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

| | | |
|---|---|---|
| Re: **THE APPLICATION OF BP EXPLORATION (ALASKA) INC.** for an order to modify Conservation Order 341D to include the Put River Sandstone Member of the Kalubik Formation in the definition of the Prudhoe Oil Pool | ) | **Conservation Order No. 559** |
| | ) | Prudhoe Bay Field |
| | ) | **Put River Oil Pool** |
| | ) | November 22, 2005 |

**IT APPEARING THAT:**

1. By letter dated August 19, 2005 BP Exploration (Alaska), Inc. ("BPXA"), operator of the Prudhoe Bay Unit, applied for a modification of Conservation Order 341D and Area Injection Order 4C to include the Put River Sandstone Member of the Kalubik Formation within the Prudhoe Oil Pool and to authorize injection for enhanced recovery purposes within that interval.
2. The Alaska Oil and Gas Conservation Commission ("Commission") published notice of opportunity for public hearing in the Anchorage Daily News on September 1, 2005.
3. On September 13 and September 30, 2005 BPXA submitted addenda addressing questions posed by the Commission staff concerning its application.
4. The Commission held a public hearing on this application on October 6, 2005 at the Alaska Oil and Gas Conservation Commission offices at 333 West 7th Avenue, Suite 100, Anchorage, Alaska 99501.
5. The Commission received no protests to or comments on BPXA's application.
6. BPXA submitted additional information to the Commission on November 3, 2005.

**FINDINGS:**

1. **Put River Sandstone – Application Request**

   The Put River Sandstone ("PRS") Member of the Kalubik Formation is located within the Prudhoe Bay Unit and stratigraphically overlies the Prudhoe Oil Pool, as currently defined in Conservation Order No. 341D, in the vicinity of Drill Sites 1, 2, 5, 6, 15, 18, NGI, and WGI. BPXA proposes including the PRS in the Prudhoe Oil Pool. The addition of the PRS is based upon the direct juxtaposition of, and pressure communication with the northern extent of the PRS with the Sag River Formation, which is part of the current Prudhoe Oil Pool. The areal limit of the Prudhoe Oil Pool will remain unchanged. The portion of the PRS in pressure communication with the Sag River Formation was included as part of the Prudhoe Bay (Permo-Triassic) Reservoir in the Prudhoe Bay Unit Agreement.

2. **Put River Sandstone – Stratigraphy and Structure**

   The PRS type section is the 9,638 to 9,719 feet measured depth interval in the Atlantic Richfield-Exxon NGI No. 1 well (API No. 50-029-20171). The type log is the Borehole Compensated Sonic Log, Run 2, dated September 28, 1975.

   The PRS Member of the Kalubik Formation was deposited in the Early Cretaceous geologic time period between 100 and 130 million years before present. The interval lies unconformably above the Jurassic and older strata and conformably below the Cretaceous Highly Radioactive Zone ("HRZ"). The Lower Cretaceous Unconformity (LCU) is the basal unconformity of the PRS. The PRS is in depositional contact with successively older formations that subcrop below the LCU to the northeast in this portion of the Prudhoe Oil Pool.

   The PRS was locally derived from an exposed highland to the northeast and represents an overall marine transgression following a period of erosion. Four vertically significant and laterally extensive sandstone bodies ("Lobes") have been correlated within the PRS interval. They are named the Southern, Central, Western, and Northern lobes and are interbedded within shales of the Kalubik Formation. The Northern Lobe is composed of stratigraphic equivalents of the other three. The remaining three lobes are stratigraphically equivalent to portions of the Northern Lobe. Paleontological evidence confirms the age equivalents of the four sandstone deposits. The locus of deposition for each sandstone lobe was controlled by sediment dispersal and the interplay of erosional and structural paleotopography along the LCU.

   There were two main pulses of sandstone deposition. The first is termed the A2 and A4 sandstones. The A2 sandstone lies directly on the LCU and is thickest in the south. The Southern Lobe is entirely composed of the A2 sandstone and is up to 41 feet thick. The A4 sandstone is separated from the A2 sandstone by a thin

shale/siltstone layer. The Central Lobe is composed entirely of A4 Sandstone where it is up to 22 feet thick.

The B sandstone overlies the A sands and represents the second pulse of coarse-grained deposition. It is up to 75 feet thick and comprises the Western Lobe. The Northern Lobe is composed of both the A and B sandstones. The B sandstone typically lies directly on the A sandstone in the Northern Lobe, with the composite sandstone body up to 69' feet thick.

Normal faulting associated with the Midfield Graben has likely caused the Western Lobe to be divided into a number of pressure compartments with very low permeability between compartments. The Northern and Southern Lobes also have faulting, but the vertical throw of these faults is small and likely does not result in significant compartmentalization. The Central Lobe does not contain significant faulting.

The Northern Lobe of the PRS interval lies directly on the Triassic Sag River Formation. The Sag River Formation is included in the definition of the Prudhoe Oil Pool.

BP's justification to include the PRS within the Prudhoe Oil Pool is based upon the direct juxtaposition of, and pressure communication of the Northern Lobe with the Prudhoe Oil Pool. However, in its southern extent, the Southern, Central, and Western lobes overlie the Jurassic Kingak Shale and are not in hydraulic communication with the Prudhoe Oil Pool.

Rock Properties: Available core data and well logs were used to estimate rock properties and net sandstone volume, with petrophysical log models calibrated to core data. Well control in the PRS interval is abundant in this densely drilled portion of the field. Net pay was determined by a gamma ray cutoff and minimum porosity of 12%. The following provides a summary of rock properties by sandstone/area:

| Sandstone | Porosity, % | Permeability, md | Water Saturation, % |
|---|---|---|---|
| Southern A2 | 19 | 173 | 46 |
| Central A4 | 19 | nm | 46 |
| Western B | 19 | nm | 28 |
| A/B north | 13 | 90 | 13 |
| A/B south | 17 | nm | 28 |

PVT data: PVT data was derived using downhole samples or using recombined samples. Fluid properties were determined using PVT analysis of downhole and surface samples from wells 2-23A, 15-09A, 15-41B and 18-27C. The Southern and Central lobes contain black oil. The Western and Northern lobes contain gas condensate. The following is a summary of the PVT properties.

| | Lobe | | | |
|---|---|---|---|---|
| | Southern | Central | Western | Northern |
| API gravity, $^{o}$ | 26.9 | 31.2 | 57 | 59 |
| Solution (or initial) GOR, scf/bbl | 548 | 485 | 24,650 | 41,200 |
| Formation Volume Factor Bbl/stb | 1.293 | 1.23 | | |
| Oil Viscosity, cp | 1.84 | 1.06 | | |
| Bubble Point (or Dew Point) pressure, psia | 2815 | 2275 | 3435 | 3215 |
| Initial Reservoir Pressure, psia | 4163 | nm | 4234 | 4191 |
| Current reservoir pressure, psia | 2710 | 3923 | 4173 | 3422 |
| Reservoir Temperature, $^{o}$F | 182 | 164 | 165 | 172 |

Hydrocarbons In Place: There are no indications of a free gas column in the Southern or Central lobes. The Western and Northern lobes are comprised of gas and gas condensate. Estimated hydrocarbons in place are as follows:

| Lobe | Estimated Oil in Place, MMSTB | Estimated Gas in Place, BCF |
|---|---|---|
| Southern | 12.6-19.2 | 6.9-10.5 |
| Central | 1.1-2.7 | .5-1.3 |
| Western | n/a | 69.6-104.4 |
| Northern | n/a | 108.4-160.4 |

3. **Well Performance:**

In recent well tests, the Ivishak Formation was isolated and the PRS was separately produced. Average production during these tests is summarized below.

| Lobe | Well | Date | Oil, STBD | Water Cut, % | Gas Rate, MSCFD |
|---|---|---|---|---|---|
| Southern | 2-23A | 8/04-3/05 | 1820 | 0 | 5000 |
| | 1-14 | 1/05 | NO FLOW- tight | | |
| Central | 15-09A | 12/04-4/05 | 240 | 0 | 120 |
| Western | 15-41B | 12/04-4/05 | 73 | 0 | 1800 |
| Northern | 18-27 | 3/05 | 165 | 0 | 6800 |

A casing leak in Well 2-27 also resulted in withdrawal from the Southern Lobe of the PRS in the period of 1994-1997. Estimated initial rates from this leak were 750 BOPD and 2 MMCFD.

4. **Development Options/Plan**

As provided in Conservation Order No. 341E, the Northern Lobe is a portion of the Prudhoe Oil Pool gas cap and will be managed as an area within that pool.

Using material balance calculations for the Southern and Central Lobes, primary depletion is estimated to recover approximately 10% of the oil in place. No aquifer influx is anticipated within the PRS. Waterflooding is currently under evaluation for the Southern Lobe. Early screening of analog reservoirs suggests incremental recovery of 10-25% with waterflooding.

A reservoir simulation study is being conducted to evaluate the waterflood options. Development of the Southern Lobe is anticipated to include one to five production wells and one to five injection wells. Offtake will be managed to balance voidage replacement. Peak production rates of 3000-5000 BOPD are anticipated with a maximum water injection rate of 25,000 BWPD.

The production wells may be completed by perforating the PRS in existing Ivishak wells or drilling sidetracks into the PRS. Well spacing will be irregular with well locations determined considering local faulting and reservoir stratigraphy.

5. **Facilities**

The PRS will be developed from existing pads (primarily Drill Sites 1, 2, 6, 15, and 18) and facilities within the Prudhoe Bay field. Existing Prudhoe Bay Unit production and injection facilities will be used.

6. **Well Design and Completion**

All wells will be designed to the same specifications as current Prudhoe Oil Pool well designs. Idle wells currently completed in the Ivishak Formation may be used for PRS development. Injectors may be pre-produced prior to converting to permanent injection.

a. Surface Safety Valves: Actuated surface safety valves (“SSVs”) are included in the wellhead equipment for the PRS wells.

b. Subsurface Safety Valves ("SSSVs"): As per requirements of Conservation Order 363, if gas or miscible gas injectors are drilled, a surface controlled SSSV must be installed. All other well completions will be equipped with a nipple profile at a depth below the base permafrost should the need arise to install a downhole flow control device.

7. **Gas-Oil Ratio Allowable**

Average GOR during production testing of DS 2-23A exceeded that allowed by 20 AAC 25.240 and the reservoir pressure measured at the end of the test was below bubble point pressure. To assure greater ultimate recovery, pressure maintenance is needed prior to further withdrawal.

However, general practice will be to pre-produce injectors for up to three weeks, which helps increase later injectivity. This short period of production should not cause loss of reserves.

**CONCLUSIONS:**

1. The application requirements of 20 AAC 25.520 have been met.
2. The stratigraphically equivalent and lithologically similar Southern, Western, Northern, and Central Lobes of the PRS share a common depositional, structural and digenetic history.
3. Discontinuous sandstone deposition and post depositional normal faulting have caused pressure compartmentalization within and between the four sandstone Lobes comprising the PRS.
4. Each of the four sandstone Lobes comprising the PRS will require a unique depletion plan in order to obtain optimal recovery.
5. The Northern Lobe is in hydraulic communication with the rest of the Prudhoe Oil Pool and is saturated with hydrocarbons common to the Prudhoe Oil Pool gas cap.
6. The Western Lobe is a gas condensate reservoir containing between 69.6-104.4 billion cubic feet of gas at reservoir conditions.
7. The Southern Lobe of the PRS is the main oil target development area.

8. To assure greater ultimate recovery, pressure maintenance is needed prior to further withdrawal. Therefore, the gas-oil ratio limitations of 20 AAC 25.240 should not be waived until an enhanced recovery project operates within the Southern Lobe. Pre-production of injectors for up to three weeks should be allowed. This will not cause reserves loss; rather injectivity should be increased as a result of pre-production.
9. Adequate surveillance of the Put River development is required to ensure proper reservoir management.
10. The Commission needs to be apprised of surveillance plans and results on a yearly basis.

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

In addition to statewide requirements under 20 AAC 25 (to the extent not superseded by these rules), the following rules apply to the Put River Oil Pool within the following described area:

UMIAT MERIDIAN

T11N R14E
Sections: 3, 4, 9, 10, 11(SW/4), 14(W/2), 15, 16, 21, 22, 23(W/2 and SE/4), 25(S/2), 26, 27, 28, 33, 34, 35, 36

T11N R15E
Sections: 29(S/2), 30(S/2), 31, 32

T10N R14E
Sections: 1, 2, 3, 11, 12, 13, 14

T10N R15E
Sections: 5, 6, 7, 8, 17, 18

**Rule 1 Pool Definition**

The Put River Oil Pool is defined as the sandstone reservoirs in the Southern, Central and Western lobes that correlate with the interval 9,638 to 9,719 measured feet on the Borehole Compensated Sonic Log, Run 2, Dated September 28, 1975, in the Atlantic Richfield-Exxon NGI No. 1 well, but excluding the Northern Lobe reservoirs that are in pressure communication with the Prudhoe Oil Pool gas cap in the Sag River Formation.

**Rule 2 Casing and Cementing Practices**

(a) In addition to the requirements of 20 AAC 25.030, the conductor casing must be set at least 75' TVD below the surface.

(b) In addition to the requirements of 20 AAC 25.030, the surface casing must be set at least 500' TVD below the base of the permafrost.

**Rule 3 Automatic Shut-in Equipment**

(a) All wells must be equipped with a fail-safe automatic surface safety valve system capable of preventing an uncontrolled flow.
(b) All wells must be equipped with a landing nipple at a depth below permafrost, which is suitable for the future installation of a downhole flow control device. The Commission may require such installation by administrative action.
(c) Operation and performance tests must be conducted at intervals and times as prescribed by the Commission to confirm that the safety valve systems are in proper working condition.

**Rule 4 Common Production Facilities and Surface Commingling**

(a) Production from the Put River Oil Pool may be commingled with production from the Prudhoe Bay Oil Pool, and other oil pools located in the Prudhoe Bay Unit in surface facilities prior to custody transfer.
(b) The Prudhoe Bay Unit Western Operating Metering Plan, described by letter from BPXA dated April 23, 2002 and detailed within the "Prudhoe Bay Unit (PBU) Western Satellite Production Metering Plan – Policies and Procedures Document" dated August 1, 2002 is approved for allocation of production from Put River Oil Pool wells.
(c) Put River Oil Pool wells will use well allocation factors derived for their designated flow station.
(d) All wells must be tested a minimum of once per month. The Commission may require more frequent or longer tests if the allocation quality deteriorates.
(e) Technical process review meetings shall be held at least annually.
(f) The operator shall submit a monthly report and file(s) containing daily allocation data and daily test data for agency surveillance and evaluation.

**Rule 5 Reservoir Pressure Monitoring**

(a) Prior to regular production or injection, an initial pressure survey must be taken in each well.
(b) A minimum of one bottom-hole pressure survey per producing Lobe within the Put River Sandstone shall be run annually. The surveys required by part (a) of this rule may be used to fulfill the minimum requirements.

(c) If six or more wells are active within a Lobe of the Put River Oil Pool, a second bottom-hole pressure survey shall be run annually.
(d) The reservoir pressure datum will be 8100'ss.
(e) Pressure surveys may be stabilized static pressure measurements at bottom-hole or extrapolated from surface (single phase fluid conditions), pressure fall-off, pressure buildup, multi-rate tests, drill stem tests, or open-hole formation tests.
(f) Data and results from pressure surveys shall be submitted with the annual reservoir surveillance report. All data necessary for analysis of each survey need not be submitted with the report but must be available to the Commission upon request.
(g) Results and data from special reservoir pressure monitoring tests shall also be submitted in accordance with part (e) of this rule.

**Rule 6 Gas-Oil Ratio Exemption**

(a) Wells producing from the Put River Oil Pool area are exempt from the gas-oil-ratio limits of 20 AAC 25.240(a) so long as the requirements of 20 AAC 25.240(b) are met.
(b) For production within the Southern Lobe of the Put River Sandstone, except as allowed under (c) of this rule, the exemption from the gas-oil-ratio limit is not effective until waterflood has been initiated and the Commission by administrative approval has authorized application of the exemption.
(c) Notwithstanding (a) and (b) of this rule, pre-production of injectors for up to three weeks is allowed without regard to 20 AAC 25.240(a) and (b)

**Rule 7 Approved Depletion Plan**

(a) Waterflood operations are approved within the Western and Southern Lobes of the Put River Oil Pool.
(b) Commission approval is required prior to commencement of all other enhanced recovery operations.

**Rule 7 Annual Reservoir Review**

An annual report must be filed yearly. The report must include future development plans, reservoir depletion plans, and surveillance information for the prior calendar year, including:
(a) Voidage balance by month of produced, and injected fluids and cumulative status.
(b) Reservoir pressure map at datum, summary and analysis of reservoir pressure surveys within the pool.
(c) Results and, where appropriate, analysis of production and injection surveys, tracer surveys, observation well surveys, and any other special monitoring.
(d) Review of pool production allocation factors and issues over the prior year.
(e) Progress of enhanced recovery project implementation and reservoir management summary including results of reservoir simulation studies.

**Rule 8 Waiver of "Application for Sundry Approval" Requirement for Workover Operations** (ref. C.O. 556)

(a) Except as provided in (d) and (e) of this rule, the requirement to submit an Application for Sundry Approvals (Form 10-403) and supporting documentation for workover activities described in 20 AAC 25.280(a) (1), (2), (3) and (5) is waived or modified for development wells as provided in the Commission document entitled "Well Work Operations and Sundry Notice/Reporting Requirements for Pools Subject to Sundry Waiver Rules," dated July 15, 2005 (referred to below as "Sundry Matrix"). This waiver and modification do not affect the operator's responsibility to submit a Report of Sundry Well Operations (Form 10-404) within 30 days following the completion of a workover operation.

(b) Except as provided in (d) and (e) of this rule, the requirement to submit an Application for Sundry Approvals (Form 10-403) and supporting documentation for workover activities described in 20 AAC 25.280(a) (1) and (5) is modified for service wells as provided in the Sundry Matrix. This modification does not affect the operator's responsibility to submit a Report of Sundry Well Operations (Form 10-404) within 30 days following the completion of a workover operation.

(c) The Sundry Matrix summarizes the sundry approval and reporting requirements that apply to various categories of operations in the specific well types under Commission regulations as modified by these rules.

(d) The waivers provided under (a) of this rule do not apply to wells that are required to be reported to the Commission under the provisions of Rule 9.

(e) The Commission reserves the discretion to require that an operator submit an Application for Sundry Approvals for a particular well or for a particular operation on any well.

(f) Each week the operator shall provide the Commission with a report of workover operations performed the previous week that did not require submission of a Form 10-403. (These operations are listed in Column 2 of the Sundry Matrix.) The report must include the date, well, permit to drill number, nominal operation completed, and a brief description of that operation including depths of perforations, perforations, and stimulated zones.

(g) Nothing in this rule precludes an operator from filing an Application for Sundry Approvals (Form 10-403) in advance of any well work or from including Sundry authorized operations (listed in column 3 of the Sundry Matrix in the weekly report required by (f) of this rule.

(h) Unless notice and public hearing are otherwise required, the Commission may administratively waive the requirements of any provision of this rule or administratively amend any provision including the Sundry Matrix, 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.

**Rule 9 Annular Pressures**

(a) At the time of installation or replacement, the operator shall conduct and document a pressure test of tubulars and completion equipment in each development well that is sufficient to demonstrate that planned well operations will not result in failure of well integrity, uncontrolled release of fluid or pressure, or threat to human safety.

(b) The operator shall monitor each development well daily to check for sustained pressure, except if prevented by extreme weather conditions, emergency situations, or similar unavoidable circumstances. Monitoring results shall be made available for Commission inspection.

(c) The operator shall notify the Commission within three working days after the operator identifies a well as having (a) sustained inner annulus pressure that exceeds 2500 psig for wells processed through the Lisburne Processing Center and 2000 psig for all other development wells, or (b) sustained outer annulus pressure that exceeds 1000 psig.

(d) The Commission may require the operator to submit in an Application for Sundry Approvals (Form 10-403) a proposal for corrective action or increased surveillance for any development well having sustained pressure that exceeds a limit set out in paragraph 3 of this rule. The Commission may approve the operator's proposal or may require other corrective action or surveillance. The Commission may require that corrective action be verified by mechanical integrity testing or other Commission approved diagnostic tests. The operator shall give the Commission sufficient notice of the testing schedule to allow the Commission to witness the tests.

(e) If the operator identifies sustained pressure in the inner annulus of a development well that exceeds 45% of the burst pressure rating of the well's production casing for inner annulus pressure, or sustained pressure in the outer annulus that exceeds 45% of the burst pressure rating of the well's surface casing for outer annulus pressure, the operator shall notify the Commission within three working days and take corrective action. Unless well conditions require the operator to take emergency corrective action before Commission approval can be obtained, the operator shall submit in an Application for Sundry Approvals (Form 10-403) a proposal for corrective action. The Commission may approve the operator's proposal or may require other corrective action. The Commission may also require that corrective action be verified by mechanical integrity testing or other Commission approved diagnostic tests. The operator shall give the Commission sufficient notice of the testing schedule to allow the Commission to witness the tests.

(f) Except as otherwise approved by the Commission under (d) or (e) of this rule, before a shut-in well is placed in service, any annulus pressure must be relieved to a sufficient degree (1) that the inner annulus pressure at operating temperature will be below 2000 psig, and (2) that the outer annulus pressure at operating temperature will be below 1000 psig. However, a well that is subject to (c) but not (e) of this rule may reach an annulus pressure at operating temperature that is described in the operator's notification to the Commission under (c) of this rule, unless the Commission prescribes a different limit.

(g) For purposes of this rule,

"inner annulus" means the space in a well between tubing and production casing;

"outer annulus" means the space in a well between production casing and surface casing;

"sustained pressure" means pressure that (a) is measurable at the casing head of an annulus, (b) is not caused solely by temperature fluctuations, and (c) is not pressure that has been applied intentionally.

**Rule 10 Use of Multiphase Flowmeters in Well Testing**

For purposes of satisfying well test measurement requirements of 20 AAC 25.230, the use of multiphase meters will be approved only in accordance with the provisions of the Commission's document, "Guidelines for Qualification of Multiphase Meters for Well Testing" dated November 30, 2004. The Commission may administratively waive a requirement of these Guidelines or administratively amend the Guidelines as long as the change does not promote waste or jeopardize correlative rights, and is based on sound engineering and geoscience principles. This rule shall expire on December 31, 2007.

**Rule 11 Administrative Action**

Unless notice and public hearing are otherwise required, the Commission may administratively waive the requirements of any rule stated above or administratively amend any rule, including the "Sundry Matrix" referred to in Rule 8, 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 November 22, 2005.

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 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).