

**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 BP ) Area Injection Order No. 26**  
**EXPLORATION (ALASKA) INC. for )**  
**an order authorizing underground ) Prudhoe Bay Field**  
**injection of fluids for enhanced oil ) Schrader Bluff Oil Pool**  
**recovery in a proposed Orion Oil ) Orion Development Area**  
**Pool, Prudhoe Bay Field, North )**  
**Slope, Alaska ) January 5, 2004**

**IT APPEARING THAT:**

1. By letter and application dated October 6, 2003, BP Exploration (Alaska) Inc. ("BPXA") in its capacity as Unit Operator of the Prudhoe Bay Unit ("PBU") requested an order from the Alaska Oil and Gas Conservation Commission ("Commission") authorizing the injection of fluids for enhanced oil recovery in a proposed Orion Oil Pool within the PBU.
2. Notice of a public hearing was published in the Anchorage Daily News on October 20, 2003.
3. The Commission held a public hearing December 4, 2003 at 9:00 AM at the Alaska Oil and Gas Conservation Commission at 333 West 7<sup>th</sup> Avenue, Suite 100, Anchorage, Alaska.

**FINDINGS:**

1. Operator:  
BPXA is operator of the property in the area in which injection is proposed.
2. Project Area Pool and Formations Authorized for Enhanced Recovery:  
Enhanced recovery injection for the Orion development is proposed within the Schrader Bluff Oil Pool. The target injection zones are correlative to Prudhoe Bay Unit well V-201 between the measured depths ("MD") of 4,549 feet and 5,106 feet (Schrader Bluff Formation).

3. Proposed Injection Area:

BPXA requested authorization to inject fluids for the purpose of enhanced recovery operations on lands within Umiat Meridian T12N-R10E, T12N-R11E, T11N-R11E, and T11N-R12E in the Prudhoe Bay Unit.

4. Operators/Surface Owners Notification:

BPXA provided operators and surface owners within one-quarter mile of the proposed area with a copy of the application for injection. The only affected operator is BPXA, operator of Prudhoe Bay Unit and the Milne Point Unit. The State of Alaska, Department of Natural Resources is the only affected surface owner.

5. Description of Operation:

Initial development of the Schrader Bluff Oil Pool in the affected area, referred to in this order as the Orion development area, is planned in three phases, beginning near the crest of the structure and progressively moving toward the outer margins of the pool. Peak production rates are expected to be between 30,000 and 50,000 barrels of oil per day ("BOPD"). Waterflood injection rates are estimated to peak between 100,000 and 125,000 barrels of water per day ("BWPD").

6. Hydrocarbon Recovery:

The Schrader Bluff Oil Pool is estimated to contain 1,070-1,785 million stock tank barrels ("STB") of original oil in place ("OOIP") within the Orion development area, based on exploratory drilling and seismic mapping. Computer simulation results indicate primary recovery within the major sands of the development area is expected to be 5 to 10% of the OOIP, and implementing a waterflood may increase recovery to 20 to 25% of the OOIP.

7. Geologic Information:

- a. Stratigraphy: The Schrader Bluff Oil Pool encompasses reservoirs assigned to the Late Cretaceous-aged Schrader Bluff Formation ("Schrader Bluff"). The Schrader Bluff is divided into two stratigraphic intervals that are designated, from deepest to shallowest, the "O sands" and the "N sands." The O and N sand intervals were deposited in marine shoreface and shallow shelf environments.

The Schrader Bluff O sands are divided into seven separate reservoir intervals that are named, from deepest to shallowest, OBf, OBe, Obd, OBc, OBb, OBa, and OA. Each of these intervals coarsens upward from non-reservoir, laminated muddy siltstone at the base to reservoir-quality sandstone at the top.

The lower portion of the Schrader Bluff N sands is dominated by mudstone and siltstone. However, the sediments coarsen upward, and fine- to medium-grained sandstone is prevalent in the upper part of the N sands. Three reservoir intervals are recognized within the N sands. They are, from oldest to youngest, Nc, Nb, and Na.

- b. Structure Overview: The structural dip ranges from 1 to 4 degrees to the east and northeast, and is broken by three sets of normal faults from Northwest to Southeast, North to South, and East to West. The Northwest to Southeast fault trend has throws up to 200 feet. The North to South striking faults, downthrown to the west and east, have throws of up to 100 feet. East to West faults are less common, and form the reservoir trap on the southwestern side of the Orion development area.
- c. Confining Intervals: The upper contact between the N Sands and the overlying Prince Creek Formation is a generally an abrupt transition from sandstone to mudstone forming the upper confinement. The Lower Prince Creek Formation (Ma-Mc sands) typically contains over 30 feet of laterally continuous shales and mudstones. Mudstones and muddy siltstones up to 1000 feet thick provide the basal confinement of the Schrader sandstones.

8. Well Logs:

The logs of existing injection wells are on file with the Commission.

9. Mechanical Integrity and Well Design of Injection Wells:

The casing programs for L-103i, L-111i, L-115i, L-117i, and V-105i were permitted and completed in accordance with 20 AAC 25.030. These wells are designed to allow dual injection with packers installed for zonal isolation. Cement-bond-logs have been run and demonstrate isolation of injected fluids to the Kuparuk River and Schrader Bluff Formations. Mechanical integrity tests have been performed on all wells.

10. Type of Fluid / Source:

Fluids requested for injection are:

- (a) produced water from Prudhoe Bay Unit production facilities for the purposes of pressure maintenance and enhanced recovery;
- (b) source water from the Prince Creek Formation (also known as the Ugnu formation);
- (c) tracer survey fluid to monitor reservoir performance;
- (d) fluids injected for purposes of stimulation per 20 AAC 25.280(a)(2);
- (e) source water from the Seawater Treatment Plant; and
- (f) non-hazardous water collected from well-house cellars and standing ponds.

11. Water Composition and Compatibility with Formation:

The composition of produced water will be a mixture of connate water and injection water, and will change over time depending on the rate and composition of injection water. Based on analyses of Polaris water samples, no significant compatibility problems are expected between connate water and injection water.

12. Injection Rates and Pressures, Fracture Information:

A stress test performed in well S-213 indicates a fracture gradient of 0.66 psi/ft for the basal mudstone of the OBa interval. This is a typical silty mudstone within the Polaris Oil Pool. Minimum stress values for the sandstones show an average fracture gradient of 0.61 psi/ft, indicating a stress contrast of approximately 255 psi between reservoir sandstone and confining mudstone. This agrees with the stress contrast of 300 psi estimated using a dipole sonic log from well W-200 (or a fracture gradient in the mudstones of approximately 0.67.) On the basis of this test information, the Commission ordered (Area Injection Order 25, dated 2/4/03) that Polaris Oil Pool normal injection pressure be limited to 0.67 psi/ft to ensure injection stays within the intended injection interval.

Subsequently, BPXA performed step rate water injection tests in two Polaris wells, W-212i and S-215i. The Schrader Bluff Formation in these wells should be comparable to that in the Orion development area. Injection rates of up to 10000 BWPD and injection gradients of 0.75-0.8 psi/ft were achieved. Temperature surveys showed the water to be confined to the intended intervals, with no fluid movement behind pipe. This pressure exceeded that obtained with the stress test described above.

The Commission granted approval (see Enhanced Recovery Injection Order No. 1) of a pilot water injection test to be conducted in well V-105. Confirmation of vertical confinement within the Schrader Bluff Oil Pool is an objective of the pilot project. BPXA requested a maximum surface injection pressure of 2800 psi with an average surface operating pressure of 2200 psi. The injection rate will be controlled by flow restriction at the downhole injection mandrel, and hence pressure will be restricted adjacent to the perforations in the Schrader Bluff formation.

13. Freshwater exemption:

Aquifer Exemption Order #1, dated July 11, 1986 exempts all portions of aquifers beneath the Western Operating Area of the Prudhoe Bay Unit, including the area designated for the proposed waterflood pilot project.

14. Mechanical Condition of Adjacent Wells:

Adjacent wells to the existing proposed injectors have been reviewed for mechanical isolation. The records of cement jobs and cement bond logs were reviewed. All wells appear to have mechanical isolation between the Schrader Bluff and all other intervals.

**CONCLUSIONS:**

1. The application requirements of 20 AAC 25.402 have been met.
2. Water injection will significantly improve recovery.
3. Dual injection is appropriate so long as mechanical isolation of the pools within the wellbore is assured and water injection is allocated between the pools.
4. The proposed injection operations will be conducted in permeable strata, which can reasonably be expected to accept injected fluids at pressures less than the fracture pressure of the confining strata.
5. Injected fluids will be confined within the appropriate receiving intervals by impermeable lithology, cement isolation of the wellbore and appropriate operating conditions.
6. Injection pressures will be above the fracture gradient of Schrader Bluff Sandstones. Pressure should be maintained below the fracture gradient of the confining mudstones. Results from the pilot water injection test in Well V-105 will be used to determine if injection pressure may be increased above 0.67 psi/ft.
7. Reservoir and well surveillance, coupled with regularly scheduled mechanical integrity tests will demonstrate appropriate performance of the enhanced oil recovery project or disclose possible abnormalities.
8. Sufficient information has been provided to authorize five (5) existing wells to inject water into the Schrader Bluff Oil Pool for the purposes of pressure maintenance and enhanced oil recovery. Authorization to inject in additional wells subject to the provisions of this order is appropriate upon verification of the mechanical condition of all wells within a one-quarter mile radius.

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

1. Enhanced Recovery Injection Order No. 1 dated October 14, 2003 continues in effect according to its terms.
2. The underground injection of fluids for enhanced oil recovery is authorized in the area defined below, subject to the following rules and the statewide requirements under 20 AAC 25 (to the extent not superseded by these rules).

**Umiat Meridian**

<u>Township Range, UM</u>	<u>Lease</u>	<u>Sections</u>
T12N-R10E	ADL 025637	13 and 24 N/2
T12N-R11E	ADL 047446	17, 18, 19, and 20

	ADL 047447	16 S/2 and NW/4 and S/2 NE/4, 21, and 22
	ADL 028238	25 SW/4, 26, 35, and 36
	ADL 028239	27, 28, 33 E/2 and N/2 NW/4, and 34
	ADL 047449	29 N/2 and SE/4, and 30 N/2 NE/4
T11N-R11E	ADL 028240	1, 2, 11 E/2 and E/2 NW/4, and 12
	ADL 028241	3 N/2 and N/2 S/2, and 4 NE/4 N/2 SE/4
	ADL 028245	13 N/2 and SE/4, 14 E/2 NE/4, and 24 E/2 NE/4
T11N-R12E	ADL 047450	7, and 8 S/2 and NW/4
	ADL 028263	16 SW/4 and S/2 NW/4, and 21 SW/4 and S/2 NW/4 and NW/4 NW/4 and W/2 SE/4
	ADL 028262	17, 18, 19 N/2 and SE/4 and N/2 SW/4, and 20
	ADL 047452	28 W/2 and W/2 E/2
	ADL 047453	29 N/2 and N/2 SE/4

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

Fluids appropriate for enhanced oil recovery may be injected for purposes of pressure maintenance and enhanced recovery within the Orion development area into strata that are common to, and correlate with, the interval between measured depths 4,549 feet MD and 5,106 feet MD in the PBU V-201 well and between the measured depths of 4174 feet and 4800 feet in Milne Point Unit well A-1.

**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**

Fluids authorized for injection include:

- a. produced water from Prudhoe Bay Unit production facilities for the purposes of pressure maintenance and enhanced recovery;
- b. tracer survey fluid to monitor reservoir performance;
- c. source water from a sea water treatment plant;
- d. source water from the Prince Creek (Ugnu) Formation; and
- e. non-hazardous filtered water collected from Schrader Bluff Oil Pool well house cellars and well pads in the Orion development area.

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

- a. Injection operations must ensure that injected fluids do not fracture or migrate out of the approved injection stratum.
- b. Injection pressure shall be limited to .67 psi/ft, except to the extent allowed per Enhanced Recovery Injection Order No. 1 or as otherwise approved by the Commission.
- c. If fluids are found to be fracturing the confining zone or migrating out of the approved injection interval, the Operator must immediately shut in the injector(s). Injection may not be restarted unless approved by the Commission.

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

Tubing-casing annulus pressures within each injection well must be checked and recorded daily to ensure there is no pressure communication or leakage in any casing, tubing or packer.

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

A schedule must be developed and coordinated with the Commission that ensures that the tubing-casing annulus for each injection well is pressure tested prior to initiating injection, following well workovers affecting mechanical integrity, and at least once every four years thereafter.

**Rule 7 Multiple Completion of Water Injection Wells**

- a. Water injectors may be completed to allow for injection in multiple pools within the same wellbore so long as mechanical isolation between pools is demonstrated and approved by the Commission.
- b. Prior to initiation of co-mingled injection, the Commission must approve methods for allocation of injection to the separate pools.
- c. Results of logs or surveys used for determining the allocation of water injection between pools, if applicable, must be supplied in the annual reservoir surveillance report.
- d. An approved injection order is required prior to commencement of injection in each pool.

**Rule 8 Notification of Improper Class II Injection**

Injection of fluids other than those listed in Rule 2 without prior authorization is considered improper Class II injection. Upon discovery of such an event, the operator must immediately notify the Commission, provide details of the operation, and propose actions to prevent recurrence. Additionally, notification requirements of any other State or Federal agency remain the operator's responsibility.

**Rule 9 Plugging and Abandonment of Fluid Injection Wells**

An injection well located within the affected area must not be plugged or abandoned unless approved by the Commission in accordance with 20 AAC 25.

**Rule 10 Other conditions**

- a. It is a condition of this authorization that the operator complies with all applicable Commission regulations.
- b. The Commission may suspend, revoke, or modify this authorization if injected fluids fail to be confined within the designated injection strata.

**Rule 11 Administrative Actions**

Unless notice and public hearing is otherwise required, the Commission may administratively waive the requirements of any rule stated above or administratively amend any rule 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 into freshwater.

DONE at Anchorage, Alaska and dated January 5, 2004.

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Sarah Palin, Chair  
Alaska Oil and Gas Conservation Commission

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Daniel T. Seamount, Jr., Commissioner  
Alaska Oil and Gas Conservation Commission

AS 31.05.080 provides that within 20 days after receipt of written notice of the entry of an order, a person affected by it must file with the Commission an application for rehearing. A request for rehearing must be received by 4:30 PM on the 23<sup>rd</sup> day following the date of the order, or next working day if a holiday or weekend, to be timely filed. The Commission shall grant or refuse the application in whole or in part within 10 days. The Commission can refuse an application by not acting on it within the 10-day period. An affected person has 30 days from the date the Commission refuses the application or mails (or otherwise distributes) an order upon rehearing, both being the final order of the Commission, to appeal the decision to Superior Court. Where a request for rehearing is denied by non-action of the Commission, the 30-day period for appeal to Superior Court runs from the date on which the request is deemed denied (i.e., 10<sup>th</sup> day after the application for rehearing was filed).