

# ALBERTA ENERGY AND UTILITIES BOARD

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Calgary Alberta

## AVALANCHE ENERGY LIMITED REVIEW OF APPLICATIONS FOR A HOLDING, REDUCED SPACING, AND WELL LICENCES KEOMA/ENTICE AREA

Addendum to Decision 2000-49  
Applications No. 1040201, 1041048,  
1041629, and 1042292

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### 1 BACKGROUND

The Alberta Energy and Utilities Board (EUB/Board) issued *Decision 2000-49* (attached) on July 14, 2000, approving a holding and reduced spacing application and reinstating three well licences. The Board subsequently granted a request filed under Section 42 of the Energy Resources Conservation Act by the Delainey family, participants at the original hearing, to provide additional information with regard to its conclusion that the Delainey's water well problems were caused by biofouling.

### 2 CONCLUSION

The Board concluded that there was no apparent link between the water well problems and Avalanche's activities for the following reasons.

First, the Paskapoo Formation aquifers are isolated from deeper zones by cemented surface casing. This would ordinarily provide a barrier to the transmission of contaminants, such as gas or fluid, into Paskapoo aquifers. In fact, testing of the gas wells did not reveal H<sub>2</sub>S present in the gas. Further, the Paskapoo Formation was described as containing many sand bodies (aquifers) of limited size encased in impermeable shale. This is supported by the variability in depths of area water wells. Therefore, it is unlikely that an individual Paskapoo aquifer is extensive enough to provide a pathway between the gas wells and the water wells. If a pathway did exist and contaminants were transported to the water wells, a change in the major ion chemistry of the well water would have occurred. Water analysis showed, however, that major ion chemistry in the well water is relatively stable.

Further evidence in support of the Board's conclusion included the

- short period of time between Avalanche activity and water well problems;
- water wells located closer Avalanche activities being unaffected;
- history of water well biofouling in the area;
- existence of black material and H<sub>2</sub>S odour in the water wells; and
- chlorination of the water wells resulting in only temporary improvement in water quality.

At the conclusion of the hearing, the Board directed that additional testing be conducted on the Stewart/Petersen and Delainey water wells, in particular by video inspection and analysis for bacteria and metals, in order to more firmly determine whether biofouling was responsible for the poor water quality.

Results from the posthearing water testing and video examination of the Stewart/Petersen water well confirmed high levels of sulphate-reducing bacteria (SRB). Because of the plastic casing in the well, bacteria were unable to anchor to the surface of the casing, causing copious amounts of bacteria to float in the water column. A representative sample of SRB in the water was therefore readily obtainable for testing and, as indicated above, significant levels were present in this well. It is the Board's view that the Stewart/Petersen well was biofouled.

The bacterial analysis (BART™) of the Delainey well showed nominal levels of sulphate-reducing bacteria, plus minor levels of aerobic and iron-reducing bacteria.

However, other test evidence suggested that SRB were present. A severe bacterial incrustation of the casing was visible on the video record of the water well. Also, the metals analysis conducted on the black slime obtained from the Delainey water filter indicated high levels of iron and sulphur. SRB reduce large quantities of sulphate into hydrogen sulphide gas as the bacteria grow. H<sub>2</sub>S gas reacts with dissolved metals, such as iron, to generate black sulphide deposits. During testing of the water well, hydrogen sulphide odour was apparent.

It must be noted that the Delainey water well, unlike the Stewart/Petersen well, has metal casing to which the bacterial consortia strongly adhere, producing few "floaters" in the water column. Therefore, the Board believes that the water sample collected for BART™ testing was not representative of the bacteria adhering to the water well casing. However, as mentioned above, the video record, metal analysis of the black slime, and H<sub>2</sub>S odour confirmed that the water well was severely biofouled.

Upon consideration of all of the evidence regarding the state of the Delainey well, including the unlikelihood of Avalanche's gas wells contributing to the poor water, it is the Board's view that the water problems arise from biofouling, notwithstanding the low count of SRBs.

Dated at Calgary, Alberta, on December 8, 2000.

#### **ALBERTA ENERGY AND UTILITIES BOARD**

*(Original signed by)*

T. M. McGee  
Board Member

*(Original signed by)*

G. J. Miller  
Board Member

*(Original signed by)*

W. G. Remmer, P.Eng.  
Acting Board Member

# **ALBERTA ENERGY AND UTILITIES BOARD**

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**Calgary Alberta**

## **AVALANCHE ENERGY LIMITED APPLICATIONS FOR A HOLDING, REDUCED SPACING AND REVIEW OF WELL LICENCES KEOMA/ENTICE AREA**

**Decision 2000-49  
Applications No. 1040201, 1041048,  
1041629, and 1042292**

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### **1 DECISION**

Having carefully considered all of the evidence received, the Alberta Energy and Utilities Board (EUB/Board) directs the following:

- Application No. 1040201 for a holding and reduced spacing is approved.
- Well Licence No. 223124, issued as a result of consideration of Application No. 1041048 for a licence to drill a well from a surface location in Legal Subdivision (LSD) 9, Section 14, Township 26, Range 27, West of the 4th Meridian, is varied and reinstated subject to the following condition: Avalanche must recondition the Stewart/Peterson water well and install pressure sensors therein to determine if drilling, fracturing, and completion operations at Avalanche's well can be detected at the water well.
- Well Licence No. 223336, issued as a result of consideration of Application No. 1041629 for a licence to drill a well from a surface location in LSD 8, Section 9, Township 26, Range 26, West of the 4th Meridian, is confirmed and reinstated.
- Well Licence No. 223642, issued as a result of consideration of Application No. 1042292 for a licence to drill a well from a surface location in LSD 1, Section 12, Township 26, Range 27, West of the 4th Meridian, is varied and reinstated subject to the following condition: If Avalanche proceeds to drill the 1-12 well prior to its 9-14-26-27 well, then the condition for a pressure monitoring program will apply to this licence.
- Avalanche must provide the appropriate documentation of its internal procedures to demonstrate its understanding of and commitment to compliance with EUB notification and public consultation requirements prior to the issuance or reinstatement of the above applications.

The reasons for the Board's decision are presented below.

### **2 APPLICATIONS AND HEARING**

#### **2.1 Applications and Interventions**

Avalanche Energy Limited (Avalanche) submitted Application No. 1040201 to the EUB to obtain approval for a holding and reduced well spacing. It sought to drill to a density of two wells per pool per section for the production of sweet natural gas from the Edmonton and Belly

River Groups. The EUB received objections from residents within the boundary of the proposed holding. Accordingly, the Board directed, pursuant to Section 29 of the Energy Resources Conservation Act (ERCA), that a public hearing be held to consider the application.

Avalanche subsequently submitted Applications No. 1041048, 1041629, and 1042292 to the EUB to obtain approval to drill three sweet natural gas wells in the Keoma/Entice area. Well licences were issued for these wells in May and June 1999. Upon receipt of objections from area residents, the Board directed, pursuant to Section 43 of the ERCA, that these well licences be reviewed in conjunction with the hearing for the holding and reduced well spacing. The Board also directed that the well licences be suspended pending a decision from the hearing.

The details of Avalanche's spacing and well licence applications are included in Appendix 1. The attached figure represents Avalanche's proposed holding area and the applied-for well locations.

## **2.2 Hearing**

The applications and interventions were considered at a hearing commencing January 18, 2000, in Calgary, Alberta, before Board Members T. M. McGee and G. J. Miller and Acting Board Member W. G. Remmer, P.Eng. In response to a Board request for additional evidence, a sampling program on a number of water wells was conducted in April 2000, with written argument on the sampling program submitted in June 2000. The evidence and associated arguments obtained as a result of the testing have been considered part of the record of the hearing.

The panel and staff viewed the proposed surface locations and the surrounding area on January 10, 2000. Those who appeared at the hearing and abbreviations used in this report are listed in Appendix 2.

## **3 PRELIMINARY MATTERS**

Avalanche raised the issue that a number of parties registered at the onset of the hearing without having met the requirements for filing a submission in accordance with the EUB's *Rules of Practice*. A number of interveners responded that they only recently became aware of the applications and the hearing and were seeking more information to determine the extent, if any, of their concerns. Suggestions were also made that an adjournment would allow these interveners more time to prepare and possibly allow for additional testing and monitoring to be done. There were also representations made that if the hearing were held in Keoma, it would be more convenient and result in higher attendance.

The Board determined that these interveners might, in fact, benefit from proceeding with the giving of evidence and cross-examinations. This would allow them to receive Avalanche's information regarding the subject applications, as well as to measure the cross-examination of this information by the two legal counsels in attendance. The Board also pointed out that it would have been receptive to holding the hearing in Keoma had the request been made prior to the start of the hearing.

## 4 ISSUES

The Board believes the issues concerning the applications to be

- need for reduced spacing and the three licensed wells,
- impacts, and
- notification requirements and public consultation.

## 5 NEED FOR REDUCED SPACING AND THE THREE LICENSED WELLS

### 5.1 Views of the Applicant

Avalanche described the Edmonton and Belly River Groups as a series of shallow sand sequences occurring at depths of 900 to 1200 metres (m) from surface and containing sweet natural gas under low pressure. It indicated that the low pressures associated with these sands resulted in low-deliverability gas wells. Avalanche stated that if these low-pressure/low-deliverability gas wells were produced under the current spacing regulations of one well per pool per section, they would become uneconomic prior to optimizing recovery from the pool(s). Avalanche anticipated that an overall improvement in recovery in the range of 16 per cent would occur if two wells per pool per section were drilled where warranted.

Avalanche stated that some 35 per cent of its reserve base was within the shallower Edmonton Group and over 64 per cent was within the deeper Belly River Group. Within the Edmonton Group, Avalanche believed that producing only one well per pool per section would lead to some 40 per cent of producible gas not being recovered. Within the Belly River Group, Avalanche expected that producing a second well in the section where warranted could result in the production of as much as an additional 14 thousand cubic metres ( $14 \times 10^3 \text{ m}^3$ ) in incremental gas.

Avalanche was unable to provide a specific number of gas wells that it expected to drill if the reduced spacing application were approved. Avalanche stated that if an initial well in a section proved to be dry, no second well would be drilled in that section. Avalanche further explained that if the initial well encountered a good quality reservoir with a rate in excess of 350 thousand cubic feet per day (350 mcf/d, or  $9.9 \times 10^3 \text{ m}^3/\text{d}$ ), it believed this rate would effectively drain the full section and a subsequent second well in the section would not be required.

Avalanche also stated that drilling two wells per section where appropriate would accelerate production from these pools and thereby shorten the expected life span of its project from 20 years to approximately 13 years. It also stated the additional wells would improve the economics of the project, as they would absorb the facility and well operation costs.

Avalanche stated that it had undertaken to directionally drill a number of wells from the edges of sections in order to minimize impacts on agricultural use and would continue this practice for any second well in a section whenever possible. Avalanche stated that it would attempt to site wells adjacent to road allowances, preferably in LSD 8 and 14. Avalanche also stated that it would pursue commingled production and dually complete wells when appropriate, so that gas from more than one pool may be produced within a single wellbore, thereby reducing the number of wells and related surface impacts required for development of this project.

Avalanche discussed the three well licence applications in 8-9-26-26W4M (8-9 well), 1-12- 26-27W4M (1-12 well), and 9-14-26-27W4M (9-14 well), which are located within the area of the holding. It maintained that as each of these wells would be the first well in the section or drilling spacing unit (DSU), the approval of the reduced spacing was not required to produce these wells. It pointed out that the present spacing regulations allow for one well per pool per section and that each of these wells is required in order to evaluate the potential for further drilling and to recover any reserves underlying the three sections.

Avalanche noted the concerns raised concerning the proximity of the 9-14 surface location to the Hamlet of Keoma. It explained that it believed the 9-14 well may be the only well required in the section; however, it stated that if a second well were required, the location would be at 14-14. Avalanche did not want to drill the 14-14 location first, as the 9-14 location was chosen to optimize interwell distances and maximize recovery from the pool. Further, Avalanche stated the surface owner of Section 14 permitted well sites on his property only because they were located as close to roads as possible. Avalanche believed its options were limited with regard to drilling the 9-14 well from any other surface location with the consent of the surface owner.

## **5.2 Views of the Interveners**

The interveners did not offer any rebuttal of the evidence Avalanche submitted regarding the need for the reduced spacing. Some interveners did express concern that, in view of the mineral title being freehold, monetary benefit accruing to Albertans would not be in the magnitude of what would accrue if the mineral title were Crown. Some interveners also believed that selling natural gas outside of Canada would increase its cost to Albertans.

Some of the interveners believed that accelerated production of a finite resource should not occur prior to establishing sources of renewable energy. Interveners also expressed concern over the number of wells being considered if approval of reduced spacing resulted in two individual wells per section for each pool encountered under a section of land.

The interveners did not dispute Avalanche's rights to the minerals in question or offer any rebuttal evidence regarding the need for the three individual wells. While the primary objection to the 1-12 and 9-14 wells was their potential effect on groundwater, some interveners also questioned Avalanche on its decision to drill its first well in Section 14 at LSD 9, rather than a surface location farther from the Hamlet of Keoma. The Delaineys maintained that they did not want the 9-14 well approved, since it would be visible from their residence.

## **5.3 Views of the Board**

The Board agrees that additional wells are required in order to maximize recovery from the Edmonton and Belly River Groups. The Board notes that two, and even four, wells per pool per section have been approved for the Edmonton and Belly River Groups, not only in areas proximate to this area of application, but also in fields such as Bashaw and Nevis. The Board therefore accepts that reduced spacing will recover additional reserves, accelerate production from the field, and shorten the time required for the wells and associated production facilities.

The Board accepts that Avalanche has acquired the petroleum and natural gas rights to produce all zones to the base of the Belly River Group underlying the lands within the sections specified in the well licence applications. The Board is satisfied that Avalanche has the right to explore for and produce the reserves underlying these sections and that the need for the proposed wells has been established.

The Board emphasizes that approval of the reduced spacing application does not substitute for the individual well licence applications and approvals required to drill additional wells. The Board agrees that Avalanche must review each proposed well location and consult with potentially affected parties to ensure that impacts are minimized prior to submitting its application for a well licence to the EUB.

The Board notes Avalanche's proposal to limit the number of wells per section and pool where possible and to select surface locations for its wells that minimize the impact on land use and provide close tie-in to pipelines when possible. The Board acknowledges that commingled production and dual completions will also assist in reducing the total number of wells and the associated surface impacts.

Regarding the 8-9, 1-12, and 9-14 wells, the Board notes that these are located within the area of the holding and reduced spacing applications. The Board agrees that the three wells are needed to determine if reserves are present and that if additional wells are required, they would be permitted with the establishment of the reduced spacing. The objections against the 8-9 and 1-12 wells did not appear to be specific to the surface locations proposed, but rather related to the interveners' concerns regarding impacts on domestic water wells and on emissions in the area. The Board also appreciates that residents may not favour well site locations that are visible from their property but expects the major visual impact to be limited to the drilling phase only. The Board must weigh the potential impacts against the production potential before considering reinstatement of the licences.

The Board notes that the issues of Alberta gas export policy and the collection of associated royalties are matters of provincial government policy. The Board did not receive evidence or compelling argument that would raise a public interest issue relative to these policies and has not considered them further relative to these applications.

## **6 IMPACTS**

The Board believes that the potential impacts of the proposed reduced spacing and single well licences must be evaluated and weighed against the benefits of increased recovery and reduced life span of the wells. The impacts have been broadly grouped under the headings of domestic water wells, emissions, and noise.

## **6.1 Domestic Water Wells**

### **6.1.1 Views of the Applicant**

Avalanche stated that its past drilling activities in the area had not affected domestic water wells. In particular, Avalanche maintained that its drilling and completion operations at its 6-11-26-27W4M (6-11) and 8-23-26-27W4M (8-23) gas wells and the surface hole drilled and cased at the 9-14 well did not cause the hydrogen sulphide (H<sub>2</sub>S) odour or black coloration in the Delaineys' and Stewart/Peterson's domestic well water.

Avalanche noted that in its gas wells in the Keoma area drinking water aquifers are covered by surface casing and cement. It elaborated that it had a water well drilling company drill the surface hole and cement the surface casing in place. Avalanche believes that this method of installation ensures superior protection of drinking water.

Avalanche presented several lines of evidence to support its position. It stated that the source of water for area residents was from the Paskapoo Formation and that, based on its geologic nature, a continuous subsurface pathway is unlikely to exist between the gas wells and the water wells. Avalanche stated that the Paskapoo Formation is laterally continuous across the Keoma area, but the many sandstone aquifers it contains are of limited areal extent. It noted that these aquifers are difficult to trace, even within a quarter section. Avalanche explained that records for the area show that water well depths vary significantly and that both water quality and quantity are variable, confirming that local water wells are producing from a number of different aquifers.

Avalanche then stated that even if the aquifer sand extended between its gas wells and the Delainey and Stewart/Peterson water wells, it was impossible for anything to have travelled that distance in a matter of days, as claimed by the water well owners. The applicant noted that the natural direction of groundwater flow in the Keoma area is from west to east and that neither the 16-11 or 8-23 well was directly to the west of the affected water wells. Avalanche calculated that it would take a minimum of 400 days for fluid to travel the approximately 1050 m between the 16-11 location and the water wells. Further, the applicant noted that the major ions in the Delainey and Stewart/Peterson well water had not changed significantly over time, which would have been expected if drilling fluid had been introduced into their aquifer from Avalanche drilling and completion operations. Further, Avalanche pointed out that other water wells closer to the 16-11 well than the Delainey and Stewart/Peterson wells had not been impacted by its drilling and completion operations.

The applicant also indicated that its wells could not be the source of the H<sub>2</sub>S odour in the water wells, as sour gas bearing horizons were not encountered in its gas wells. Avalanche maintained that the H<sub>2</sub>S odour and coloration of the Delainey and Stewart/Peterson well water was the result of naturally occurring sulphate reducing bacteria present in the water wells. The applicant noted that a water treatment system was present when the Stewarts purchased their home, indicating that water quality was an issue for the previous owner.

Avalanche indicated that Mr. and Mrs. Proc had raised a concern about their water well. The applicant indicated that a water well sampling program had been discussed with the Procs, but the parties had been unable to reach an agreement on a mutually acceptable program.

Avalanche responded to the Board's April 2000 request for additional information and analysis of the domestic well water by collecting water samples, a sludge sample (Delainey well only), two-hour pump tests, and video-camera records at the Delainey and Stewart/Peterson wells, plus a water sample from the Proc well.

Avalanche interpreted these additional data as confirming its initial position that both the Delainey and Stewart/Peterson water wells were extremely biofouled with sulphate reducing bacteria, and that the water problem was not the result of Avalanche activities. In addition, Avalanche pointed out that the pre- and post-treatment water chemistry data presented at the hearing suggested that the water treatment systems at both the Delainey and Stewart/Peterson residences were malfunctioning, as water quality after treatment was poorer than the raw water quality. Avalanche noted that long-time Keoma residents' water treatment systems were able to successfully treat the water. Avalanche maintained that it did not believe that cleaning, chlorinating and resampling the Delainey and Stewart/Peterson water wells would provide additional information that would aid the Board in its decision.

Avalanche compared the 1993, January 2000, and May 2000 water analyses for the Proc well and maintained that water quality at the well had remained constant over time and that no hydrocarbons were detected. Avalanche explained that minor variations in major ion concentration over time were typical of all groundwaters.

### **6.1.2 Views of the Interveners**

Mr. and Mrs. Delainey indicated that their well water had turned black and had an H<sub>2</sub>S odour shortly after Avalanche drilled or conducted completion operations at the 16-11 and 8-23 gas wells. The Delaineys stated that the 16-11 and 8-23 wells were drilled at the end of October 1998 and were fractured in the middle of November. They said they contacted Avalanche on about November 18 or 19, when their water began to give off an H<sub>2</sub>S odour. They noted that Avalanche was not prompt in dealing with their concern.

Mr. Stewart and Ms. Peterson stated that in September 1998 they had viewed the house in Keoma that they subsequently purchased and that at that time the water was clear and did not smell. They stated that they took possession of the house on November 27, 1998, after an inspection with the realtor. Stewart/Peterson stated that an H<sub>2</sub>S smell was apparent during the inspection but they were excited about the purchase of their new home and did not realize that the smell was coming from the water. Stewart/Peterson indicated that they tried a number of different water treatment systems at great expense, but the water quality did not improve.

The Delaineys and Stewart/Peterson stated that the water at both residences had turned black near the beginning of June 1999. They said that Avalanche tested their water on June 17, 1999, and paid for a shock chlorination treatment of both water systems. Although the chlorination procedure was carried out on June 25, 1999, both parties maintained that the water quality did not improve in the long term. Stewart/Peterson stated that they then decided to have a cistern installed and now have water trucked in.

The Delaineys and Stewart/Peterson believed that the Avalanche operations had caused the deterioration of their well water and that further Avalanche drilling in the area would exacerbate the problem. Both families noted that they had shock chlorinated their water wells and therefore did not accept the Avalanche explanation that sulphate reducing bacteria was the cause of the water quality problem. As well, both families indicated that although the applicant retained expertise to assist them with identifying the source of the water quality problem, they believed that Avalanche was more interested in absolving itself of blame, rather than addressing the water well owners' concerns.

With respect to other information submitted by Avalanche, the Delaineys and Stewart/Peterson noted that the groundwater travel times presented by Avalanche represented natural groundwater flow conditions. They presented calculations illustrating that an induced pressure gradient caused by drilling fluid entering the aquifer could travel 1000 m in less than four days. They interpreted this as meaning that fluid could travel from the 16-11 well to their water wells in a few days. They also noted that although the regional direction of groundwater flow is from west to east, local scale variations could be present.

The Delaineys and Stewart/Peterson agreed that the additional data collected in April 2000 indicates that the water wells contain iron and sulphate reducing bacteria, but indicated that they believed it was still necessary to recondition and resample the water wells to conclusively determine the cause of elevated sulphides in the water.

### **6.1.3 Views of the Board**

The Board has reviewed the evidence related to the Delainey and Stewart/Peterson water well problem, and notes that Avalanche expended considerable effort in identifying reasons why its operations were not the source of this problem. However, the Board finds it surprising that Avalanche originally failed to gather direct evidence to put before the Board confirming its position that these water quality problems stemmed from biofouling by sulphate reducing bacteria, not Avalanche operations. The Board also believes that it would have benefited all parties if the water quality concerns had been pursued with Alberta Environment such that the cause of the deterioration in water quality could have been investigated at an earlier stage.

Based on the lack of direct evidence as to the source of the Delainey and Stewart/Peterson water quality problem, the Board directed Avalanche, the Delaineys, and Stewart/Peterson to launch a cooperative effort to gather this information in April 2000. The Board also granted a request from Mr. and Mrs. Proc to have their well included in this sampling program.

The Board understands that the Delainey and Stewart/Peterson families have been severely impacted by the lack of resolution of their water situations and that reconditioning of the water wells is necessary. However, based on the additional April 2000 information, the Board believes that the evidence supports Avalanches' explanation that the Delainey and Stewart/Peterson water wells are severely biofouled with iron and sulphate reducing bacteria, which is unlikely to be related to Avalanche activity.

The Board understands that the interveners still believe that Avalanche's drilling activity has impacted their water wells because the water quality deteriorated shortly after the gas wells were

drilled. The Board recognizes that Avalanche has attempted to show that a causal/relationship with the drilling and completion of the gas wells to a change in water quality does not exist but has failed to convince the interveners that it is safe to drill the proposed gas wells. In order to provide additional assurance and to assist in ongoing relations, the Board believes that Avalanche should first conduct a cement bond log at the 9-14 well to confirm the integrity of cement operations performed by the water well drilling company. Additionally, Avalanche must monitor the Stewart/Peterson water well during and for 30 days following the drilling and completion of the 9-14 gas well. As the Stewart/Peterson water well is not currently in use, the Board believes it to be the best choice for a monitoring site. Should Avalanche decide to drill the 1-12 well before resuming operations at the 9-14 well, then a similar approach must be taken. At the 1-12 location, monitoring must also take place during drilling and cementing of the surface casing. The specifics of the monitoring program should be discussed with the interveners and must include reconditioning the Stewart/Peterson well and the temporary installation of a pressure sensor to determine if the drilling, fracturing, and completion of the 9-14 well can be detected at the water well.

The Board also notes that Avalanche's interpretation of the April 2000 data includes comments suggesting that the series of water chemistries presented at the hearing indicates that the Delainey and Stewart/Peterson water treatment systems were malfunctioning. The Board suggests that it would have been appropriate for Avalanche to have provided this expertise to these interveners prior to the hearing in an attempt to resolve the situation.

The Board agrees with the Avalanche position that the Procs' water quality has not been impacted by Avalanche activity, based on the 1993, January 2000, and May 2000 sampling events. These three analyses indicate stable water chemistry over time. The Board notes that the 1993 sample predates Avalanche activity in the area.

## **6.2 Emissions**

### **6.2.1 Views of the Applicant**

Avalanche identified a number of potential sources of emissions as a result of its activity in the Keoma area. Avalanche stated that the majority of wells in this area required fracture stimulation to produce from the reservoir. Initial flow-back of the fracture fluids created a visible white plume in the atmosphere. Avalanche attested that the plume consisted of carbon dioxide (CO<sub>2</sub>) and nitrogen and is harmless. Avalanche maintained that these gases are not combustible and would therefore be impossible to burn during the initial flow-back. Avalanche also identified that some methane was vented in conjunction with the fracture treatment. Given the concerns raised by the interveners, Avalanche stated that in future it would use a flow-back tank following fracture treatments, which makes the plume less visible. Avalanche also stated that it intended to use "clear frac" in this area, which would introduce nitrogen as the activating gas and reduce the CO<sub>2</sub> in terms of greenhouse gas emissions.

Avalanche stated that well tests on the majority of its wells in the Keoma area had been conducted by venting the gas to the atmosphere. It pointed out that the information obtained from these tests was often required to justify expenditures on infrastructure such as pipeline tie-ins. Avalanche estimated the vented volumes of gas to be approximately 500 000 cubic feet

(14 10<sup>3</sup> m<sup>3</sup>) per well and considered this to be a small volume. Avalanche further suggested that the EUB should be clearer in quantifying the amount that is considered a “small volume” as allowed in *Guide 60: Upstream Petroleum Industry Flaring Guide*. Avalanche indicated it would be prepared to follow best practices for well testing.

Avalanche stated that it hoped to drill its infill or reduced spacing wells adjacent to its pipeline system, thereby allowing it the opportunity for in-line testing through the pipeline instead of venting. Although Avalanche did not feel that a flare stack was necessary, in light of concerns raised at the hearing Avalanche advised that it had purchased a portable flare stack and separator package for those wells it was unable to test in line.

Avalanche explained that production from its wells was gathered in the subject area at a compressor station at 16-18-26-26W4M (16-18). It stated that it used a glycol dehydrator at this facility, which was vented to the water storage tank. In response to concerns raised regarding the potential for toxic emissions being vented from the glycol dehydrator to the atmosphere, specifically BTEX (benzene, toluene, ethylbenzene, and xylene). Avalanche stated that its initial test on the inlet gas at its 1-22-27-26W4M compressor, which gathered production from similar reservoirs, indicated that trace amounts of benzene were present in the gas. Avalanche acknowledged that subsequent testing of the rich and lean glycol at the 16-18 compressor station dehydrator, conducted under the guidance of Mr. Picard, an emissions expert retained by the Procs, indicated that benzene and ethylbenzene were below laboratory detection levels. It accepted that the test results also indicated trace amounts of toluene and xylene were detected, as well as trace amounts of reduced sulphur compounds.

Avalanche concurred that the emissions of BTEX, hydrocarbons, and sulphur compounds (including mercaptans) expected from the glycol dehydrator at the compressor station were capable of being combusted. However, it was Avalanche’s evidence that, even taking into consideration a doubling of input as an optimistic result of the reduced spacing, the minimal volumes of these pollutants emitted from the compressor station did not justify the cost of a thermal oxidizer for combusting the emissions from the glycol dehydrator at this site.

Avalanche retained a dispersion modelling expert, Mr. Dowsett, who provided estimates of downwind concentrations of BTEX, hydrocarbons, and sulphur compounds (including mercaptans) expected from the glycol dehydrator at the 16-18 compressor station based on a current throughput of 11 million cubic feet per day (mmcf/d) and an ultimate potential throughput of 30 mmcf/d. The 30 mmcf/d throughput was considered to be representative of the maximum throughput that could be constructed at the current site. Volumes in excess of 30 mmcf/d would be directed to other processing facilities. Downwind concentrations of these pollutants were estimated for the Proc residence and the Norman residence, plus the maximum concentration regardless of location. These predictions were then provided to Avalanche’s toxicology expert, Dr. Davies, for assessment of odour and health impacts associated with these concentrations. He compared the concentrations with those levels deemed by authorities to be safe from a human health perspective and with concentrations measured in other environmental settings and odour thresholds. The symptoms described by the Procs were also compared to medical literature to establish a degree of correlation. Dr. Davies emphasized the need to consider the received dose of the substance, not just its intrinsic toxicity. He stated that he was not aware of a recognized test to determine whether a person has a sensitivity to BTEX.

Dr. Davies believed the predicted concentrations at the residences of BTEX, hydrocarbons, and sulphur compounds, including mercaptans, from the 16-18 glycol dehydrator to be well below safe levels established by regulatory agencies and below normal background concentrations. He also believed there to be a poor degree of correlation between the Procs' symptoms and those reported in the medical literature or the concentrations associated with those symptoms. Avalanche and its experts did not disagree with the symptoms reported by the Procs but believed that these symptoms were not likely to be related to emissions from Avalanche's activities. In response to gas density concerns raised by Mr. Carnegie, Avalanche's dispersion modelling expert, Mr. Dowsett, clarified that gases existing as mixtures do not separate. Therefore, he stated, heavier components, such as toluene, would disperse with the mixture rather than dropping out and should therefore not have an impact on food sources or health.

Regarding odours, Dr. Davies concluded that a sensitive or acute individual might be able to detect an odour close to the 16-18 facility but the predicted concentrations of mercaptans from the glycol dehydrator would be well below the average odour threshold and odours would not be detected at the Proc or Norman residences. Avalanche reported that it had not received any complaints of odours escaping the lease site related to its operations at the 16-18 compressor station. However, Avalanche indicated that there was a pipeline odourant spill at the ATCO Gas Pipeline station, located at the 16-18 compressor site, in January 2000 and acknowledged that this spill did result in odour complaints from people in the area.

### **6.2.2 Views of the Interveners**

A number of interveners were concerned about the negative impact of Avalanche's well test venting operations on their health and on the environment and about the corresponding increase in atmospheric emissions that could occur with approval of the reduced spacing application. They raised significant concern regarding the volumes of methane currently vented to the atmosphere as a result of well testing and fracture treatments and the potentially increased amount if Avalanche were allowed to drill more than one well per pool per section. Mr. Picard commented that burning (flaring) the methane from well tests, instead of venting, would reduce the global warming potential of those emissions.

The Procs' submission reflected that increasing health concerns had plagued them since around November 1998. More predominantly, Mrs. Proc's symptoms included headaches, weight loss, burning of the eyes and nose, memory loss, lethargy, nausea, abdominal pain, and blood in the urine. Mr. Proc had shown similar symptoms to a lesser degree. It was the Procs' belief that the cause of their deterioration in health was due directly to the venting and emission activities conducted by Avalanche in the area around their property. The Procs noted that their symptoms appeared to worsen when wells were being vented and seemed to be alleviated when they left the area of their property. The Procs attributed the lesser impact on Mr. Proc to his being away from the property during the working day. They also stated that other people began to show similar symptoms when staying at their home. Dr. van Olm, attending as one of the Procs' expert witnesses, submitted that their symptoms were attributable to exposure to toluene, mercaptans, and other sulphides, as well as possibly benzene. He considered benzene to be the most dangerous of the substances the Procs may have been exposed to. It was Dr. van Olm's opinion that Mrs. Proc suffered from two kinds of exposure, the first being accidental releases of toxins from gas wells and the glycol dehydrator, particularly when the wind was to the east. He

referred specifically to the products of Avalanche's activities as the cause. Given the symptoms and quality of life of the Procs, he saw no alternative explanation. Second, Dr. van Olm explained Mrs. Proc's continuous symptoms, when no venting occurred, as resulting from permanent contamination of the Procs' soil and groundwater with these same toxins. He feared that the Procs' property was no longer fit for habitation. Dr. van Olm confirmed that he had taken samples of the soil and water but had not pursued having these samples tested for the toxins he believed could be present. Under cross-examination, Dr. van Olm admitted that there was no evidence indicating the presence of very intense or high levels of any of the compounds he believed responsible for Mrs. Proc's symptoms. He was not of the opinion that the Procs were acutely sensitive. Rather, he believed that this may be a case of long-term low-dose exposure to a mixture of many petrochemicals. He also pointed out that the applicant's evidence was based on only one test at one location, which he did not believe represented very reliable information. Dr. van Olm also considered it inappropriate for Dr. Davies to judge whether Mrs. Proc's symptoms were due to oil and gas products, not having met with Mrs. Proc and not being someone who practised medicine.

The Procs retained Mr. Picard as an expert witness to evaluate the emissions from the 16-18 compressor. Mr. Picard testified that the amount of emissions from the glycol dehydrator at the compressor station was particularly low. However, he did note that the presence of methyl mercaptan in the glycol dehydrator emissions created the potential for off-site odours to occur. Mr. Picard suggested that an enclosed thermal oxidizer could be used to dispose of the off-gas streams from the glycol dehydrator. He pointed out that thermal oxidizers were typically used on glycol dehydrators where odour problems needed to be addressed. The Procs stated that emissions from the facility should be gathered and oxidized. The Normans also raised concerns regarding the potential for toxins to be emitted near their home. Avalanche had provided the Normans with a letter dated July 7, 1999, committing that there would be no emissions other than compressor exhaust from the 16-18 facility. In view of the discussions raised prior to and during the hearing, the Normans believed that they had been misled by Avalanche regarding the emissions from the facility.

These parties requested that the Board require Avalanche to recover all emissions from the glycol dehydrator at the compressor station, as well as collect gases during a well test by either in-line testing or flaring. Mr. Picard submitted that a trailer-mounted flare stack could be purchased for about \$15 000 or could be rented for about \$450 per month.

Mr. Plumecke questioned why technologies were not being used to render all emissions from Avalanche's operations harmless if such technologies existed. He contended that even though the emissions may be considered small, they were still a concern from a cumulative effect standpoint.

Mr. Carnegie also expressed concern about gases such as toluene that have densities greater than that of air. He was concerned that gases with a greater density than air from Avalanche's operations may accumulate or be channelled by irrigation ditches or canals and have an impact on food sources or health.

### 6.2.3 Views of the Board

The Board is encouraged by Avalanche's proposed steps to reduce the volumes vented for well testing. Avalanche's proposal to drill infill wells close to existing pipeline infrastructure will result in more wells being tested in line rather than vented. The purchase of a portable flare stack will convert more of the remaining emissions, thus reducing the global warming potential. The Board notes that EUB staff are currently reviewing the requirements for flaring small volumes of gas as part of an update to EUB *Guide 60: Upstream Petroleum Industry Flaring Guide* and this will provide more specifics on this issue.

The Board considers the technique used by Mr. Picard for sampling and estimating the tank vent gases to be acceptable. The Board notes that the BTEX emission rate of 15.86 kilograms per year is well below the permissible benzene emission limit of 3 tonnes per year outlined in EUB *Informational Letter (IL) 97-4: Emissions from Glycol Dehydrators*. The modelling based upon a current throughput of 11 mmcf/d and an ultimate potential throughput of 30 mmcf/d is reasonable. The comparison of the predicted and established safe levels is a routine approach. The Board notes that the predicted concentrations are well below levels believed to be safe and agrees with Dr. Davies's argument that the dose must be considered. The Board acknowledges the symptoms described by the Procs and does not doubt their testimony. Given that the predicted concentrations are much lower than the established safe levels, however, it is difficult to conclude that Avalanche's activities are the direct cause of the Procs' symptoms. The Board believes that it would have been beneficial if Dr. van Olm had also considered, as part of his investigations, a range of possible sources for the contaminants affecting the Procs and the dose-response relationship as suggested by Dr. Davies.

The Board will not require Avalanche to install an enclosed thermal oxidizer but suggests that Avalanche discuss this further with the residents in the area as it may be of value to install the device in an effort to improve its relations in the community.

## 6.3 Noise

### 6.3.1 Views of the Applicant

Avalanche identified that its well testing operations had raised some inquiries in 1998 regarding noise levels. As a result, Avalanche stated that it adopted a policy of notifying nearby residents of proposed testing and using a trailer-mounted separator, complete with silencers, for testing wells proximate to residents. Avalanche also responded to a number of concerns regarding noise levels from the 16-18 compressor facility. Avalanche stated that it had constructed a berm on the west side of the facility and had reduced the fan speed on one of the compressor units, which achieved an overall facility noise reduction. Avalanche had agreed to install silencers on the cooler fans but stated at the hearing that it believed that the berm construction and fan reduction had resolved the noise concerns. Although evidence was presented to indicate that the facility was in compliance with the EUB's *Noise Control Directive*,<sup>1</sup> Avalanche committed at the hearing to proceed with the installation of the silencers if the interveners so requested.

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<sup>1</sup> *Interim Directive (ID) 99-08 and Guide 38: Noise Control Directive User Guide*, which prescribes noise levels, in this particular instance, to be no greater than 40 dBA nighttime and 50 dBA daytime at residences in the vicinity of the facility.

Avalanche also identified that one of the compressors was designed to blow down the pressure to suction pressure if the unit shut down, causing noise generation for a period of one to two minutes. Avalanche stated that it had directed that the compressor be adjusted to ensure that, in the event of a shutdown, the unit would remain static until the operator restarted it. Avalanche also provided evidence indicating that if the facility did require expansion to a third compressor unit, the increase in noise would be minimal and would still comply with EUB regulations.

### **6.3.2 Views of the Interveners**

Interveners raised concerns regarding the noise level currently being generated from the 16-18 facility and the impact that additional wells would have on potential expansion of the facility and further increase of noise levels. Interveners believed that the installation of silencers on the cooler fans would reduce the existing noise to an acceptable level but were concerned that the increased production resulting from additional wells would result in an additional compressor being added to the facility. Some interveners also requested that an additional berm be constructed on the east side of the compressor lease site to reduce the noise even further. A specific request was made that Avalanche not restart the compressor station at Keoma during nighttime hours to minimize noise impacts to residents while sleeping. Some interveners also believed that the noise levels from Avalanche's well testing and venting operations had been excessive and would increase if the reduced spacing application were approved.

### **6.3.3 Views of the Board**

While the existing noise level generated from the 16-18 compressor is not an issue specific to the applications before it, the Board recognizes the concerns raised by the interveners. The evidence presented indicated that the noise levels are within EUB's noise guidelines, but the Board recognizes that steps can be taken to further reduce noise attenuation in the area should it be necessary in accordance with *Guide 38*. The Board acknowledges the steps Avalanche has taken to date to reduce the sound levels and concurs with the interveners that silencers on the cooler fans will assist in reducing the noise further. The Board also emphasizes that expansion of the existing facility to add further compression would require a public involvement program and a subsequent application to the EUB, in accordance with *Guide 56*.<sup>2</sup> The Board also recognizes that the commitments Avalanche made regarding reducing its venting operations should assist in reducing the noise generated by its well testing operations.

## **7 NOTIFICATION REQUIREMENTS AND PUBLIC CONSULTATION**

### **7.1 Views of the Applicant**

Avalanche stated that it has a proactive public consultation program whereby landowners and affected parties are notified of planned operations. In addressing the program specific to the subject applications, Avalanche stated that on a number of occasions it hand delivered notification letters to affected parties. Avalanche presented evidence that the letters were left in the door of the house if the parties were not home. In addition to the EUB's notification requirements regarding the reduced spacing application, Avalanche attempted to ensure access

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<sup>2</sup> *Guide 56: Energy Development Application Guide and Schedules.*

to more people by retaining a land agent to hand deliver notices to all parties within the prescribed area. Under cross-examination, Avalanche conceded that its staff had filed the reduced spacing application with the understanding that the notification letters had been mailed out in late March 1999. Evidence from the land agent indicated that it had personally distributed the letters from mid-April to mid-May 1999. Avalanche admitted that it incorrectly represented that there were no objections to the reduced spacing application. However, Avalanche stated that it had communicated with the EUB regarding potential objectors to the reduced spacing application and that there was no attempt to mislead or deny anyone information regarding the project.

With regard to the individual well licence applications, Avalanche believed that the intent of notification of a proposed activity is to approach those parties who might or might not be directly and adversely affected by an application but who might see the activity regardless of whether or not they were in the prescribed notification radius defined in *Guide 56*. Avalanche argued that it met that intent by advising the Keoma residents of the EUB's licensing of the 9-14 well and of Avalanche's plans to drill it. In defending its decision to apply for routine well licences, Avalanche stated that it had not found anything technical that would indicate that the gas well drilling was affecting the Delaineys' and Stewart/Peterson's water wells. Avalanche believed it was working with the Delaineys and Stewart/Peterson on their water problems on a without-prejudice basis and that their concerns did not represent objections that needed to be identified on the well licence applications. Avalanche stated that it had a policy by which, if an objection was received from a landowner, it was prepared to stall operations until those issues had been resolved. Avalanche cited that it voluntarily suspended operations at the 9-14 well based on further discussions with one of the interveners.

Avalanche recognized that a number of its letters either did not fully represent the applicable information or did not provide sufficient detail for the affected parties to appreciate and understand the issues and applications. Avalanche also stated that it recognized the importance of responding more quickly to questions and concerns raised by parties in the area of development. Avalanche stated that in September 1999 it retained an employee to improve Avalanche's public consultation procedures regarding applications and well operation activities. Avalanche stated that it also intended to attempt to set up a committee with area residents to ensure that development of the area would proceed with parties being aware of and having input into decisions being made.

Avalanche argued that its consultation was reasonably extensive, although unsuccessful, and requested the Board to not confuse the outcome of the consultation with its efforts to notify and consult with the public. While a number of interveners stated that they either had not received notification letters or did not recall having received them, it was Avalanche's position that affected parties must take some onus for two-way communication.

## **7.2 Views of the Intervenors**

Intervenors raised a number of concerns regarding Avalanche's approach to communicating information regarding its proposed development and its lack of compliance with EUB application requirements.

Intervenors raised the issue that Avalanche's reduced spacing application to the EUB claimed that affected parties had not raised concerns after a three-week period. They pointed out that the notification to the majority of the intervenors had not been delivered until after the reduced spacing application had been submitted to the EUB. Intervenors also maintained that Avalanche should have made its information packages more detailed with regard to the proposed development and what impact it could have. Specifically, intervenors stated that they did not understand the number of wells reduced spacing had the potential to permit.

The Delaineys and Stewart/Peterson gave evidence that Avalanche was well aware of their concerns regarding the deterioration of their water wells but proceeded to apply to the EUB for routine well licences and reduced spacing without declaring or resolving these concerns. Mr. Delaine had, in fact, identified his objection to the reduced spacing when contacted by the land agent. Stewart/Peterson believed that they and the Delaineys had done a portion of Avalanche's public consultation for them in canvassing neighbours and summarizing their concerns.

The Procs voiced frustration with the difficulty in extracting information from Avalanche. They perceived this as unwillingness by Avalanche to provide the information necessary for parties to make an informed choice and suggested that Avalanche should provide a significantly broader range of information to people in the area. The Procs believed that Avalanche should work with the public to synchronize its activities with the activities of the public. They also maintained that Avalanche should also have done its utmost to reduce or contain the impact of its operations, thereby relieving the objections of the affected citizens.

The Normans raised a number of concerns regarding Avalanche's approach and follow-up in dealing with matters specific to the application for the compressor station. They requested that a community advisory committee be set up to monitor any activity by Avalanche. They believed that this would help keep the public's best interest as a priority and prevent any misinformation.

### **7.3 Views of the Board**

It is apparent to the Board that there was a decided lack of communication and understanding between Avalanche and the intervenors as well as among Avalanche's own staff and its contractors and agents. As a result, the Board heard evidence that Avalanche failed to properly disclose objections it was aware of in its application material and gave conflicting evidence regarding the success of Avalanche's public contact program and whether targeted parties received the applicable information. The Board also heard that Avalanche itself was unaware until the hearing of when notification occurred regarding the reduced spacing application. The Board appreciates that Avalanche recognized the limitations of the effectiveness of its program identified during the hearing and is taking steps, such as retaining a public consultation adviser and organizing a community advisory committee, to attempt to minimize future concerns. The Board believes this may also assist Avalanche in overcoming the mistrust that appeared to be prevalent among the intervenors present at the hearing. The Board also concurs that more timely and detailed responses are necessary for Avalanche to ensure that parties are fully apprised of development plans, aware of the impact the activity will have on them, and able to participate in discussions regarding methods to minimize impacts.

The Board is particularly concerned with Avalanche's perception of the requirements of *Guide 56* to identify potential objections or concerns at the time of application. The EUB has set out clear direction in *Guide 56* regarding its expectations concerning industry's consultation responsibilities and public involvement. Failure to adequately consult with the public may have serious consequences, as the EUB is required by statute to consider objections raised by parties who may be directly and adversely affected. A company is expected to attempt to address concerns that are raised and to reconcile differences, if possible. Any objections or concerns that are raised and not resolved must be disclosed and thoroughly addressed in a nonroutine application. While Avalanche may have been attempting to address and resolve the residents' concerns, this in no way obviates Avalanche from the responsibility of notifying the EUB that these concerns exist. Furthermore, Avalanche may not, and should not, judge the merit of the concerns raised, as these are issues that the EUB has statutory responsibility to consider. The Board also recognizes that the interveners are responsible for reviewing information provided to them and discussing their concerns with Avalanche in order to reconcile differences, if possible.

The Board will require Avalanche to review its internal procedures regarding notification and public consultation and implement appropriate changes to ensure compliance with EUB requirements. Avalanche must provide satisfactory documentation to the EUB's Facilities Applications audit team on its internal procedures to demonstrate a full understanding of and compliance with the EUB's public consultation requirements for *Guide 56* applications. This submission will be required prior to issuance of approvals or reinstatement of the well licences.

In addition, Avalanche will be required to audit all *Guide 56* applications submitted to the EUB since January 1, 2000 to confirm that notification and consultation requirements have been achieved. Avalanche must compile these data and submit its information by the close of business on September 15, 2000. EUB staff will review this audit material and will then place a higher audit priority on future Avalanche applications over at least the next six months and implement escalating enforcement actions where necessary to ensure ongoing compliance.

## **8 OTHER MATTERS**

The Board notes that in final argument the interveners' lawyers suggested that if the applications were approved, a number of conditions be attached to the approvals. The Board has considered the need for additional conditions regarding water well testing, emissions, and noise and finds that additional licence conditions are not required over the commitments made by Avalanche at the hearing. In regard to testing for surface casing vent flows and cement compressive strength, the Board believes that the current requirements specified in EUB guides and regulations are appropriate and that additional conditions are not required. The Board has received no evidence to justify a leak detection and pipeline monitoring program for the

Avalanche pipeline system. Therefore the Board believes that, given that the gathering system is low-pressure, made of polyethylene, and transports sweet gas, the potential for leaks is very low and such a monitoring system is not required.

DATED at Calgary, Alberta, on July 14, 2000.

*(Original signed by)*

T. M. McGee  
Board Member

*(Original signed by)*

G. J. Miller  
Board Member

*(Original signed by)*

W. G. Remmer, P.Eng.  
Acting Board Member

## **APPENDIX 1**

### **Application No. 1040201**

Avalanche Energy Limited (Avalanche) applied under the Oil and Gas Conservation Regulations and the Oil and Gas Conservation Act to establish a holding and special well spacing for the production of gas from the Edmonton and Belly River Groups in the following area:

- Township 25 Range 26 West of the 4th Meridian: Section 19 and Sections 28 to 34 inclusive
- Township 25 Range 27 West of the 4th Meridian: Sections 8 to 17 inclusive, Sections 20 to 29 inclusive, and Sections 31 to 36 inclusive
- Township 26 Range 26 West of the 4th Meridian: Sections 1 to 36 inclusive
- Township 26 Range 27 West of the 4th Meridian: Sections 1 to 36 inclusive
- Township 27 Range 26 West of the 4th Meridian: Sections 1 to 6 inclusive, and Sections 11 and 12

Avalanche proposes that within the holding

- a producing well shall be at least 500 m from each other well producing from the same pool,
- a producing well shall be at least 200 m from the boundary of the holding, and
- only two wells may be produced per section from the same pool.

### **Application No. 1041048**

Avalanche applied pursuant to Section 2.020 of the Oil and Gas Conservation Regulations for a licence to drill a vertical sweet natural gas well from a surface location in LSD 9-14-26-27W4M (9-14). Licence No. 223124 was issued on May 21, 1999.

### **Application No. 1041629**

Avalanche applied pursuant to Section 2.020 of the Oil and Gas Conservation Regulations for a licence to drill a vertical sweet natural gas well from a surface location in LSD 8-9-26-26W4M (8-9). Licence No. 223336 was issued on June 1, 1999.

### **Application No. 1042292**

Avalanche applied pursuant to Section 2.020 of the Oil and Gas Conservation Regulations for a licence to drill a vertical sweet natural gas well from a surface location in LSD 1-12-26-27W4M (1-12). Licence No. 223642 was issued on June 14, 1999.

## APPENDIX 2

### THOSE WHO APPEARED AT THE HEARING

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#### Principals and Representatives (Abbreviations Used in Report)

#### Witnesses

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Avalanche Energy Limited  
B. K. O’Ferrall  
S. M. Munro

R. F. Mercier, P.Eng.  
W. MacDonald  
D. S. Cassidy, P.Geol.  
D. B. Davies, Ph.D.,  
of Cantox Environmental Inc.  
I. Dowsett, R.E.T.,  
of RWDI West Inc.  
R. Nowak, Ph.D., P.Geol.,  
of Groundwater Exploration & Research  
Ltd.  
T. Dobrowski, Ph.D., P.Eng.,  
of Komex International Ltd.

The Stewart/Peterson and Delainey Panel  
(Stewart/Peterson and the Delaineys)  
G. S. Fitch

G. Stewart  
T. Peterson  
D. Delainey  
K. Delainey  
J. Freeman,  
of Matrix Solutions  
M. Mawer,  
of ReMax Realty  
R. Haessner-Mawer,  
of ReMax Realty

The Proc Panel (the Procs)  
R. Secord

J. Proc  
S. Proc  
D. Picard, M.Eng., P.Eng.,  
of Clearstone Engineering Ltd.  
T. M. M. J. van Olm, M.D.F.R.C.P.(C)

The Norman Panel (the Normans)  
R. Secord

G. Norman  
R. Irvin

B. Brown  
M. Haarmann  
D. Carnegie  
E. Plumecke

**THOSE WHO APPEARED AT THE HEARING (continued)**

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Principals and Representatives  
(Abbreviations Used in Report)

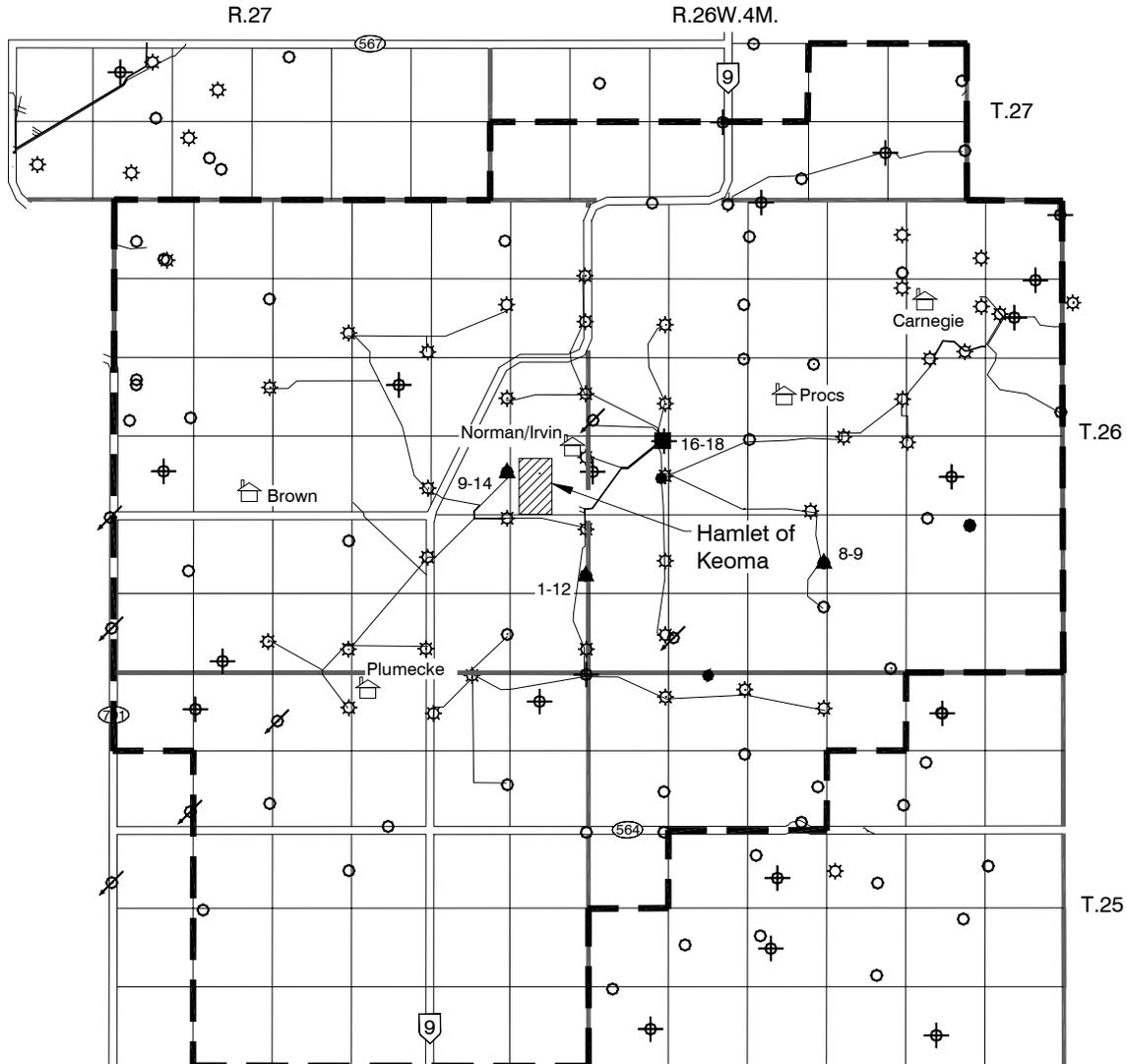
Witnesses

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Alberta Energy and Utilities Board staff  
D. Larder, Board Counsel  
D. Brezina, Board Counsel  
C. Lochhead  
S. L. Cowitz, C.E.T.  
C. Grant, C.E.T.  
B. Austin, P.Geol.  
M. Brown, P.Eng.

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M. Bulmer, B. Schmitt, B. Church, G. Anderson, and B. Bailey registered as participants at the start of the hearing but did not provide direct evidence.



Legend

- |  |                              |  |                |  |  |
|--|------------------------------|--|----------------|--|--|
|  | Proposed miscellaneous order |  | Abandoned well |  | Stewarts, Delainys, and Haarmann properties are within Hamlet of Keoma |
|  | Proposed single sweet well   |  | Standing well  |  |  |
|  | Compressor station           |  | Gas well       |  |  |
|  | Residence                    |  | Oil well       |  |  |
|  | Pipeline                     |  | Injection well |  |  |

**Entice, Ardenode, Gayford, Irricana, and Strathmore fields**

Applications No. 1040201, 1041048, 1041629, 1042292

Avalanche Energy Limited

Decision 2000-49

