

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

**Re: THE APPLICATION OF BP) Area Injection Order No. 24
EXPLORATION (ALASKA) INC.)
for an order to allow for) Prudhoe Bay Field
underground injection of fluids) Borealis Oil Pool
within the Borealis Oil Pool,)
Prudhoe Bay Field, North Slope,)
Alaska) May 29, 2002**

IT APPEARING THAT:

1. By letter dated February 28, 2002, BP Exploration (Alaska), Inc. ("BPXA") in its capacity as Borealis Operator and Unit Operator of the Prudhoe Bay Unit ("PBU") requested an order from the Alaska Oil and Gas Conservation Commission ("Commission") to define a proposed Borealis Oil Pool within the PBU and to prescribe rules governing the development and operation of the pool. Concurrently, BPXA requested authorization for water injection to enhance recovery from the Borealis Oil Pool.
2. The Commission published notice of opportunity for public hearing in the Anchorage Daily News on March 4, 2002.
3. The Commission held a public hearing April 5, 2002 at 9:00 am, that was continued on April 11, 2002 at 9:00 am, and May 2, 2002 at 9:15 am, at the Alaska Oil and Gas Conservation Commission at 333 West 7th Avenue, Suite 100, Anchorage, Alaska 99501.
4. The Commission received no protests to BPXA's application for the Area Injection Order.
5. 20 AAC 25.460 authorizes the Commission to issue an order permitting the underground injection of fluids on an area basis for wells within the same field, facility site, reservoir, project, or similar area.
6. Concurrent with this Area Injection Order 24 ("AIO 24") the Commission is issuing Conservation Order 471 to govern the development and operation of the Borealis Oil Pool.

FINDINGS:

1. BPXA is the operator of the Borealis Oil Pool, in the Prudhoe Bay Field.

2. Project Area and Pool Description:

- a. Proposed Injection Area: BPXA requested authorization to inject fluids for the purpose of enhanced recovery operations in the Borealis Oil Pool, Prudhoe Bay Field, North Slope Alaska.
- b. Borealis Oil Pool: The Borealis Oil Pool is defined as the accumulations of hydrocarbons common to and correlating with the interval between 6534' and 6952' measured depth ("MD") in the West Kuparuk State 1 well.

3. Operators/Surface Owners:

BPXA provided all operators and surface owners within one-quarter mile of the Borealis Oil Pool with a copy of the application for injection. Those operators are: BPXA, operator of MPU and Prudhoe Bay Unit, Phillips Alaska, Inc., operator of the Kuparuk River Unit, and J. Andrew Bachner. The State of Alaska, Department of Natural Resources is the only affected surface owner.

4. Description of Operation:

Two L Pad injectors have been drilled and completed and should be available to begin water injection upon approval of this Area Injection Order. Development plans include drilling a series of production and injection wells beginning at L Pad then moving to V Pad. Between 20-50 production and injection wells are projected. Additional wells may be drilled from Z Pad. Peak water injection is expected to be between 20,000 and 40,000 barrels of water per day ("bwpd"). Produced water from GC-2 will be utilized for injection. Peak annualized production is expected to be between 10,000 and 15,000 barrels of oil per day ("bopd").

5. Geologic Information:

- a. Available Data: Seismic data and well records have been used to characterize the Borealis Pool accumulation.
- b. Stratigraphy: The affected reservoir is the early Cretaceous-aged Kuparuk River Formation ("Kuparuk"), which consists of very fine to medium grained quartz-rich sandstone, interbedded with siltstone and mudstone.

Within the Borealis Oil Pool, BPXA divides the Kuparuk into four stratigraphic intervals that are designated, from oldest to youngest, A, B, C and D. The C interval contains the primary reservoir sands of the Borealis Pool, and secondary accumulations occur in the A sands.

- c. Structure Overview: Within the Borealis Oil Pool, the top of the Kuparuk lies between 6,200 and 6,900 feet true vertical depth subsea ("TVD subsea"). The structure of interest is a northwest-to-southeast trending antiform that is broken by two sets of faults: an older set of northwest-southeast trending faults and a younger set of north-south striking faults. The complexity of faulting within the Borealis Pool suggests the reservoir may be divided into separate compartments.

- d. Trapping Mechanism: Hydrocarbons are structurally and stratigraphically trapped within the Borealis Oil Pool. The oil accumulation is bounded to the southwest by northwest and north-south trending faults and the oil/water contact ("OWC"). To the northeast, the accumulation is limited by the down-dip intersection of the top of the reservoir with the OWC and with a series of north-south trending faults. To the southeast, the reservoir is truncated by an intra-formational unconformity and onlap onto the Prudhoe high. To the northeast, the reservoir sand intervals degrade to non-reservoir quality.
 - e. Confining Intervals: Upper confinement for the Kuparuk reservoir sands within the Borealis Pool is provided by the impermeable shales and siltstones of the Kuparuk D interval, the Kalubik Formation, and the HRZ, which have a combined thickness of that exceeds 300 feet. Lower confinement is provided by shale and siltstone of the Miluveach and Kingak Formations.
6. Well Logs: The logs of existing injection wells are on file with the Commission.
 7. Mechanical Integrity: Cement bond logs have been run on wells L-115 and L-117; both demonstrate isolation of injected fluids to the Kuparuk. The L-115 and L-117 wells are completed in accordance with 20 AAC 25.412.

A state witnessed MIT is required on wells prior to injection startup. In drilling all Borealis injection wells, the casing is pressure tested in accordance with 20 AAC 25.030. Injection well tubing/casing annulus pressures will be monitored and recorded on a regular basis. The Borealis Pool injection wells will be designed to comply with the requirements specified in 20 AAC 25.412.

8. Injection Fluids:

Type of Fluid/Source: BPXA is requesting authorization to inject the following fluids in the Borealis Oil Pool within the Prudhoe Bay Field:

- a. produced water from Borealis or Prudhoe Bay Unit production facilities for the purposes of pressure maintenance and enhanced recovery;
- b. non-hazardous water collected from Borealis well house cellars and standing ponds;
- c. source water from a seawater treatment plant.

Water Composition and Compatibility with Formation: Water composition of Borealis and GC-2 waters were provided. Produced water from GC-2 will be used as the primary water source for Borealis injection. Produced water from GC-2 is used in injection programs at Aurora and similar water from GC-1 is used for injection programs at Midnight Sun. These Kuparuk developments, though different pools, have had no compatibility issues between source water and injection zones of interest. Core, log and pressure-buildup analyses indicate no significant problems with clay swelling or compatibility with in-situ fluids.

BPXA analysis of the NWE 1-01 and L-101 cores indicates relatively low clay

content (5 - 35% by volume), primarily in the form of illite. Petrographic analysis indicates that clay volumes in the better quality sand sections (>20 md) are in the range of 3 - 6%. Clay volumes increase to approximately 6 - 12% in rock with permeabilities in the range of 10 - 20 md. Below 10 md, clay volumes increase to a range of 12 - 20%. Most of the identified clay is present as intergranular matrix, having been intermixed with the sand through burrowing. The overall clay composition is a mixture of roughly equal amounts of kaolinite, illite and mixed layer illite/smectite. No chlorite was reported during petrographic analysis.

The presence of iron-bearing minerals suggests that the use of strong acids should be avoided in breakdown treatments, spacers, etc.

Water from the seawater treatment plant has been successfully used for injection within the Kuparuk of the Pt. McIntyre Oil Pool.

Geochemical modeling indicates that a combination of GC-2 produced water and connate water is likely to form calcium carbonate and barium sulfate scale in the production wells and downstream production equipment. Scale precipitation will be controlled using scale inhibition methods similar to those used at Kuparuk River Unit and Milne Point Unit.

The maximum water injection is estimated at 20,000 to 40,000 bwpd.

9. Injection Pressures: The expected average surface water injection pressure for the project is 2300 psig. The estimated maximum surface injection pressure is 2800 psig. The resulting bottom hole pressure will be limited by hydraulic pressure losses in the well tubing, with a maximum expected bottom hole pressure of 5800 psi.
10. Fracture Information: The L-101 well was fracture stimulated in the Kuparuk C sand at the Borealis Pool, with a formation breakdown pressure of 4290 psi, which calculates to a fracture gradient of 0.65 psi/ft at initial reservoir conditions. This data agrees with data from offset fields containing wells completed in the Kuparuk.

The Kalubik and HRZ shales overlie the Kuparuk at the Borealis Pool. The HRZ is a thick shale sequence, which tends to behave as a plastic medium and can be expected to contain significantly higher pressures than sandstones of the Kuparuk. Mechanical properties determined from log and core data for the HRZ and Kalubik intervals indicate a fracture gradient from approximately 0.8 to 0.9 psi/ft. Dipole Sonic evaluations of these strata have measured values equal to or greater than 0.99 psi/ft confining stress.

The Kuparuk is underlain by the Miluveach/Kingak shale sequence. A leakoff test in the Kingak shale formation demonstrated leakoff at a gradient of approximately 0.85 psi/ft.

The expected maximum injection pressure in the Borealis wells will not initiate or propagate fractures through the confining strata, and, therefore, will not allow injection or formation fluid to enter any freshwater strata. There is no evidence of

injection out of zone for similar Kuparuk waterflood operations on the North Slope. Water injection operations at the Borealis Pool are expected to be above the Kuparuk parting pressure to enhance injectivity and improve recovery of oil. Fracture propagation models confirm that injection above the parting pressure will not exceed the integrity of the confining zone.

11. Aquifer Exemption: On July 11, 1986, the Commission approved Aquifer Exemption Order 1 ("AEO-1") for Class II injection activities within the Western Operating Area of the Prudhoe Bay Unit. The Borealis Pool is entirely within the area covered by AEO-1.
12. Hydrocarbon Recovery: Recovery from waterflooding will be in excess of 10% of the original oil in place, relative to primary depletion. Further discussion of hydrocarbon recovery and reservoir information are contained in CO 471 and BPXA's application for pool rules and area injection order.
13. Mechanical Condition of Adjacent Wells: All wells drilled into the Borealis Oil Pool have been drilled in conformance with Commission regulations. Two wells were drilled in 1998 and the remaining wells since 2001. Completion reports that include cement records are on file with the Commission and contain sufficient information to verify the mechanical condition of wells within a one-quarter radius of a proposed injection well.

CONCLUSIONS:

1. The application requirements of 20 AAC 25.402 have been met.
2. An area injection order is appropriate for the proposed water injection project for the Borealis Pool project under 20 AAC 25.460.
3. Information provided in this application and within the concurrent application for pool rules shows that water injection will significantly improve recovery.
4. The annual surveillance report required by CO 471 will keep the Commission apprised of the performance of the injection project and EOR process evaluation.
5. Injection of enhanced recovery fluids at pressures above fracture gradient may be necessary in order to provide sufficient pressure support. The fracture gradient of the Borealis Oil Pool is significantly below the recorded leakoff pressures of confining shale intervals and as such the water will preferentially stay within zone.
6. Injected fluids will be confined within the appropriate receiving intervals by impermeable lithology, cement isolation of the wellbore and appropriate operating conditions.
7. Reservoir surveillance, operating parameter surveillance and mechanical integrity tests will demonstrate appropriate performance of the enhanced oil recovery project or disclose possible abnormalities.

8. The Borealis Oil Pool injection wells are designed to comply with the mechanical integrity requirements specified in 20 AAC 25.412.

NOW, THEREFORE, IT IS ORDERED that the underground injection of fluids pursuant to the project described in BPXA's application is permitted in the following area, subject to the conditions, limitations, and requirements established in the rules set out below and statewide requirements under 20 AAC 25 (to the extent not superseded by these rules or the Borealis Oil Pool rules):

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- T12N-R10E: ADL 25637 Sec 13, 24
- T12N-R11E: ADL 47447 Sec 16 (SW/4 and W/2 NW/4 and W/2 SE/4), 21,
22 SW/4 and W/2 NW/4 and S/2 SE/4
ADL 47446 Sec 17, 18, 19, 20
ADL 28238 Sec 26 S/2 and W/2 NW/4 and SE/4 NW/4, 35, 36
ADL 28239 Sec 27, 28, 33, 34
ADL 47449 Sec 29, 30, 32
- T11N-R11E: ADL 28240 Sec 1, 2, 11, 12
ADL 28241 Sec 3, 4, 9, 10
ADL 28245 Sec 13, 14, 24
ADL 28244 Sec 15
ADL 28246 Sec 25
- T11N-R12E: ADL 28261 Sec 9 W/2
ADL 47450 Sec 5 S/2, 6 S/2 and NW/4 and W/2 NE/4, 7, 8
ADL 28263 Sec 16 W/2, 21 W/2
ADL 28262 Sec 17, 18, 19, 20
ADL 47452 Sec 28 W/2, 33 W/2
ADL 47453 Sec 29, 30, 31, 32
- T12N-R12E: ADL 28259 Sec 31 W/2 and W/2 SE/4

Rule 1 Authorized Injection Strata for Enhanced Recovery

Injection of authorized fluids for purposes of pressure maintenance and enhanced recovery is permitted into strata that are common to, and correlate with, the interval between 6534' and 6952' MD in the West Kuparuk State #1 well in the Prudhoe Bay Field.

Rule 2 Authorized Injection Fluids

Fluids authorized for injection within the affected area are:

- a. produced water from Borealis or Prudhoe Bay Unit production facilities for the purposes of pressure maintenance and enhanced recovery;
- b. non-hazardous water collected from Borealis well house cellars and standing ponds; and
- c. source water from a seawater treatment plant.

Rule 3 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.

The application to drill or convert a well for injection must be accompanied by sufficient information to verify the mechanical condition of wells within one-quarter mile radius. The information must include cementing records, cement quality log or formation integrity test records.

Rule 4 Monitoring the Tubing-Casing Annulus Pressure Variations

The tubing-casing annulus pressure and injection rate of each injection well must be checked at least weekly to confirm continued mechanical integrity.

Rule 5 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 6 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 7 Other conditions

- a. It is a condition of this authorization that the operator comply 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 8 Administrative Action

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 May 29, 2002.

Cammy Oechsli Taylor, Chair
Alaska Oil and Gas Conservation Commission

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 may file with the Commission an application for rehearing. A request for rehearing must be received by 4:30 PM on the 23rd 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 nonaction 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., 10th day after the application for rehearing was filed).