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Report to Secretary, Department of Energy; by Monte Canfield, Jr., Director, Energy and Minerals Div.

Issue Area: Energy: Role of Fossil Fuels in Meeting Future Needs (1609).
Contact: Energy and Minerals Div.
Budget Function: Natural Resources, Environment, and Energy: Energy (305).
Organization Concerned: Federal Energy Administration.
Congressional Relevance: House Committee on Interstate and Foreign Commerce; Senate Committee on Energy and Natural Resources.
Authority: Energy Policy and Conservation Act (P.L. 94-163).

The Energy Policy and Conservation Act requires the Federal Energy Administration (FEA) to create a Strategic Petroleum Reserve to protect against interruptions in energy and petroleum product supplies. Oil for the reserve will be stored in caverns within salt domes and in salt and limestone mines. FEA has identified nine potential sites--four salt domes, three salt mines, and two limestone mines--with capacities totaling 402 million barrels. Three of the four salt domes have been acquired through condemnation. Findings/Conclusions: The FEA permitted the previous operators of the caverns at Bayou Choctaw and West Hackberry, Louisiana, to continue production of brine after the caverns were tested and certified as suitable for crude oil storage. In order to preclude potential problems associated with continued brining at Bayou Choctaw and West Hackberry, the FEA should negotiate with the the chemical companies to eliminate brining operations. FEA officals believe that there is no need to control brine production or to retest the caverns after brining is completed since they consider cavern damage to be low risk. Two tests are necessary to determine cavern suitability--a sonar survey and a casing and cavern pressure test--which would take about 2 weeks per cavern and cost $15,000 per cavern, a total of $90,000. Recommendations: The secretary of Energy should: determine the feasibility of amending the condemnation agreements to eliminate continued brining operations, institute a formal system for controlling the brining operations if the agreements are not amended to assure that brine is not being produced in excess of safe rates of production and operating pressures, and have the caverns retested after brining has been completed. (RRS)

UNITED STATES
GENERAL ACCOUNTING OFFICE

Need To Minimize Risks Of Using Salt Caverns For The Strategic Petroleum Reserve

Under the Energy Policy and Conservation Act, the Department of Energy is required to create a Strategic Petroleum Reserve to provide protection against future disruptions in U.S. energy supplies. The Department is committed to having 500 million barrels of crude oil in storage by 1980 and thus far has been storing the oil in salt caverns located in the gulf coast area.

GAO's review of the cost and feasibility of salt cavern storage raised questions concerning the need for better information to reduce risks and uncertainties regarding the suitability of caverns for storage:

--Should the Department permit brining operations to continue in caverns after their testing and certification as suitable for crude oil storage without plans for assuring that they will remain suitable for storage after brining?

--Should crude oil be stored in caverns before adequate information on their long-term suitability for storage is obtained?

EMD-78-25

JANUARY 9, 1978

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

ENERGY AND MINERALS
DIVISION

B-178205

The Honorable
The Secretary of Energy

Dear Mr. Secretary:

The General Accounting Office (GAO) has been monitoring the Federal Energy Administration's (FEA) 1/ plans, actions and progress in developing the Strategic Petroleum Reserve. As part of this effort, we have been reviewing the cost and feasibility of salt cavern storage. This letter discusses two issues raised during our review which warrant your consideration.

The first issue relates to permitting brining operations to continue in Government-owned caverns after the caverns have been tested and certified by FEA as suitable for crude oil storage. This concerns us from two standpoints: first, FEA does not have a formal system for controlling brine production at these caverns; and secondly, FEA does not plan to recest the caverns after production ceases.

The second issue pertains to pumping crude oil into certain caverns before completing an analysis of their long-term suitability for storage. Although FEA was not certain of the continued suitability of these caverns for storage until an analysis was completed of tests recently

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1/ Although FEA is discussed throughout this report, our specific recommendations are addressed to the newly established Department of Energy (DOE) to which the functions of FEA were assigned on October 1, 1977, pursuant to the Department of Energy Organization Act (P.L. 95-91).

performed on an adjacent cavern, FEA decided not to wait for test results on the adjacent cavern and began oil fill.

In our view, FEA had no assurance that the caverns in question would continue to be suitable for storage. This lack of assurance could have led to problems in recovering oil, program delays, and unnecessary costs to the Federal Government.

BACKGROUND

The Energy Policy and Conservation Act (P.L. 94-163) requires FEA to create a Strategic Petroleum Reserve (Reserve), the purpose of which is to diminish U.S. vulnerability to the effects of a severe interruption in energy supplies and provide limited protection from the consequences of interruptions in petroleum product supplies. In December 1976, FEA submitted to the Congress a Strategic Petroleum Reserve Plan (Plan) which indicated that the Reserve would contain 150 million barrels of oil by December 1978 and 500 million barrels by December 1982. However, in his April 1977 energy message, the President called for an expansion of the program to 1 billion barrels. Subsequently, FEA's May 1977 Plan amendment set new storage targets for the Reserve of 250 million barrels by December 1978 and 500 million barrels by December 1980. FEA plans to further amend the Plan to expand the Reserve to one billion barrels.

FEA has determined that oil for the Reserve will be stored in caverns within salt domes and in salt and limestone mines. To date, nine potential sites--four salt domes, three salt mines, and two limestone mines--with existing capacities totaling 402 million barrels have been identified by FEA for storage. Of the four salt domes, FEA has acquired three through condemnation proceedings. Information on the salt domes obtained through condemnation is summarized below.

	Salt Dome		
	Bayou Choctaw	West Hackberry	Bryan Mound
Location:	Iberville Parish, Louisiana	Cameron Parish, Louisiana	Brazoria County, Texas
Number of existing caverns planned for storage:	10	5	4
Existing storage capacity:	74 million barrels	60 million barrels	63 million barrels
Estimated design and construction costs for existing caverns:	$126,700,000	$62,500,000	$52,600,000
Previous operators:	Allied Chemical Company	Olin Corporation	Dow Chemical Company

The existing caverns in these salt domes were formed over the years from brining operations. Brining is a process whereby water is injected into a salt mass, dissolving the salt and creating a cavern, with the dissolved salt (brine) being forced out of the cavern through injection of more water.

FEA's plans call for a series of tests to be run on all caverns selected for storage. The purpose of the tests is to determine the suitability of the caverns for crude oil storage. Such tests include a sonar survey to identify the shape of the caverns, to compute storage capacity, and to determine the condition of the cavern roof; and a casing and cavern pressure test to determine whether the casing and cavern will be able to withstand the pressures at which crude oil will be injected and withdrawn.

CONTINUED BRINE PRODUCTION IN APPROVED CAVERNS

As part of the condemnation proceedings, FEA permitted Allied Chemical Company and Olin Corporation to continue brine production at Bayou Choctaw and West Hackberry, respectively. The condemnation agreement for Bayou Choctaw does not specify the number of caverns which will be available for continued brine production; however, the project manager for Bayou Choctaw stated that the number was three. West Hackberry's

condemnation agreement specifically stated that three caverns will be available. These six caverns have a storage capacity of over 62.3 million barrels, representing about 46 percent of the total existing storage capacity for the 15 caverns designated for storage in these two salt domes. At a national average composite price of $11.80 a barrel, the oil to be stored in these six caverns is estimated to cost the Government about $735 million. FEA officials told us that in order to assist in precluding further litigation which would delay the condemnation proceedings, FEA agreed to allow Allied and Olin access to caverns at Bayou Choctaw and West Hackberry for brine production. Based on the advice of the Corps of Engineers--the contractors hired to appraise the storage sites--FEA decided that depriving the chemical companies of brine supplies would subject the Government to significant damage claims. An FEA official advised us that no written documentation was prepared in support of potential damage estimates since they were so obvious.

The agreements that FEA signed with the chemical companies specify the length of time the chemical companies are to receive brine supplies. In Allied's case, it is until such time Allied develops a replacement brine supply of its own, but not beyond December 31, 1980. In Olin's case, it is until May 1, 1978. FEA officials told us that Allied's brining needs are about 30,000 barrels a day and Olin's average about 14,000 barrels a day. The agreements do not, however, specify the rate of production or the operating pressure at which the brine is to be produced.

At the same time that Allied and Olin are conducting brining operations, FEA plans to proceed with the design and construction necessary to prepare the sites for oil storage. Except for $6.2 million to be spent for drilling injection wells, 1/ FEA has not determined how much of the estimated $189 million in design and construction costs for existing capacities at Bayou Choctaw and West Hackberry are attributable to the six caverns where brining operations will continue. Although we recognize that there are certain design and construction costs which will be incurred regardless of the number of caverns or barrels of storage

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1/ Contractor reports estimate that it will cost an average of $692,000 to drill an injection well, and FEA plans to drill nine new injection wells in these six caverns.

capacity, we estimate the costs associated with the six caverns to be $87 million. 1/

FEA officials stated that there is no need to control brine production nor retest the caverns after brining is completed since they considered cavern damage to be low risk due to the experience of the chemical companies in producing brine and the small amount of brine to be produced. The contractor responsible for performing cavern tests for FEA agreed with FEA officials. However, these officials acknowledged that if a cavern is operated in excess of its maximum operating pressure, it could fracture causing it to be unsuitable for storage. For each cavern rendered unsuitable for storage, FEA would have to find a suitable replacement cavern or construct a new one. Either situation, particularly the latter, would result in program delays and additional costs. These officials stated that even with proper rates of production and operating pressures, brining could still damage the caverns. For example, if too much salt is removed from the cavern roof, the seal around the casing, through which the crude is injected and withdrawn, could begin to leak. Also fractures could develop in the caverns. Either type of change could result in the crude oil escaping to the caprock (the layer of rock strata directly above the salt dome) where it can be lost.

Officials of FEA's Strategic Petroleum Reserve Office, Office of Facility Construction, stated that they have no formal system to control the brining operations but indicated that it could be done with minimal effort and expense. We discussed the type of testing necessary to assure cavern suitability after brining is completed, length of time to retest, and costs with FEA officials and the contractor. They stated that two tests would be necessary--a sonar survey and a casing

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1/ Design and construction costs for existing storage capacity at Bayou Choctaw and West Hackberry are $189 million--$127 million and $62 million respectively. On the basis of 135 million barrels of existing storage capacity, design and construction costs are equal to about $1.40 a barrel. This per barrel amount multiplied by the 23.5 million barrels for the three caverns at Bayou Choctaw and the 38.8 million barrels for the three caverns at West Hackberry equals a total of $87 million.

and cavern pressure test--which would take about two weeks per cavern and cost a total of about $90,000--$15,000 per cavern.

In discussing the possible loss of design and construction costs if the caverns were rendered unsuitable due to continued brine production, FEA officials stated that by delaying cavern design and construction until after brining operations are completed, the chances for loss of design and construction funds would be eliminated but other factors must be taken into consideration such as the price of oil and inflation. They added that postponing design and construction until after brining was completed would delay the program and possibly cause FEA to be unable to meet the administration's goal of having 500 million barrels of oil in storage by December 22, 1980. At the time of our review, however, FEA had not evaluated what the impact on meeting the goals would be due to delaying some or all of design and construction activity. They stated that such an analysis, although time-consuming, could be performed.

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In a November 10, 1977, meeting with DOE officials to discuss a draft of this report, they disagreed with several aspects of the report relative to the continued production of brine at Bayou Choctaw and West Hackberry. These officials restated their view that cavern damage as a result of continued brining is low risk and that retesting is unnecessary. They stated that the reasons for this view are (1) caverns are being tested for the ability to withstand pressure well above the accepted industry standard pressure for brine production; (2) due to the large size of the caverns, brining at temporary short-term operating pressures will not cause the overall cavern pressure to rise to dangerous levels; and (3) DOE has re-installed blanket oil in the caverns after testing and will insure that adequate blanket oil is maintained to guard against salt being washed from the cavern roof. Futhermore, they cited the thickness of the salt roofs above the caverns as an additional factor that would guard against damage occurring.

The reasons cited above may minimize cavern damage. However, without a formal system to monitor brining operations, there is no assurance that safe operating pressures are maintained. FEA and its testing contractor have acknowledged

that brining can cause cavern damage. This would appear to be substantiated by the failure of five other caverns at Bayou Choctaw, previously used for brine production, to pass casing and cavern pressure testing.

STORAGE PLANS AT BRYAN MOUND

There are five caverns at the Bryan Mound salt dome. FEA began storing crude oil in cavern 2 on October 7, 1977; in cavern 4 on November 14, 1977; and plans to use caverns 1 and 5 for storage. FEA considers the remaining cavern--cavern 3--to be too large for storage. In addition to being too large, certain questions have been raised about the suitability of cavern 3 for the storage of crude oil. Although cavern 3 was not selected for storage, its suitability for storage is important because of its location in relation to caverns selected for storage. A cavern's exact location and distance are considered in cavern design analysis to determine if caverns will grow together and the impact of such growth resulting from crude oil displacement cycles. FEA is using five such cycles for planning purposes and is assuming the storage sites will have to be emptied as many as five times because of major supply interruptions. Cavern enlargement is expected to occur during each displacement cycle. FEA made an analysis of caverns at Bryan Mound to determine location and distance. In our opinion, FEA's analysis of cavern 3 prior to beginning oil fill in an adjacent cavern was not adequate to determine the extent to which cavern 3 would have compromised the other cavern's suitability for storage.

FEA first became aware of potential problems with cavern 3 in November 1976 when a preliminary design contractor submitted a report on the Bryan Mound storage caverns. The contractor's report proposed that FEA insure that no future brining operations are conducted in cavern 3 by acquiring the cavern and, if possible, perform a directional survey of the cavern. Although the directional survey is necessary to enable FEA to determine the potential for other caverns to penetrate cavern 3 and the consequences of such penetration, tests to gather information on cavern 3 were not performed prior to oil fill. The Bryan Mound Project Manager (Project Manager) told us that FEA decided testing cavern 3 was unnecessary because FEA's analysis showed it would not have any impact on the other caverns. However, we believe that questions remain as to the accuracy of

this analysis which tends to be supported by the fact that FEA decided to perform further testing on cavern 3, as discussed below. FEA's analysis was based primarily on two documents; an aerial view diagram of the caverns and a table showing calculations of the effects of five displacement cycles on the diameters of Bryan Mound storage caverns 1, 2, 4, and 5. The aerial view diagram was obtained from Dow Chemical Company--the previous operator of cavern 3. While we do not disagree with the manner in which the analysis was performed, we do not believe the information used was adequate since FEA did not obtain sonar and directional survey data to verify the location of cavern 3 on the aerial view diagram.

In August 1977, both FEA and its contractor responsible for cavern testing and certification became concerned about cavern 3. In an August 23, 1977, meeting attended by FEA and the contractor, the contractor strongly advised that cavern 3 be tested. In a letter to FEA dated August 29, 1977, the contractor expressed concern that cavern 3 might be penetrated during future oil displacement from caverns 2 and 4. The contractor emphasized that an investigation of the cavern was imperative. In a letter to the contractor dated August 31, 1977, FEA asked the contractor to submit a proposal for performing sonar and directional surveys on cavern 3. The FEA letter also requested that the proposal include fluid samples from various depths in cavern 3. We were advised by the Project Manager that FEA was concerned over allegations that industrial waste had been dumped in cavern 3.

We first discussed cavern 3 with FEA on September 19, 1977. No tests had been run at that time; but, based on a discussion with the Project Manager, it was our understanding that oil would not be stored at Bryan Mound until cavern 3 had been tested and analyzed. Subsequently, the Project Manager advised us that there were never plans to delay oil fill until cavern 3 had been tested and analyzed.

As stated on page 7, FEA began storing crude oil in cavern 2 on October 7, 1977, and in cavern 4 on November 14, 1977. As of November 29, 1977, about 1.5 million barrels had been stored in these caverns. Cavern testing began on November 2, 1977, and was completed November 9, 1977. We last discussed the status of the tests with the contractor on December 13, 1977. The contractor stated that they had completed their analysis of the tests and had forwarded the test