

**STATE OF ALASKA**  
**ALASKA OIL AND GAS CONSERVATION COMMISSION**  
**333 West 7<sup>th</sup> Avenue, Suite 100**  
**Anchorage, Alaska 99501**

**Re: THE APPLICATION OF FOREST ) Area Injection Order No. 32**  
**OIL CORPORATION for an order )**  
**authorizing the underground ) Redoubt Unit**  
**injection of fluids for enhanced oil ) Redoubt Shoal Undefined Oil Pool**  
**recovery in the Hemlock Formation, )**  
**Redoubt Shoal Undefined Oil Pool, )**  
**Redoubt Unit, Cook Inlet, Alaska ) January 30, 2008**  
**)**

**IT APPEARING THAT:**

1. By application dated and received by the Alaska Oil and Gas Conservation Commission ("Commission") on July 30, 2007, Forest Oil Corporation ("Forest"), operator of the Redoubt Unit ("RU") requested a Commission order authorizing, under 20 AAC 25.402, the underground injection of fluids for enhanced oil recovery ("EOR") in the Hemlock Formation ("Hemlock") of the Redoubt Shoal Undefined Oil Pool.
2. The Commission published notice of the opportunity for a public hearing in the Anchorage Daily News on August 8, 2007 and in the Peninsula Clarion on August 9, 2007.
3. On August 8, 2007, Commissioner Daniel T. Seamount, Jr. recused himself from this case.
4. By emails dated August 6 and 7, 2007, and September 12, 2007, the Commission requested additional information. Forest responded on August 22, 2007, and September 14, 2007.
5. No comments, protests or requests for a public hearing were received.

**FINDINGS**

1. Operator  
Forest operates the Redoubt Shoal Undefined Oil Pool in the RU, Cook Inlet, Alaska.

2. Project Area and Proposed Enhanced Recovery Injection Interval

Enhanced recovery injection is proposed for the Redoubt Shoal Undefined Oil Pool. This pool is compartmentalized by faulting into three fault blocks: the Northern, Central and Southern fault blocks. The Central and Southern fault blocks contain the majority of reserves in the pool.

In the Central fault block, the injection zone is correlative with the interval from 14,140' to 14,945' measured depth ("MD") in the RU #1 well. In the Southern fault block, the injection zone is correlative with the interval from 14,365' to 15,222' MD in the RU #2 well.

3. Proposed Injection Area

Forest has requested authorization to inject fluids for the purpose of enhanced recovery operations on RU land within T07N R13W and T07N R14W, Seward Meridian. Most of the wells affected by the proposed injection activities were drilled from the Osprey Platform, which is located approximately 1.5 miles southeast of West Foreland, offshore Cook Inlet. However, there are also four exploratory wells within the proposed injection area that, between 1967 and 1976, were drilled and then plugged and abandoned.

4. Operators/Surface Owners Notification

Forest is the only operator and the State of Alaska is the only surface owner within one-quarter of a mile of the proposed injection area. Forest provided the State a copy of the application for enhanced oil recovery injection.

5. Description of Operation

Injection will occur within the Hemlock Formation ("Hemlock"). The Redoubt Shoal Undefined Oil Pool is being developed under statewide regulations. It has not yet been defined in vertical or regional space.

There are three active wells in the Central fault block. There is no production from the Southern fault block. Pilot waterflood enhanced recovery operations conducted in the Central fault block were authorized by Enhanced Recovery Injection Order No. 2 in August 2004. During those pilot operations, from March 2005 through September 2007, Forest utilized the RU #6 well to inject 1.3 million barrels of authorized fluids into the Hemlock and recovered 652,000 barrels of oil.

The operator plans to progressively expand development within the RU, using new and re-drilled wells from the Osprey platform. However, development options will ultimately be determined by field performance and economic factors. To facilitate reservoir management and field development, surveillance data will be collected on an ongoing basis through static bottom-hole pressure surveys, production logging, injection logging and production well testing.

6. Hydrocarbon Recovery

The estimated original oil in place ("OOIP") for the RU is 54 million barrels of oil ("MMBO"): 30 MMBO in the Central fault block and 24 MMBO in the

Southern fault block. Primary recovery from the Hemlock within the RU is expected to be 6% of the OOIP. Results of the pilot project suggest that waterflood operations will increase recovery by an additional 5% to 7% of the OOIP.

7. Geologic Information

The Hemlock reservoir within the RU resulted from fluvial deposition in meandering, coalescing stream channels. It consists of interbedded fine-grained to medium-grained sand, gravels, pebble conglomerates, dense silts and scattered thin coal beds. Conventional core analysis indicates that there are at least six lithofacies within the Hemlock.

The Redoubt Shoal Undefined Oil Pool accumulated in a northeast-trending anticline that is bound to the west by east-dipping reverse faults. The anticline is transected by several southeast-trending, normal faults.

Core data and well logs were used to estimate rock properties. Porosity is intergranular with well-cemented and competent rock. Clay volume ranges from 9% to 20% of rock volume and appears to be dispersed. Reservoir facies consist of pebble conglomerate (porosity 7% to 13%), pebble-gravel sandstone (porosity 10% to 16%), medium-grained to coarse-grained sandstone (porosity 10% to 16%) and fine-grained sandstone (porosity 12% to 14%). Permeability ranges from 0.1 millidarcy to several hundred millidarcies.

The oil from the Hemlock at RU has a gravity of approximately 26.5° API, a gas-oil ratio of 250 standard cubic feet per stock tank barrel, and a bubble point pressure of 1,490 pounds per square inch absolute (“psia”).

Upper confinement will result from an interval of tuffaceous siltstone and coal that lies at the top of the Hemlock. This interval is laterally continuous and ranges in thickness from 40’ to 80’. Lower confinement will result from a series of laterally continuous, tuffaceous siltstone and claystone layers that lie at and near the base of the Hemlock. The aggregate thickness of these layers ranges from 40’ to 50’.

8. Well Logs

The RU well logs are on file with the Commission.

9. Mechanical Integrity and Well Design of Injection Wells

The only injection well being used for EOR is RU #6, which has been injecting since March 2005 in accordance with Enhanced Recovery Injection Order 2 (“ERIO 2”). This well was converted from a producer to an injector in accordance with Commission regulations. There is no indication of any mechanical integrity issues with this well. Additional injection wells will be new or re-drilled wells.

10. Type of Fluid / Source

Fluids requested for injection are the following:

- a. produced Hemlock RU water;
- b. treated sanitary waste;
- c. treated gray water from platform and camp living facilities;
- d. produced Hemlock water from the West McArthur River Oil Pool;
- e. storm water from secondary containment areas at the Kustatan Production Facility and the West McArthur River Production Facility;
- f. deck drainage from the Osprey Platform; and
- g. produced water from the gas wells in the West Foreland field.

11. Water Compatibility with Formation

Injection performance data was collected during the pilot project authorized by ERIO 2. The compatibility information provided in conjunction with the ERIO 2 pilot project is incorporated by reference in this order.

12. Injection Rates and Pressures, Fracture Information

Injection rates for the pilot injection project using the RU #6 well range from 700 barrels of water per day to 2,400 barrels of water per day. Injection rates will increase as more production is brought online and more injection wells are added. Injection pressure typically runs between 3,000 psi and 4,600 psi and is limited to 5,000 psi by the pump at the Kustatan Production Facility. The injection rate and pressure history for the RU #6 well indicate that injection is occurring below the fracture pressure of the Hemlock and, more importantly, the confining intervals.

13. Freshwater Exemption

Six Hemlock water samples, from 4 wells, were collected and analyzed. The samples were collected from the RU #2, RU #5A, RU #6, and RU #7 wells. Total dissolved solids averaged 11,060 mg/l, with a range of 8,250 mg/l to 15,800 mg/l.

14. Mechanical Condition of Adjacent Wells

The mechanical integrity of each well in the Central fault block was analyzed. These analyses and the review of data gathered associated with ERIO 2 indicate that the mechanical integrity of these wells is acceptable. Injection performance data gathered during the operations authorized under ERIO 2 indicate no well mechanical integrity problems. There are two wells in the Southern fault block, both of which are shut in, and there is no indication of mechanical integrity issues with either well. The Southern fault block wells must be worked-over or side-tracked or new wells must be drilled to begin production and enhanced recovery operations in this fault block.

In addition to the above active or shut in wells, five wells (three in the Central fault block, one in the Southern fault block, and one in the Northern fault block, which is outside the proposed project area) penetrate the Hemlock. These wells have been plugged back and are no longer open to the Hemlock, and no integrity issues have been identified with respect to them.

## CONCLUSIONS

1. The application requirements of 20 AAC 25.402 are met.
2. Water injection will significantly improve recovery.
3. There are no known sources of freshwater in the area proposed for the development of the Redoubt Shoal Undefined Oil Pool. Therefore, a freshwater aquifer exemption is not required.
4. The proposed injection operations will be conducted in permeable strata, which can accept injected fluids at pressures below the fracture pressures of the confining strata.
5. Injected fluids will be confined within the receiving interval by impermeable lithology, cement isolation of the wellbore and operating conditions.
6. Compatibility testing and actual injection performance data obtained during the pilot project authorized by ERIO 2 demonstrate that the proposed injection fluids are compatible with the Hemlock.
7. Reservoir and well surveillance, coupled with regularly scheduled mechanical integrity tests, will help ensure the proper performance of the enhanced oil recovery project and disclose possible abnormalities.
8. The proposed injection fluids are compatible with the native fluids and rock properties of the Hemlock.

### **NOW, THEREFORE, IT IS ORDERED** that:

The underground injection of fluids for pressure maintenance and enhanced oil recovery is authorized in the Hemlock within the Affected Area, subject to the following rules and the requirements of 20 AAC 25 (to the extent not superseded by these rules).

#### **Affected Area:**

##### **Seward Meridian**

Township/Range	Section	Portions
T07N R13W	7	SW/4 of SW/4
	17	SW/4; SW/4 of NW/4; W/2 of SE/4; SE/4 of SE/4
	18	W/2; SE/4; W/2 of NE/4; SE/4 of NE/4
	19	All
	20	W/2; NE/4; W/2 of SE/4; NE/4 of SE/4
	21	W/2 of NW/4; NE/4 of NW/4
	29	W/2 of NW/4; NE/4 of NW/4; NW/4 of SW/4

	30	All
	31	NW/4; NW/4 of NE/4
T07N R14W	13	E/2 of NE/4; E/2 of SE/4; SW/4 of SE/4
	23	SE/4 of SE/4
	24	E/2; SW/4; SE/4 of NW/4
	25	All
	26	E/2; SW/4; SE/4 of NW/4
	34	E/2 of NE/4; NE/4 of SE/4
	35	N/2; SE/4; N/2 of SW/4
	36	N/2; SW/4; N/2 of SE/4; SW/4 of SE/4

**Rule 1: Authorized Injection Strata for Enhanced Recovery**

Authorized fluids may be injected for purposes of pressure maintenance and enhanced recovery within the Redoubt Shoal Undefined Oil Pool into strata that are common to, and correlate with, the interval from 14,140' to 14,945' MD in the RU #1 well in the Central fault block and the interval from 14,365' to 15,222' MD in the RU #2 well in the Southern fault block.

**Rule 2: Fluid Injection Wells**

The underground injection of fluids must be through a well that has been permitted for drilling as a service well for injection in conformance with 20 AAC 25.005, or through a well approved for conversion to a service well for injection in conformance with 20 AAC 25.280 and 20 AAC 25.412

**Rule 3: Authorized Fluids for Enhanced Recovery**

The following fluids are authorized for injection:

- a. produced Hemlock RU water;
- b. treated sanitary waste;
- c. treated gray water from platform and camp living facilities;
- d. produced Hemlock water from the West McArthur River Oil Pool;
- e. storm water from secondary containment areas at the Kustatan Production Facility and the West McArthur River Production Facility;
- f. deck drainage from the Osprey Platform; and
- g. produced water from the gas wells in the West Foreland field.

**Rule 4: Authorized Injection Pressure for Enhanced Recovery**

- a. Injection pressures must be maintained so that injected fluids do not fracture or migrate into the confining strata.
- b. If injected fluids fracture or migrate into the confining strata, the operator must immediately shut in the injection wells. Injection may not be restarted unless approved by the Commission.

**Rule 5: Monitoring Tubing-Casing Annulus Pressure**

The tubing and casing annuli pressures of each injection well must be monitored at least daily, except if prevented by an extreme weather condition, emergency situation, or similar unavoidable circumstance. The results shall be made available to the Commission upon request.

**Rule 6: Demonstration of Tubing/Casing Annulus Mechanical Integrity**

The mechanical integrity of an injection well must be demonstrated before injection begins, and before returning a well to service following a workover affecting mechanical integrity. A Commission-witnessed mechanical integrity test must be performed after injection is commenced for the first time in a well, to be scheduled when injection conditions (temperature, pressure, rate, etc.) have stabilized. Subsequent tests must be performed at least once every four years thereafter. The Commission must be notified at least 24 hours in advance of each mechanical integrity test to enable a Commission representative to witness the test. Unless an alternate means is approved by the Commission, mechanical integrity must be demonstrated by a tubing/casing annulus pressure test using a surface pressure equal to the maximum anticipated injection pressure that shows stabilizing pressure and does not change more than 10 percent during a 30-minute period. The results of all mechanical integrity tests must be provided to the Commission.

**Rule 8: Well Integrity Failure and Confinement**

Whenever any pressure communication, leakage or lack of injection zone isolation is indicated by an injection rate, operating pressure observation, test, survey, log, or other evidence, the Operator shall notify the Commission by the next business day and submit a plan of corrective action (on Form 10-403) for Commission approval. The Operator shall immediately shut in the well if continued operation would be unsafe, would threaten contamination of freshwater, or if so directed by the Commission. Monthly reports of daily tubing and casing annuli pressures and injection rates must be provided to the Commission for all injection wells indicating well integrity failure or a lack of injection zone isolation.

Every five years from the effective date of this order, the operator shall analyze the mechanical integrity of all potentially affected wells and provide a report to the Commission.

**Rule 9: Notification of Improper Class II Injection**

The injection of fluids other than those listed in Rule 3 without prior Commission authorization is improper Class II injection. Upon discovering any such event, the operator must immediately notify the Commission, provide details of the event, propose actions to prevent a recurrence, and take any other action required by the Commission. Compliance with the notification requirements of any other State or Federal agency remains the operator's responsibility.

**Rule 10: Plugging and Abandoning Fluid Injection Wells**

An injection well within the Affected Area must not be plugged and abandoned unless such action is approved by the Commission in accordance with 20 AAC 25.

**Rule 11: Other conditions**

It is a condition of this authorization that the operator complies with all applicable Commission regulations.

The Commission may suspend, revoke, or modify this authorization if any Rule is violated or injected fluids fail or might fail to be confined within the designated injection strata.

**Rule 12: Administrative Actions**

Upon application or its own motion, the Commission may, without notice and public hearing (unless such are otherwise required), administratively waive the requirements of any Rule or administratively amend this Order as long as the change does not promote waste or jeopardize correlative rights, is based on sound engineering and geoscience principles, and will not result in an increased risk of fluid movement out of the designated injection strata or into freshwater.

**DONE at Anchorage, Alaska, and dated January 31, 2008.**



John K. Norman, Chairman  
Alaska Oil and Gas Conservation Commission

Cathy P. Foerster, Commissioner  
Alaska Oil and Gas Conservation Commission

AS 31.05.080 provides that, within 20 days after written notice of the entry of an order, a person affected by the order may file with the Commission an application for reconsideration. To be timely filed, the application must be received by 4:30 p.m. on the 23<sup>rd</sup> day following the date of the order, or the next working day if the 23<sup>rd</sup> day is a state holiday or weekend. The Commission shall grant or refuse the application in whole or in part within 10 days after it is filed. The Commission can refuse the application by not acting on it within the 10-day period. A person who submitted an application for reconsideration has 30 days from the date the Commission refused the application or mailed (or otherwise distributed) an order on reconsideration, both being the final order of the Commission, to appeal the decision to Superior Court. Where an application for reconsideration is denied by nonaction of the Commission, the 30-day period for appeal to Superior Court runs from the date on which the application is deemed denied (*i.e.*, 10<sup>th</sup> day after the application for reconsideration was filed).