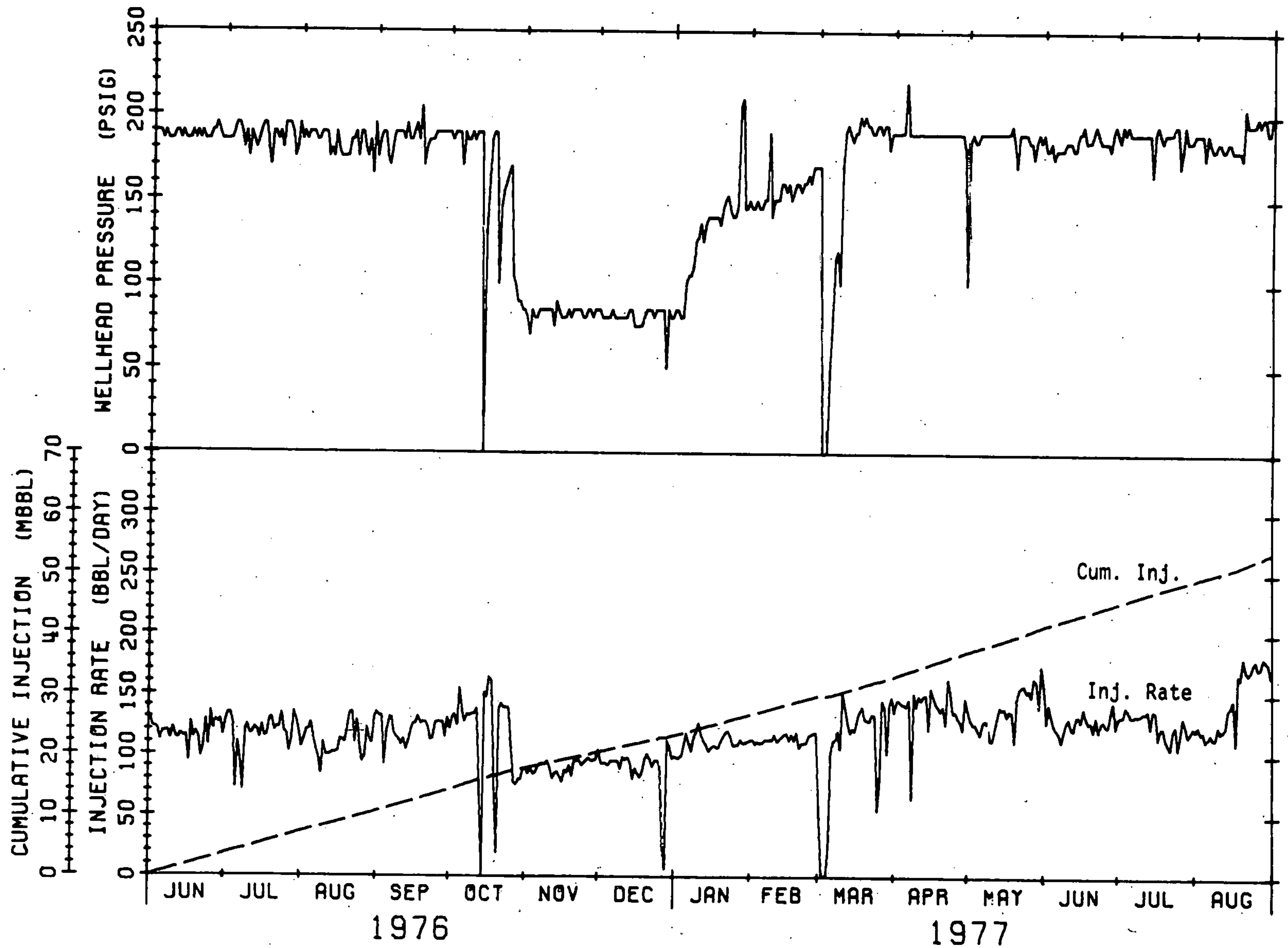


FIGURE G-13

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLOOD VOLUME INJECTED VERSUS TIME FOR WELL MP-108

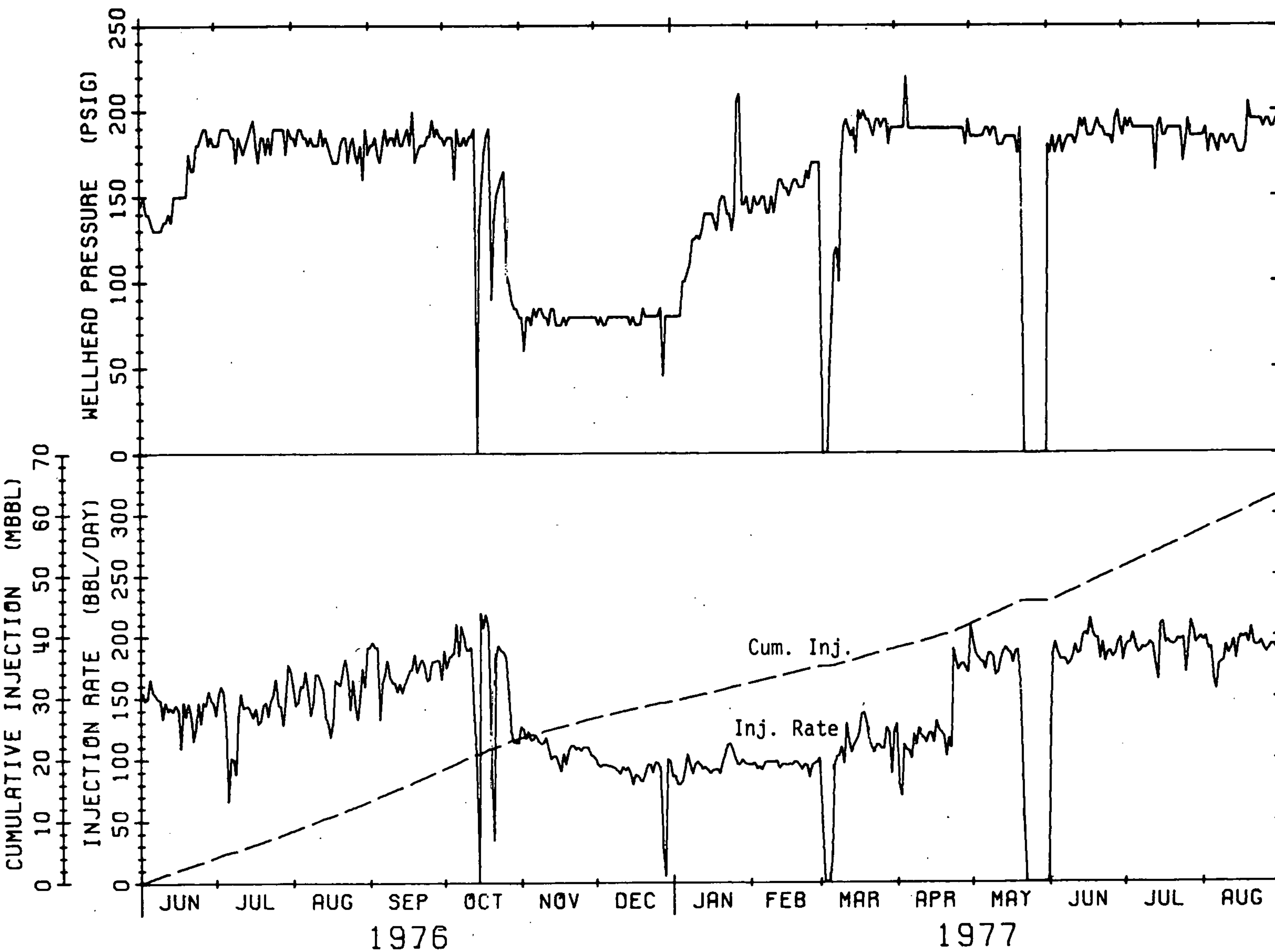


FIGURE G-14

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLOOD VOLUME INJECTED VERSUS TIME FOR WELL MP-110

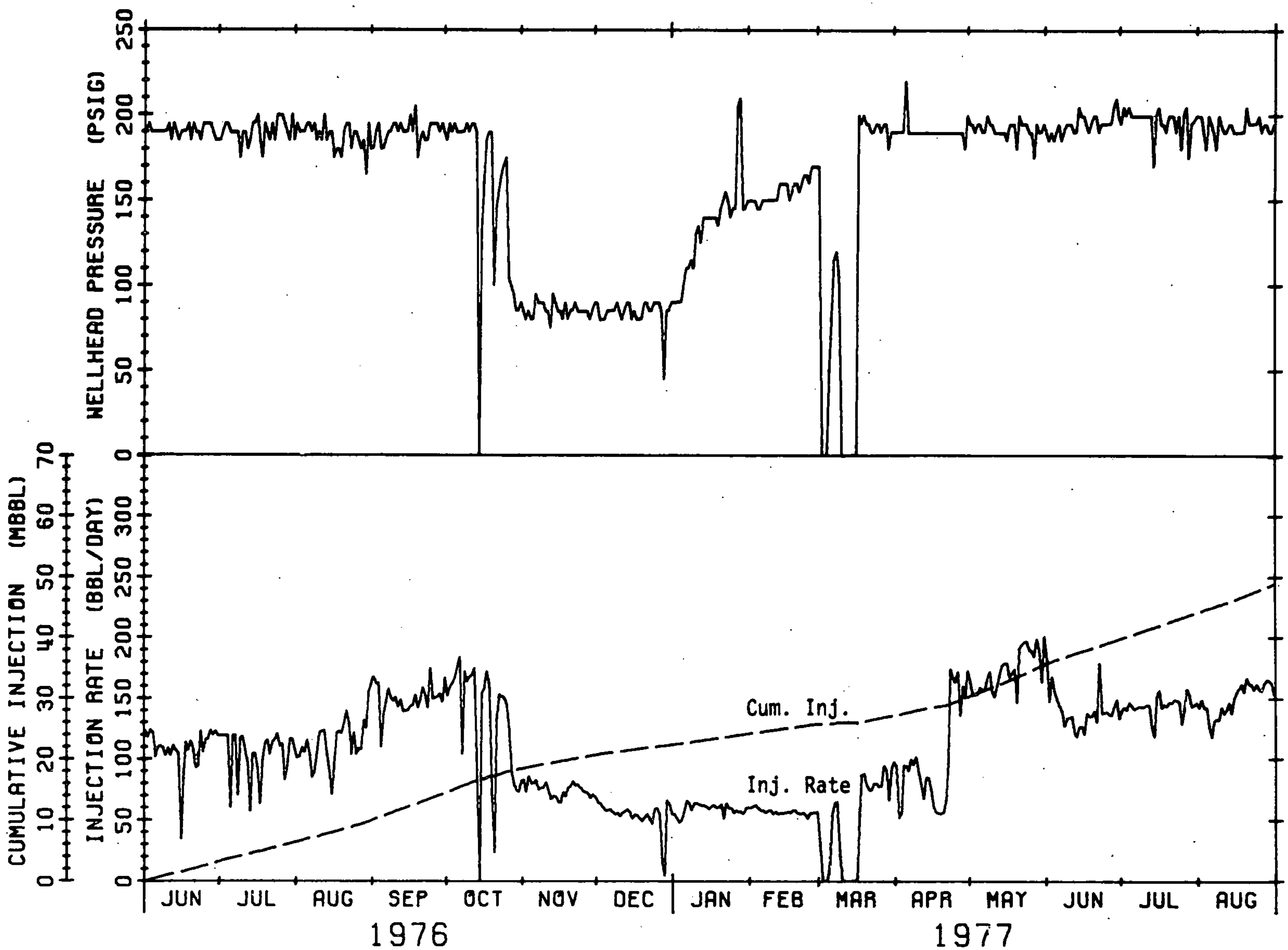


FIGURE G-15

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLOOD VOLUME INJECTED VERSUS TIME FOR WELL MP-116

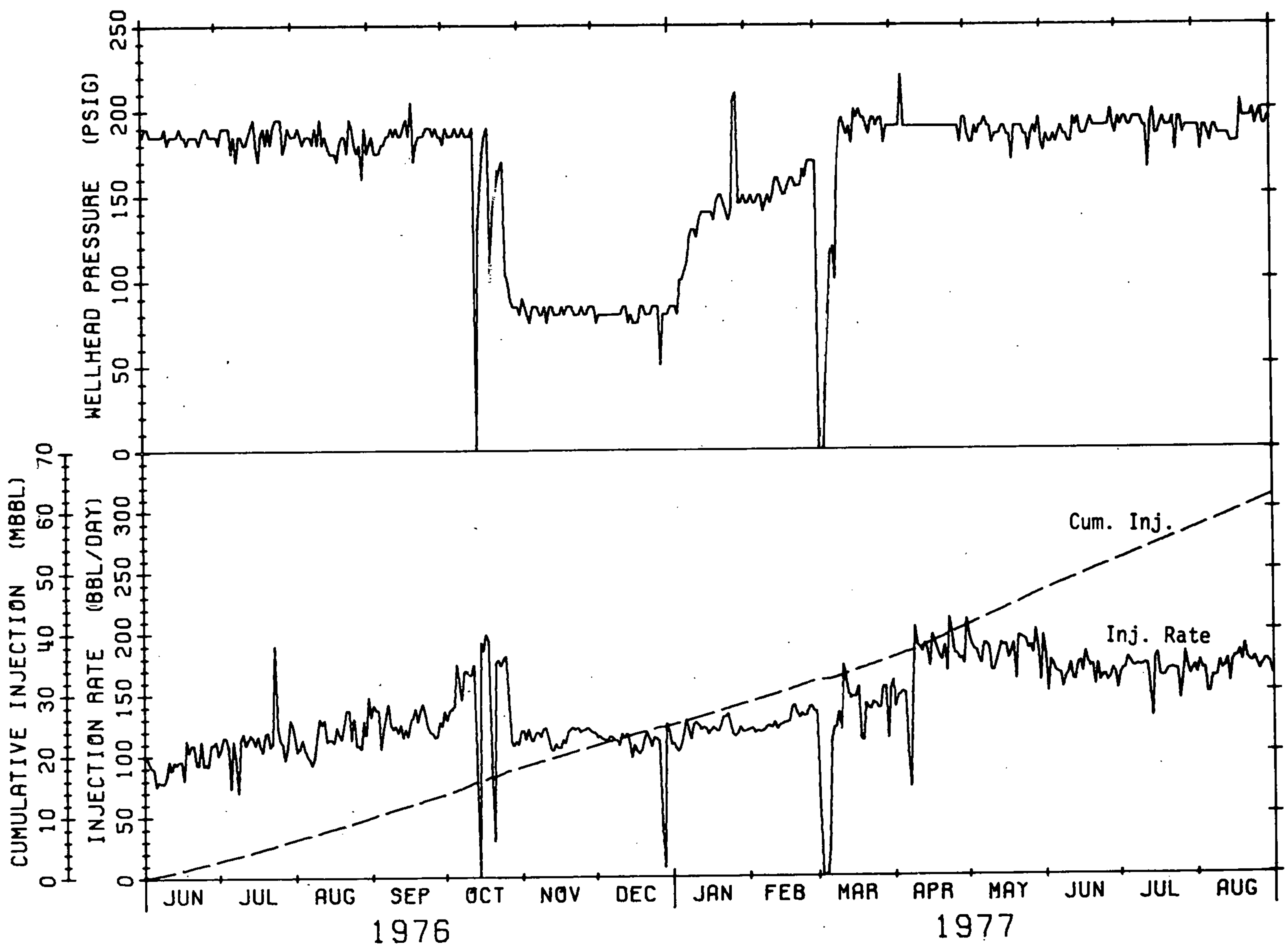


FIGURE G-16

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLOOD VOLUME INJECTED VERSUS TIME FOR WELL MP-118

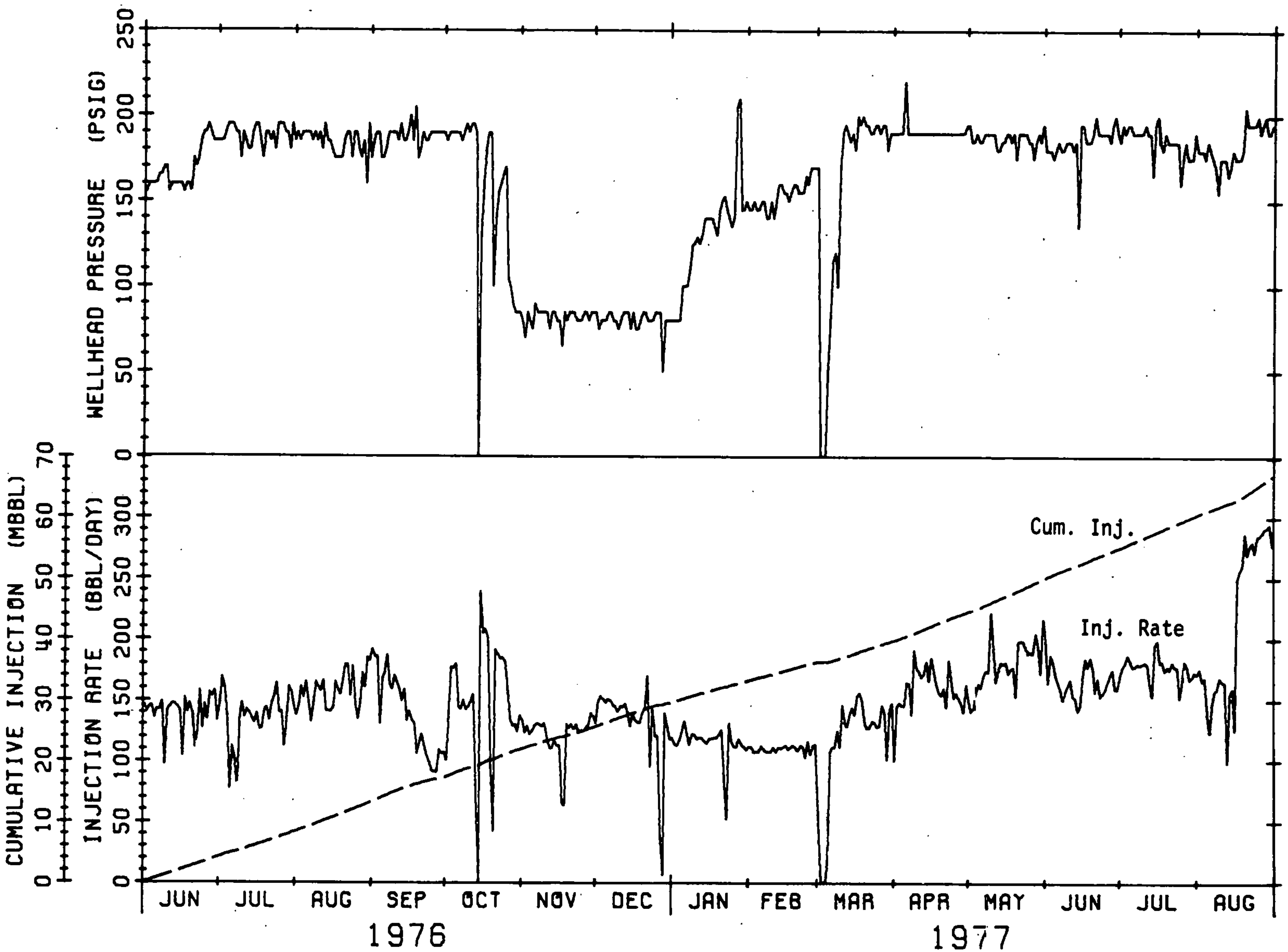


FIGURE G-17

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLOOD VOLUME INJECTED VERSUS TIME FOR WELL MP-120

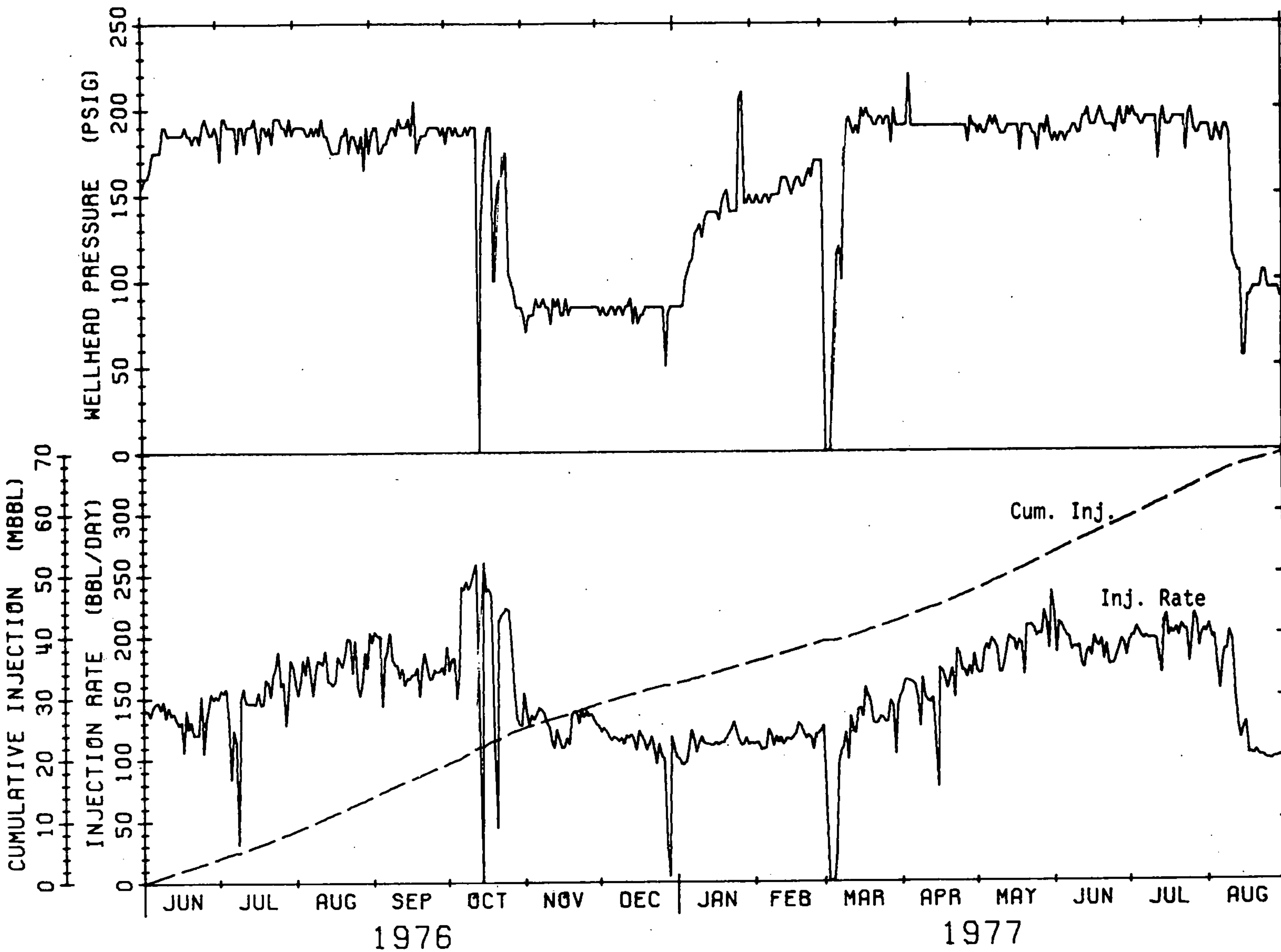


FIGURE G-18

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLOOD VOLUME INJECTED VERSUS TIME FOR WELL MP-126

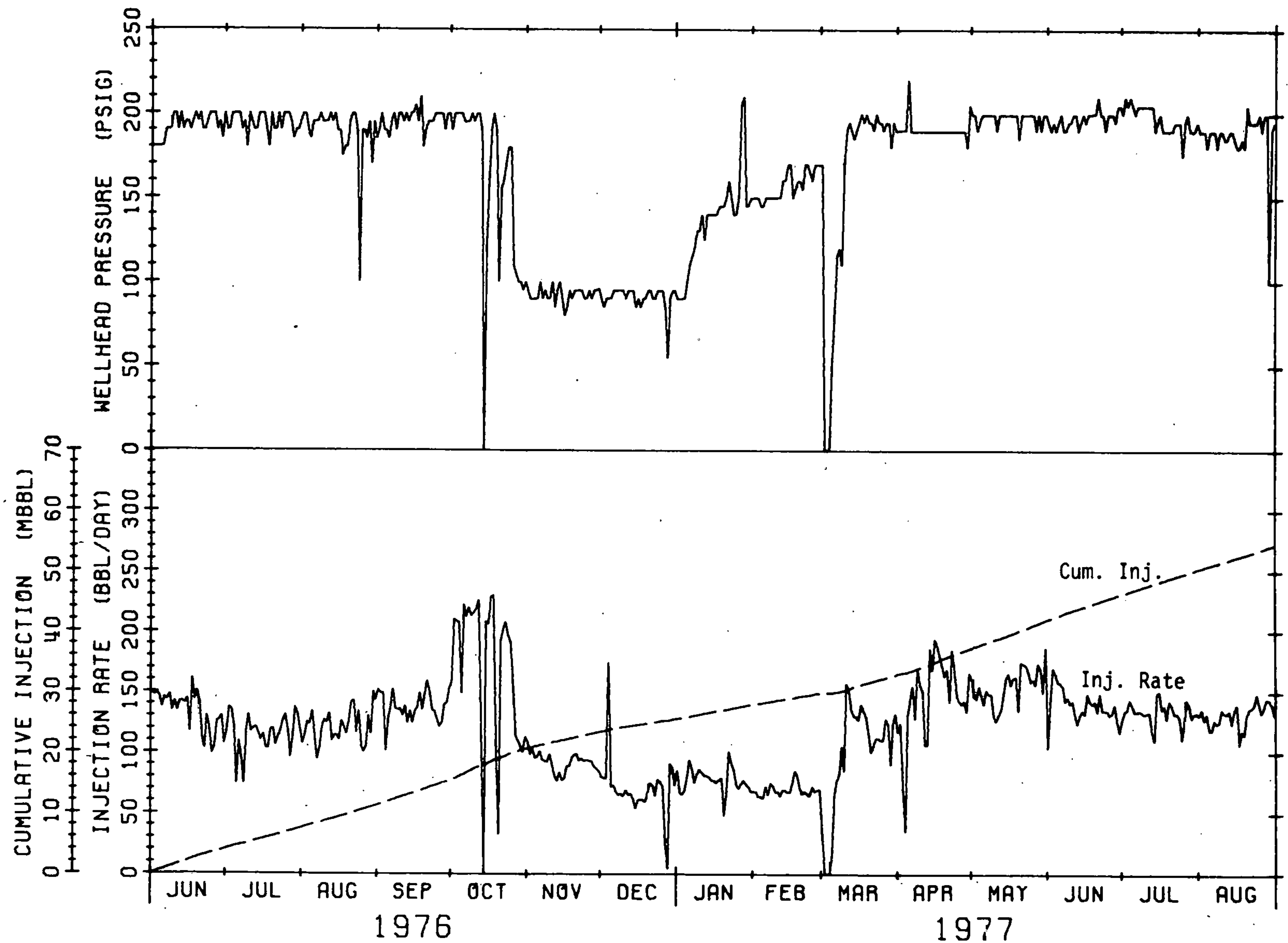


FIGURE G-19

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLOOD VOLUME INJECTED VERSUS TIME FOR WELL MP-128

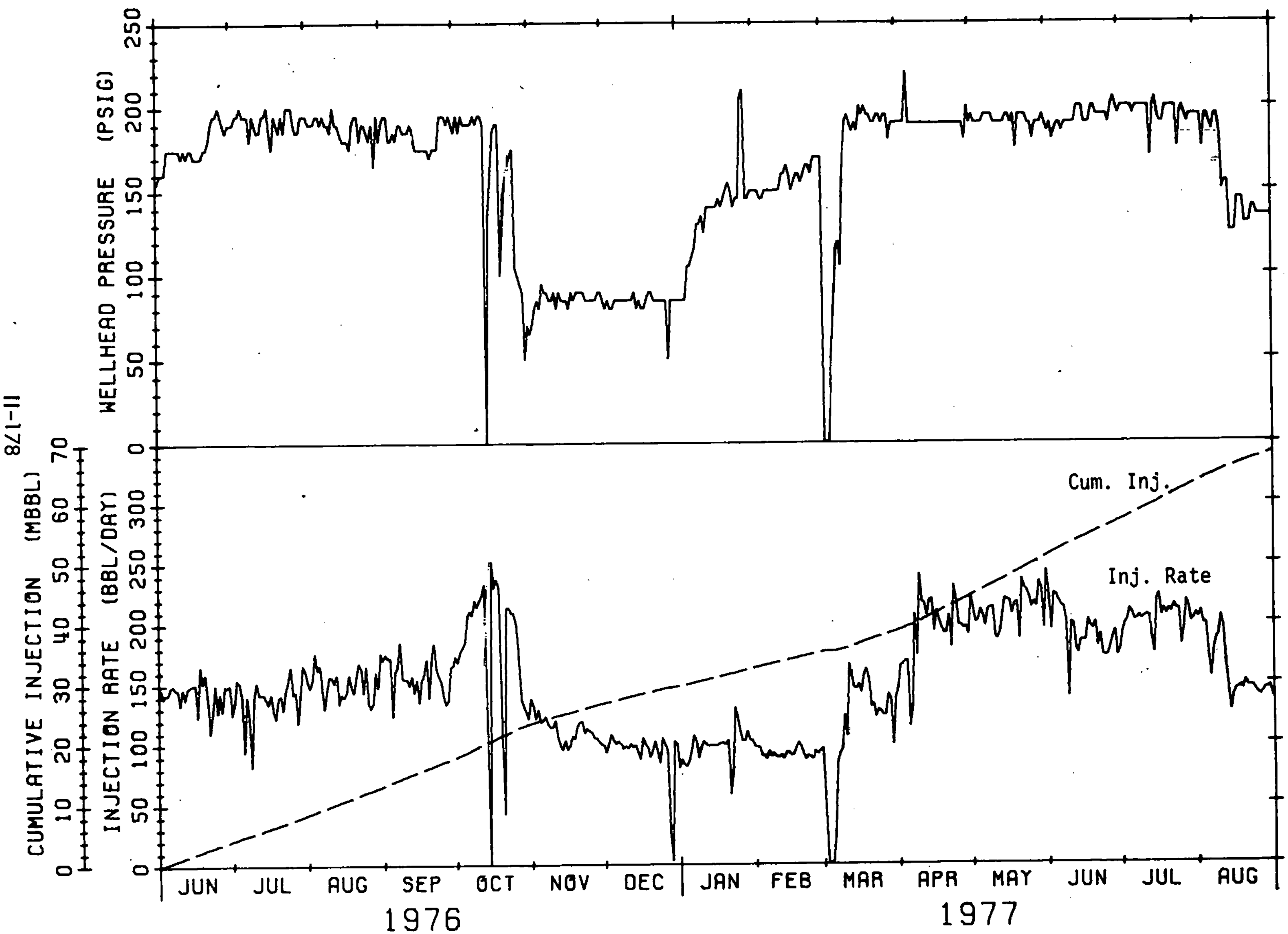


FIGURE G-20

INJECTION RATE, PRESSURE, AND CUMULATIVE PREFLOOD VOLUME INJECTED VERSUS TIME FOR WELL MP-130

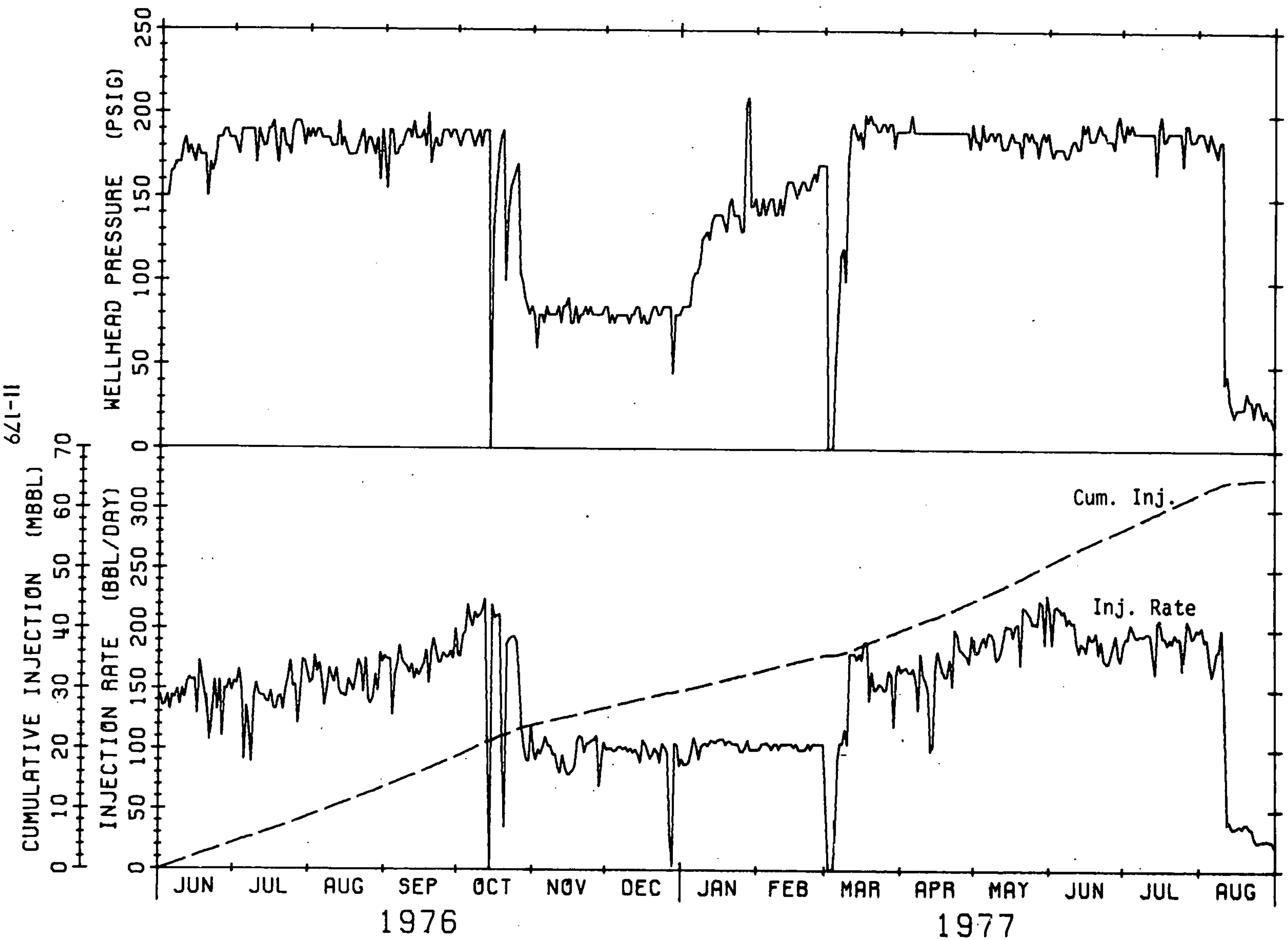


FIGURE G-21

OBSERVATION WELL SCHEMATIC

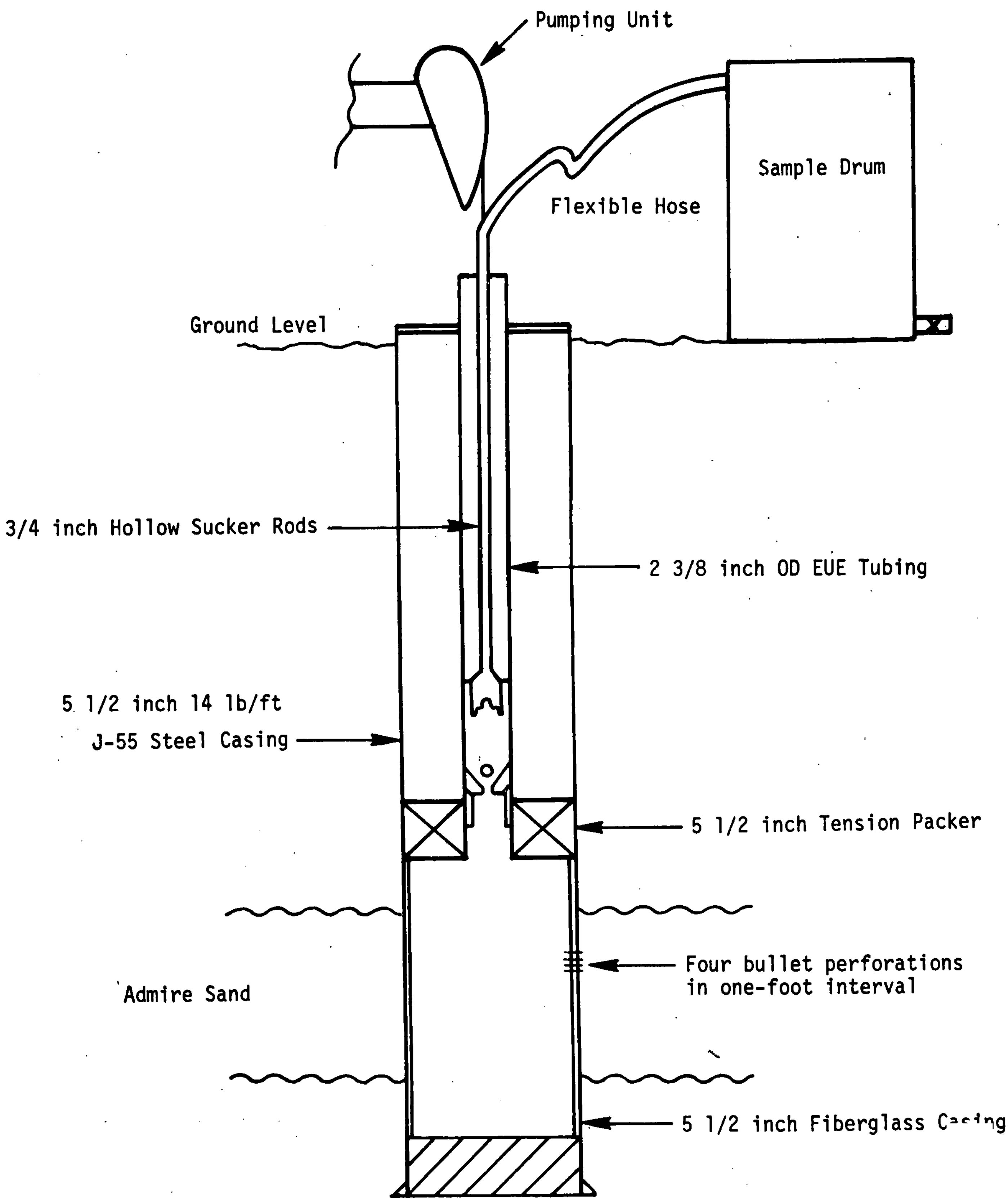


FIGURE G-22

CROSS SECTION OF GAMMA RAY LOGS

THROUGH WELLS MP-219, MP-228,

MP-227, MP-213, MP-226, AND MP-207

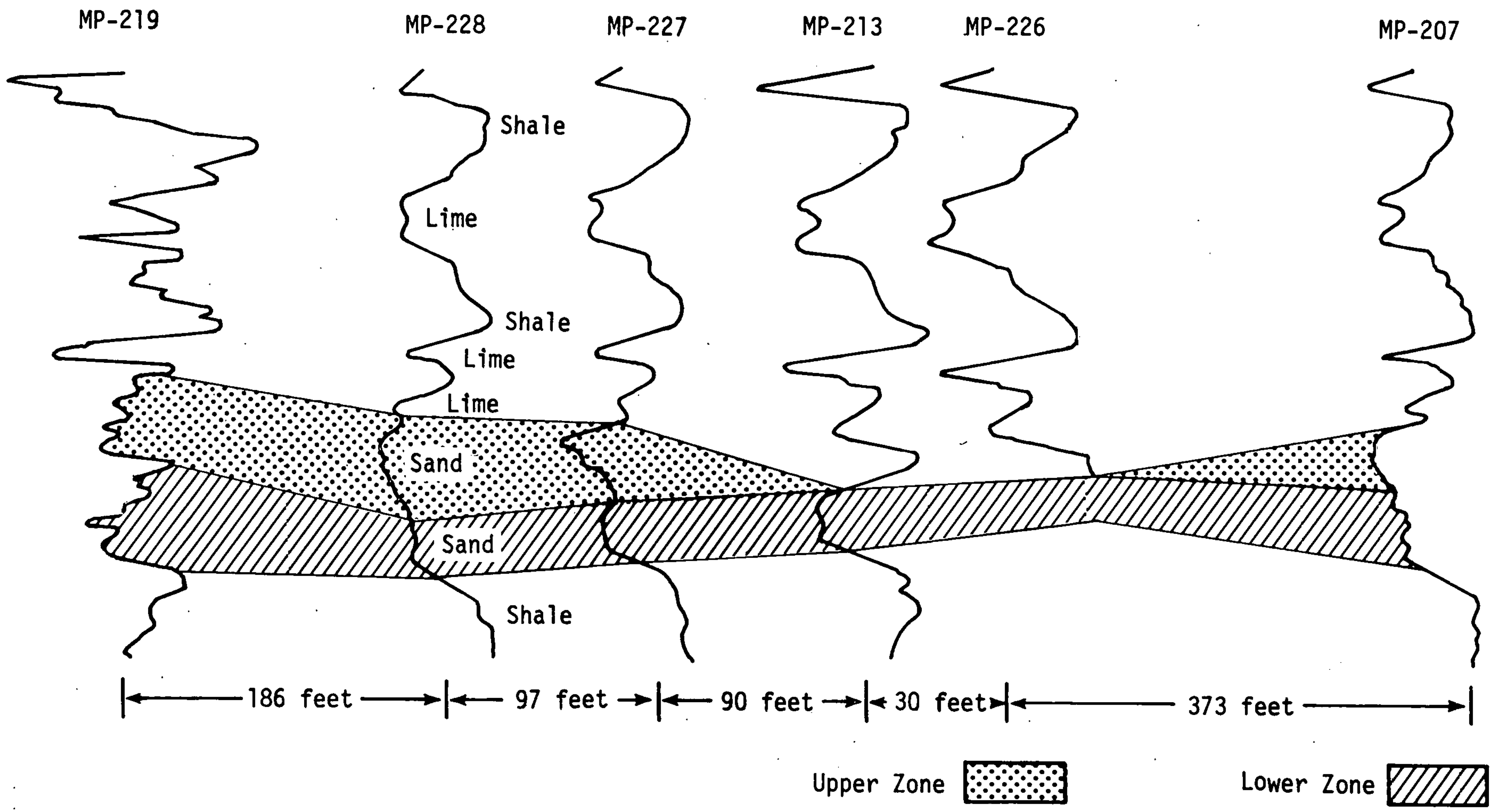


FIGURE G-23

INJECTION RATE AND CUMULATIVE MICELLAR FLUID VOLUME INJECTED VERSUS TIME FOR THE SOUTH PATTERN

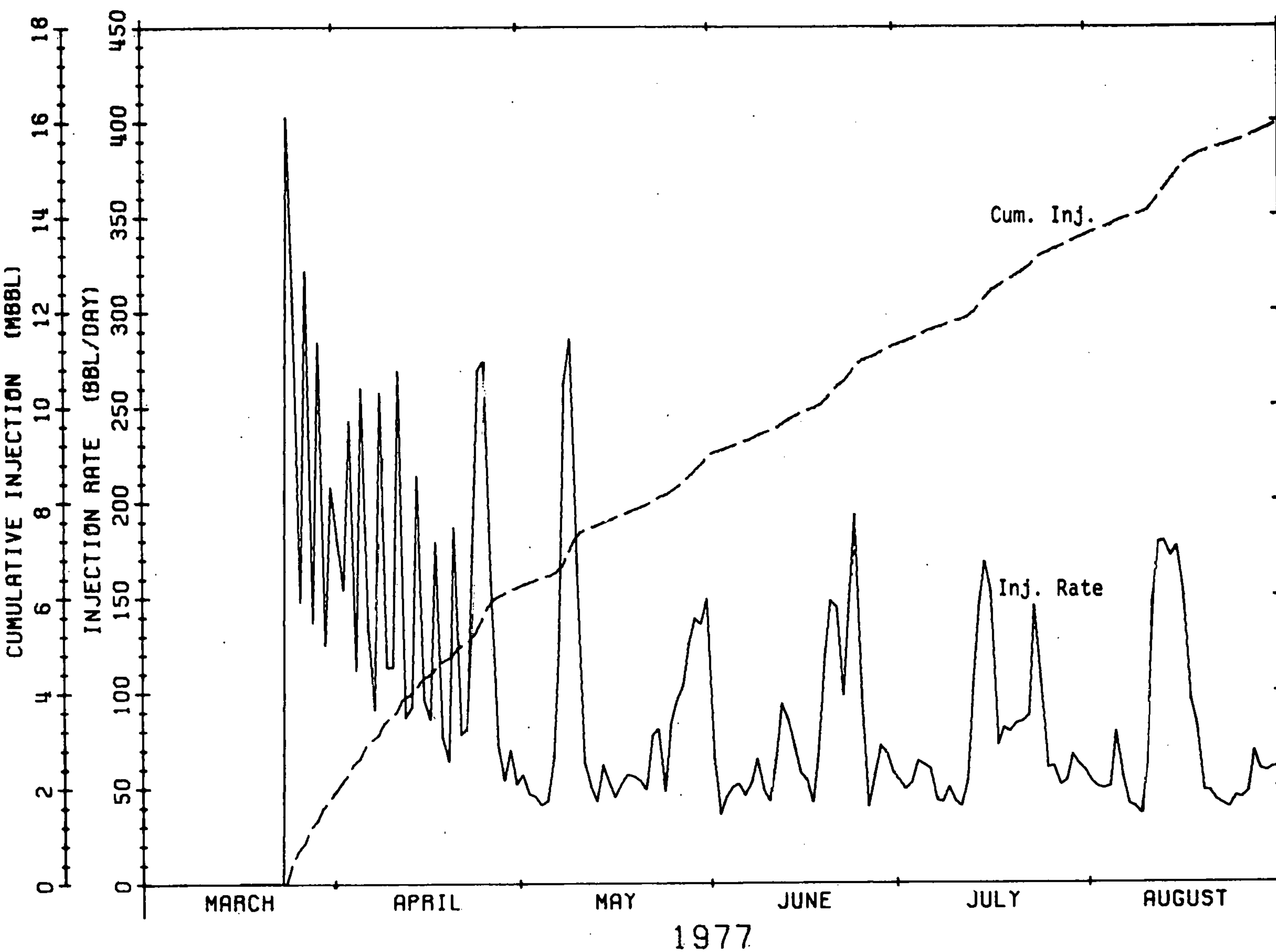


FIGURE G-24

INJECTION RATE, PRESSURE, AND CUMULATIVE MICELLAR FLUID VOLUME INJECTED VERSUS TIME FOR WELL MP-201

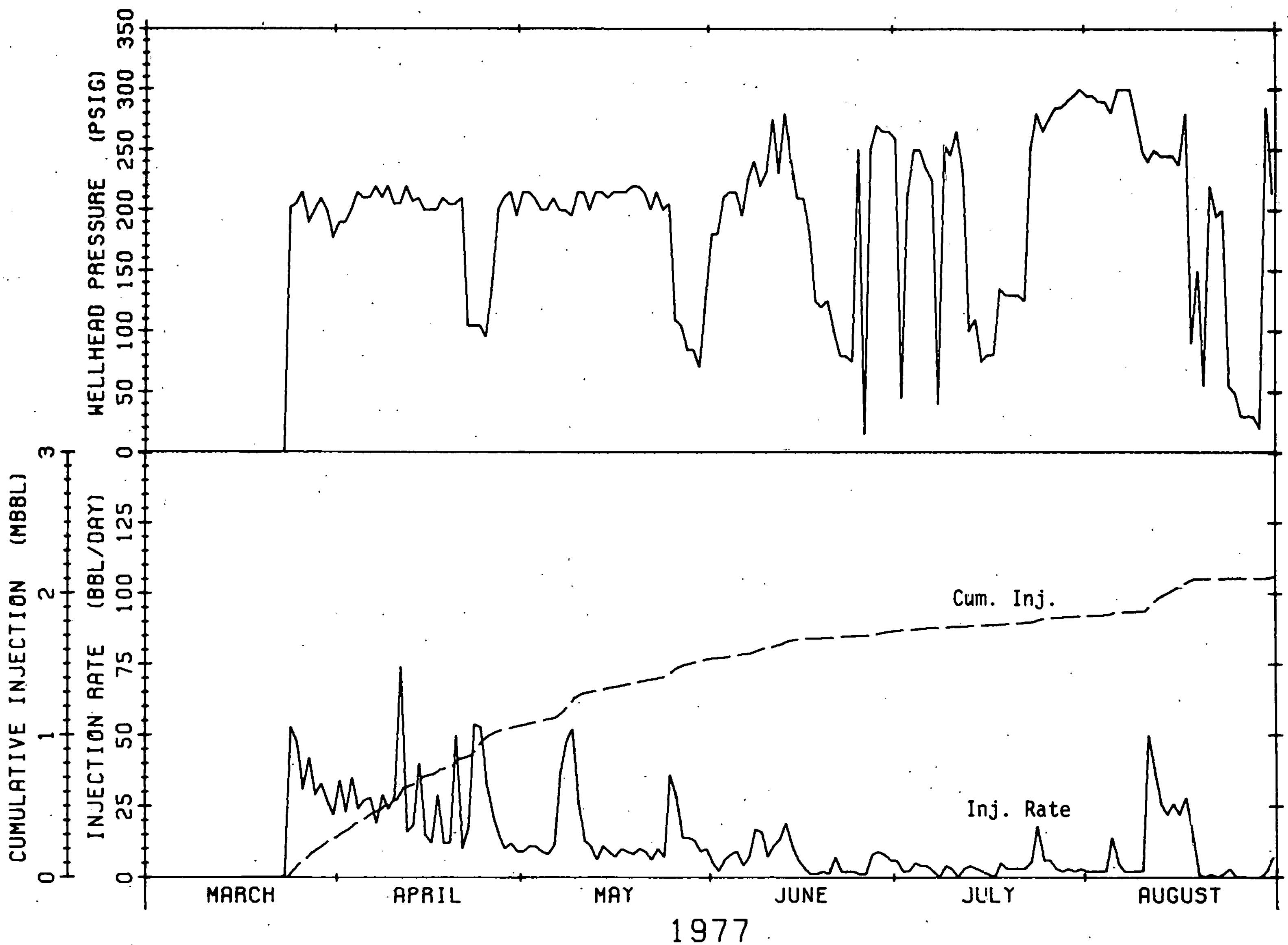


FIGURE G-25

INJECTION RATE, PRESSURE, AND CUMULATIVE MICELLAR FLUID VOLUME INJECTED VERSUS TIME FOR WELL MP-203

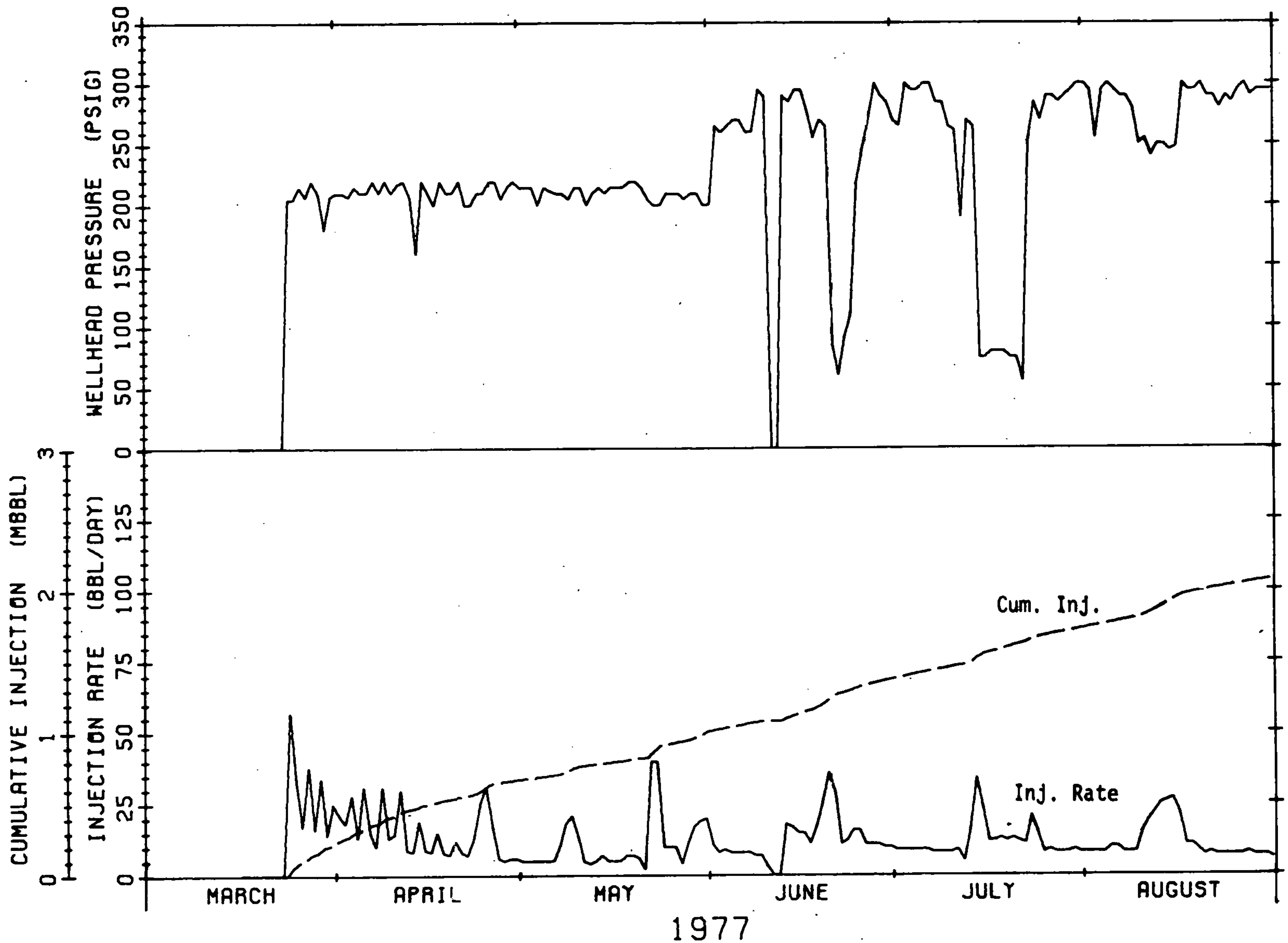


FIGURE G-26

INJECTION RATE, PRESSURE, AND CUMULATIVE MICELLAR FLUID VOLUME INJECTED VERSUS TIME FOR WELL MP-205

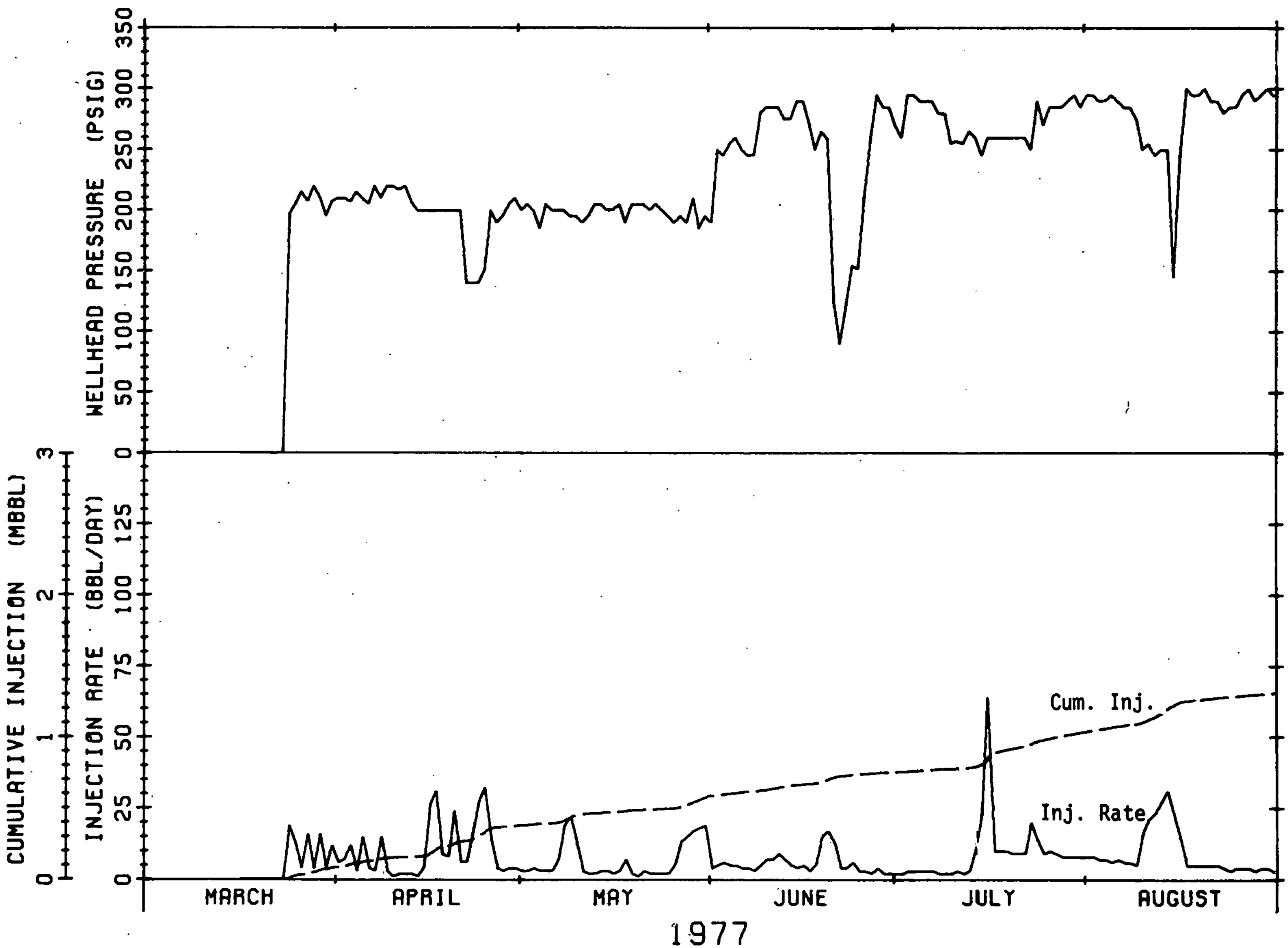


FIGURE G-27

INJECTION RATE, PRESSURE, AND CUMULATIVE MICELLAR FLUID VOLUME INJECTED VERSUS TIME FOR WELL MP-211

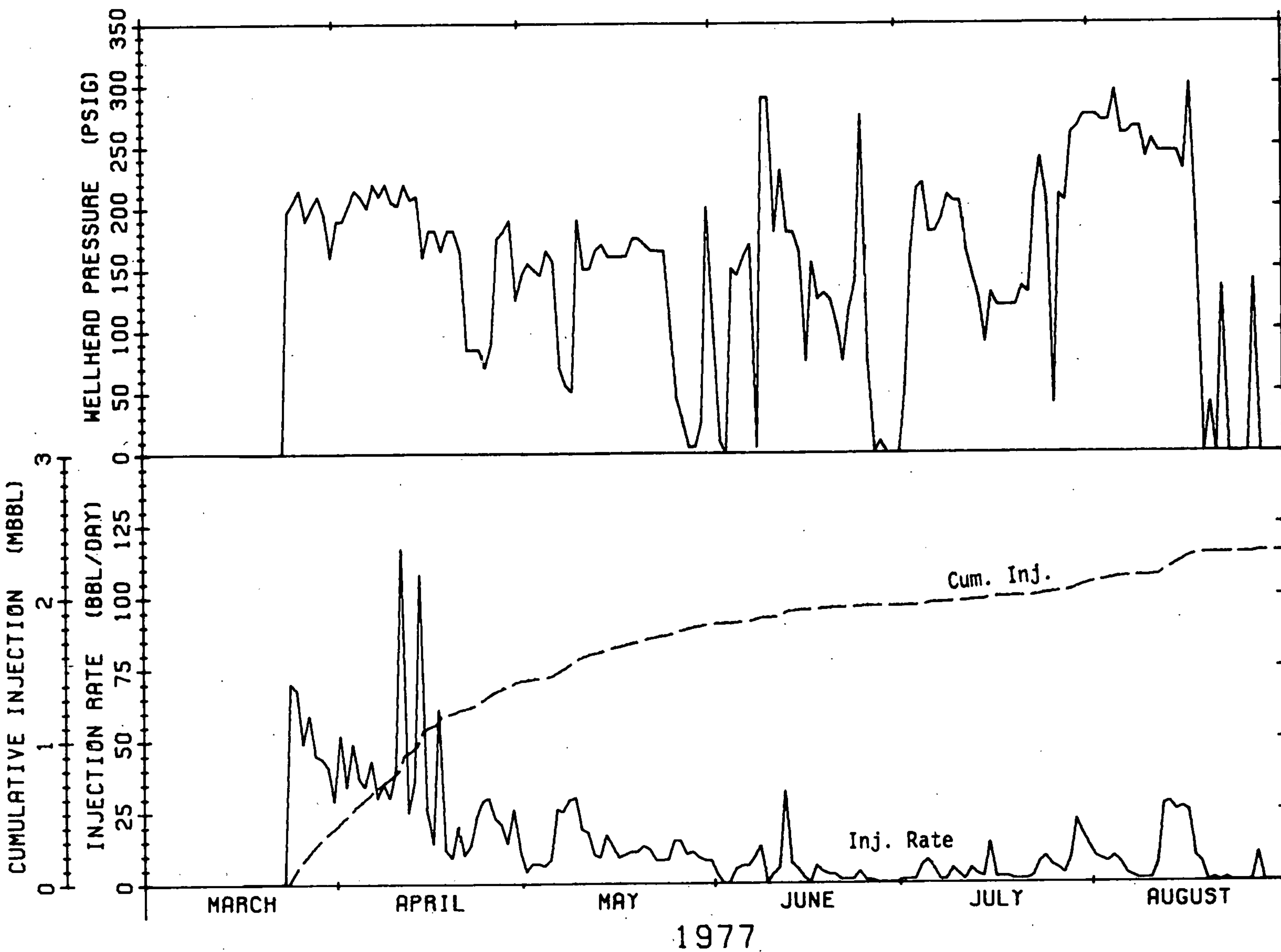


FIGURE G-28

INJECTION RATE, PRESSURE, AND CUMULATIVE MICELLAR FLUID VOLUME INJECTED VERSUS TIME FOR TWIN WELLS MP-213/226

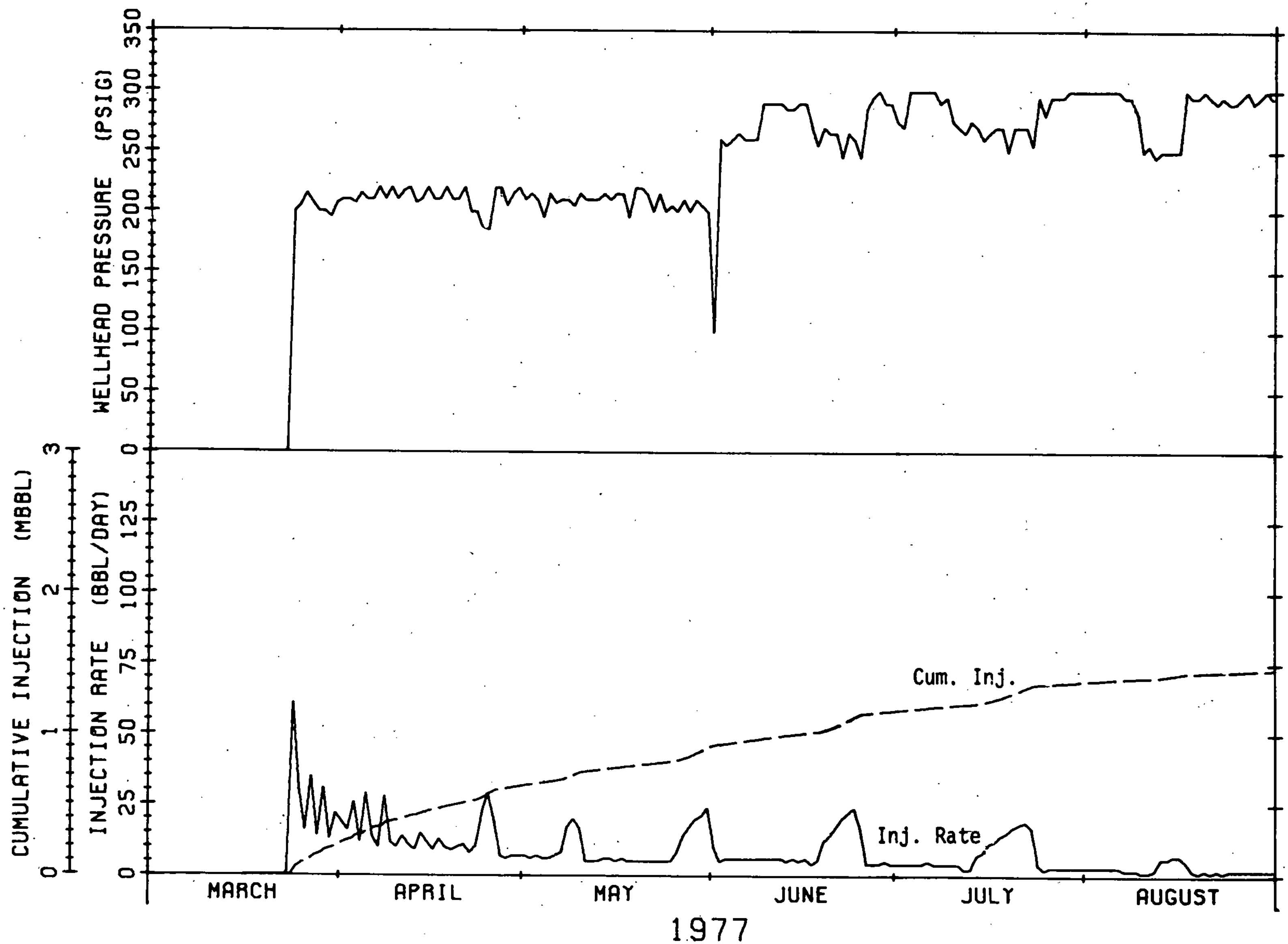


FIGURE G-29

INJECTION RATE, PRESSURE, AND CUMULATIVE MICELLAR FLUID VOLUME INJECTED VERSUS TIME FOR WELL MP-215

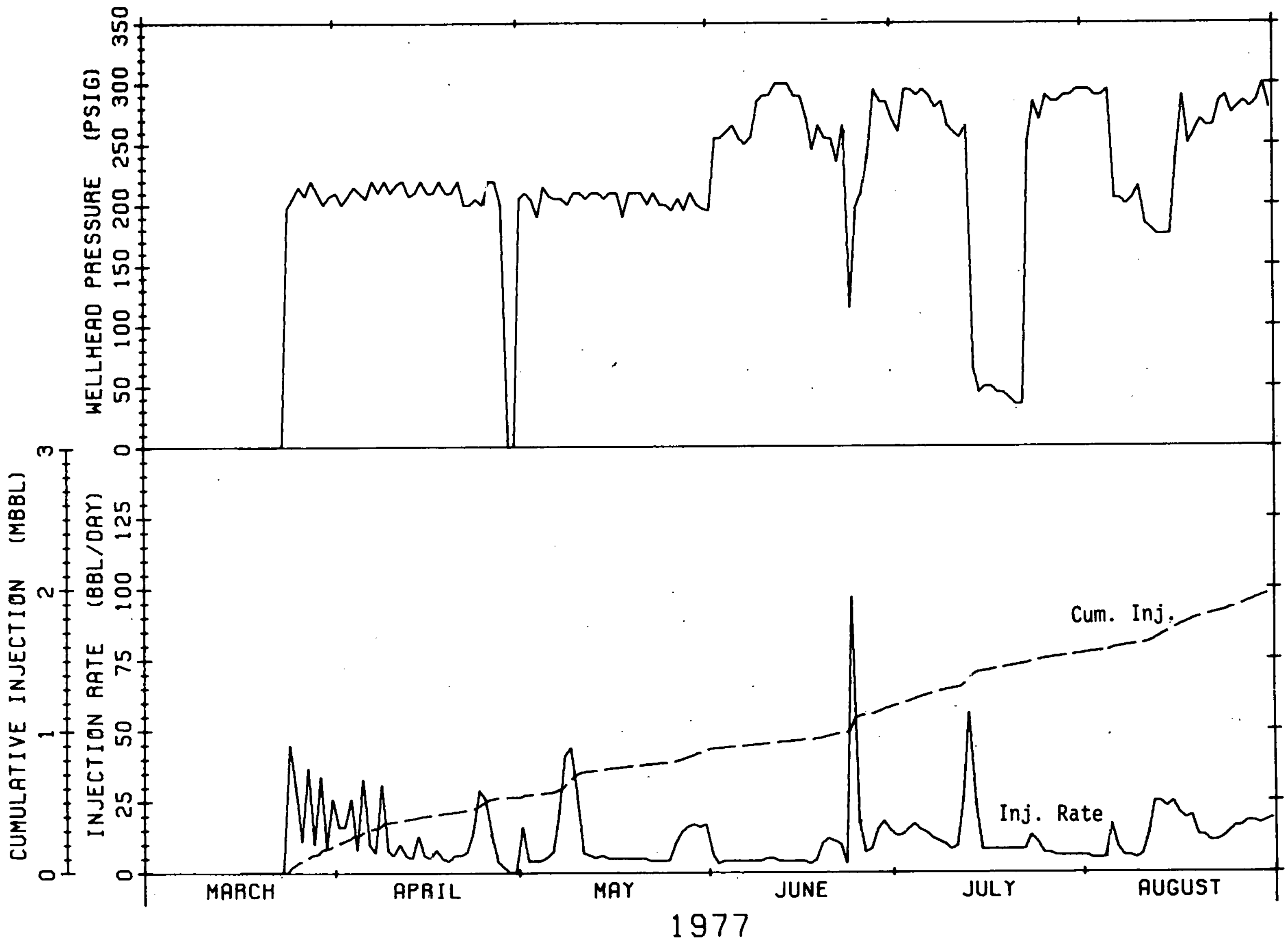


FIGURE G-30

INJECTION RATE, PRESSURE, AND CUMULATIVE MICELLAR FLUID VOLUME INJECTED VERSUS TIME FOR WELL MP-221

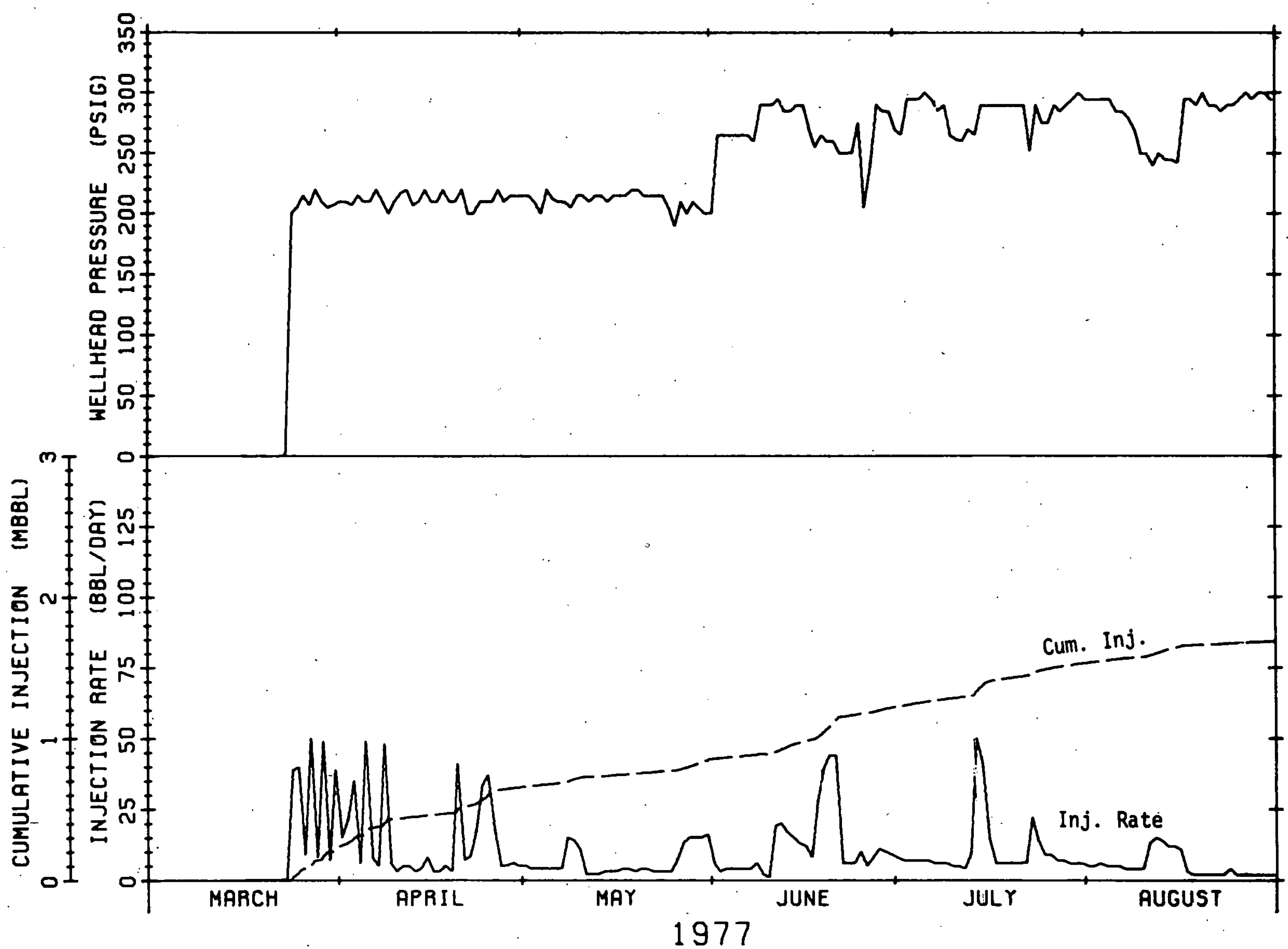


FIGURE G-31

INJECTION RATE, PRESSURE, AND CUMULATIVE MICELLAR FLUID VOLUME INJECTED VERSUS TIME FOR WELL MP-223

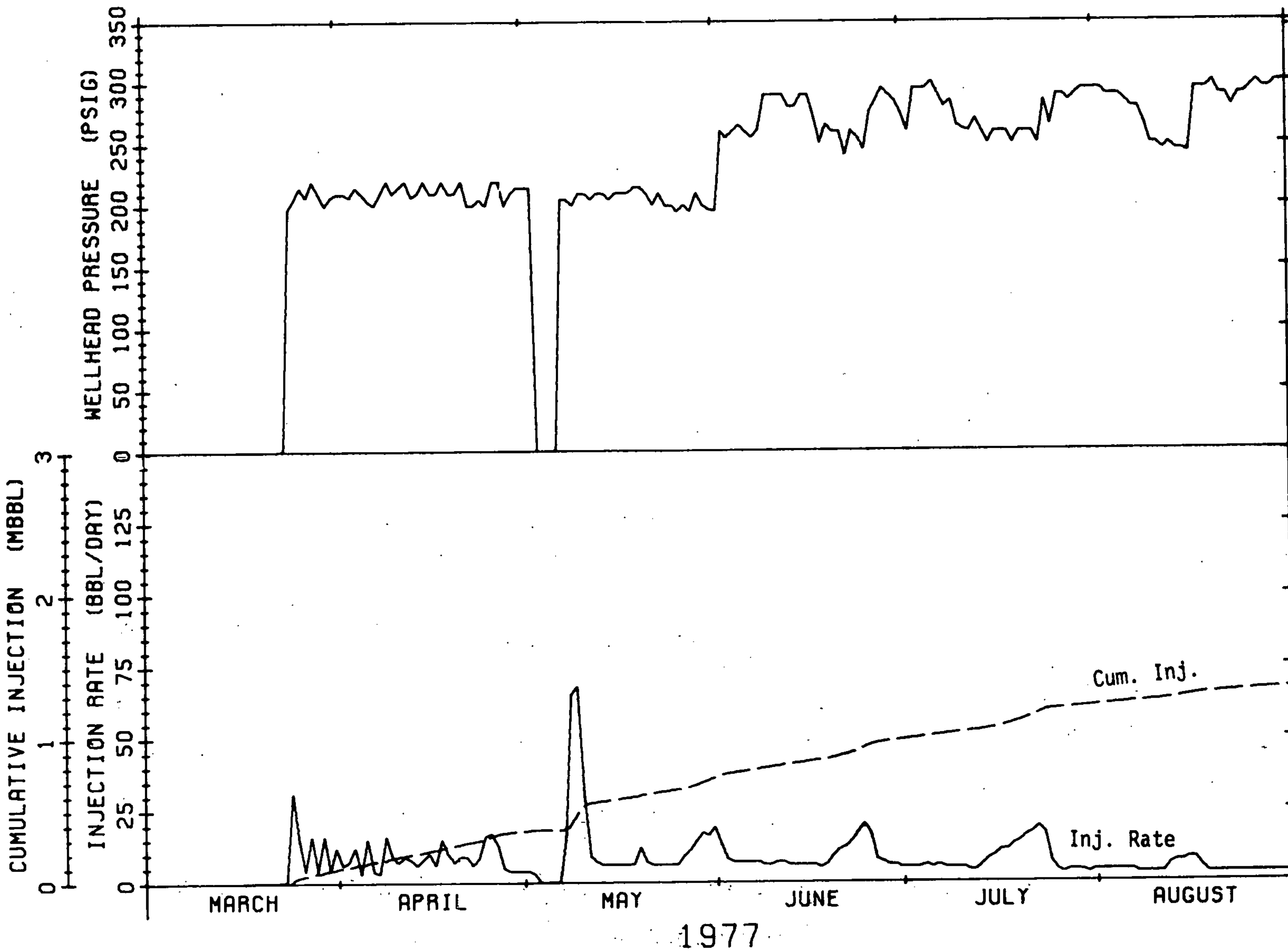
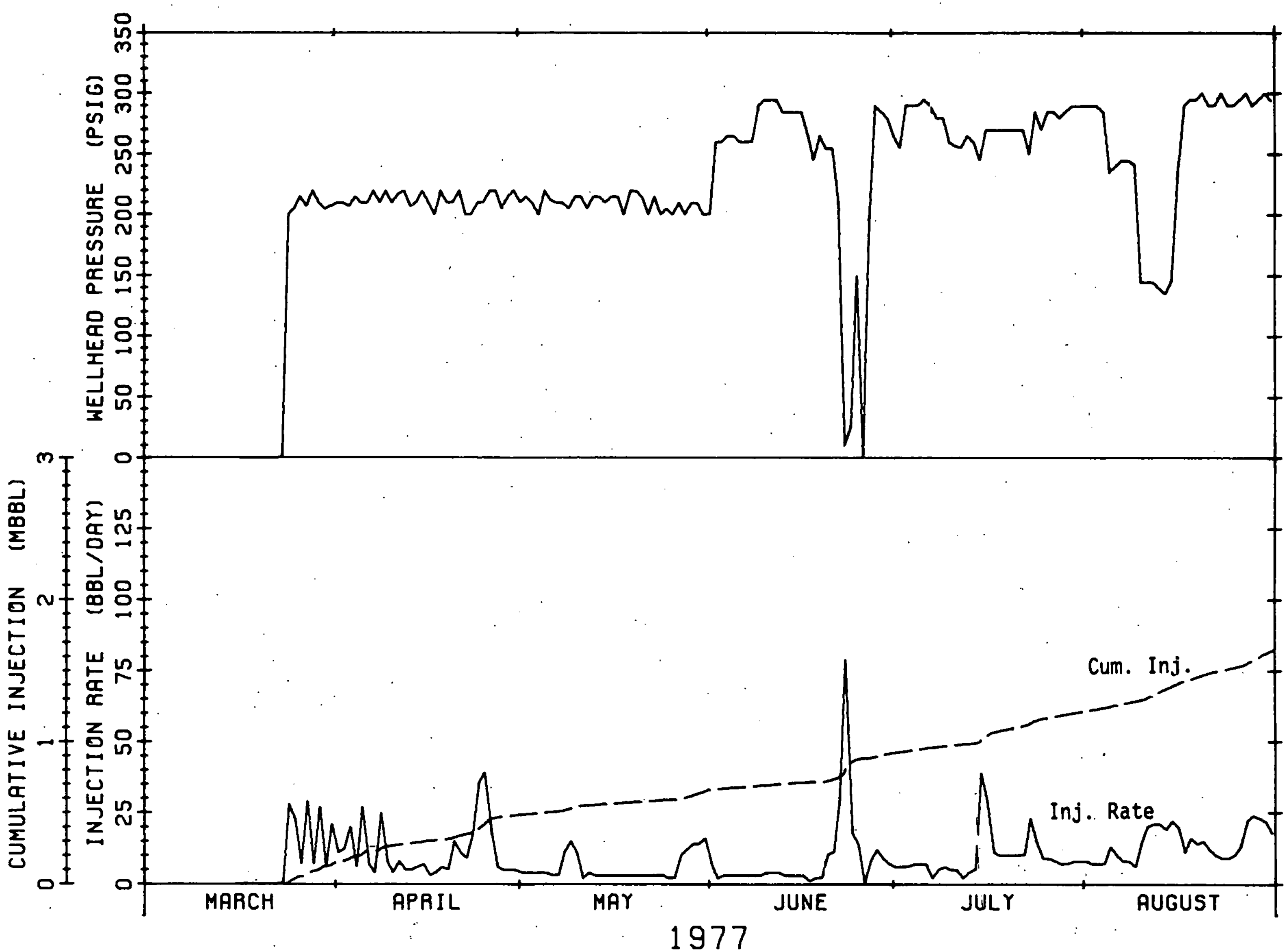


FIGURE G-32

INJECTION RATE, PRESSURE, AND CUMULATIVE MICELLAR FLUID VOLUME INJECTED VERSUS TIME FOR WELL MP-225



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