Issue: Sensitivity of SO2 concentrations to stack heights and fuel type
Stack heights and fuel types were selected to minimize air quality predictions to meet the NWT Ambient Air Quality Standards. Any changes to the stack heights or fuel types may increase ground-level SO_2 concentrations to levels greater than the ambient standards.

Reference: DAR section 7.2 and Appendix III, transcripts from public hearing February 18, 2004.

Developer's Conclusions
The Proponent states in Table III -8, -10, -12 and -24 that "Stack heights associated with concentrations in excess of the NT standards were increased to comply with NT standards".

Regarding the Planned Development Case, the Proponent was asked if the air quality assessment would be redone if the stack heights and fuel types were changed from those proposed in the DAR. The response by Lloyd Doyle of Paramount from the transcripts of the Public Hearing (February 18, page 79, starting line 9) is provided below.

> The planned development case is -- is not before the Board as a -- for a land use application, it is there purely to assess the cumulative effects and is very speculative, and certainly will not, in all likelihood, come down as presented. There will no doubt be changes and we will assess the affects to the air emissions for those changes by modelling it on a continual basis.

Environment Canada's Conclusion
The Proponent has manipulated stack heights and proposed to use sweet fuel in specific equipment in order to minimize air quality model predictions to meet the NWT ambient air quality standards. Even with this modelling effort the ground-level SO_2 concentrations are predicted to be more than 98% of ambient standards for each development case. Environment Canada's modelling results, presented below, indicate that changes to the proposed configuration such as lower stack heights or using dirtier fuel (containing more H_2S) may cause ambient standards to be exceeded. Therefore, if stack heights or fuel type is changed from what was proposed in the DAR, the air assessment including air modelling should be redone to assure ambient standards are not exceeded.

The Proponent has described the Planned Development Case as "speculative" and has not provided a timeline or a development plan of how the expansion would occur. The air assessment relies on using sweetened fuel at the battery from an on-site amine sweetening unit. Model results presented below, indicate that using well gas at the battery rather than sweetened fuel may cause ground-level SO_2 concentrations to exceed ambient standards. Therefore, development beyond the Application case without the installation of amine sweetening unit will require a new air assessment.

Environment Canada's Rationale/Evidence
Environment Canada has conducted a series model sensitivity runs to investigate how stack heights and fuel type will affect predicted SO2 concentrations. To ensure consistency in model predictions, we used the same air dispersion model, ISCST3, and the same input data sets as the Proponent used for the air quality assessment in the DAR. As an initial test, we successfully reproduced the model results presented in the DAR for each development case.

The modelling results presented in the DAR were predicted using a range of stack heights for line heaters (6.1m to 19m) and for pumpjacks (3.0m to 8.5m). The footnotes attached to tables of stack heights for line heaters and pumpjacks, DAR Tables III-8, -10, -24 and -26, state:

> "A standard line heater stack height of 6.1m was assumed. Stack heights associated with concentrations in excess of the NT standards were increased to comply with NT standards."

and

> "A standard pumpjack stack height of 3m was assumed. Stack heights associated with concentrations in excess of the NT standards were increased to comply with NT standards."

In first set of model scenarios, we used the same emissions and the same meteorology as the proponent used to predict the SO2 concentrations presented in the DAR. The only difference is that we changed the stack heights of line heaters and pumpjacks to the standards heights listed above.

Table 1: Maximum SO2 concentration (ug/m3) using standard stack heights. Percentage of NWT ambient standard is given in parentheses.

Run	Description	1-Hour	24-hour	Annual
Baseline Case				
1A	DAR*	444 (98.6%)	148 (98.7%)	20 (66.7%)
1B	**Standard Stack Heights****	**1080 (240%)**	**401 (267%)**	**32 (107%)**
Application Case				
2A	DAR*	444 (98.6%)	148 (98.7%)	20 (66.7%)
2B	**Standard Stack Heights****	**1077 (240%)**	**401 (267%)**	**33.5 (112%)**
Planned Development Case				
3A	DAR*	448.4 (99.6%)	149.5 (99.7%)	20.4 (68%)
3B	**Standard Stack Heights****	**1041 (231%)**	**391 (260%)**	**34 (113%)**
	NWT Ambient Air Quality	*450*	*150*	*30*

** Model predictions using the input files provided by the Proponent. The model results are the same as those presented in the DAR.*
*** Standard stack for line heaters (6.1m) and pumpjacks (3.0m) were used. These standards height are listed in Tables III-8, -10, -24 and -26 of the DAR.*

The model predictions, presented in Table 1, indicate that using standard stack heights for line heaters and pumpjacks will result in ground-level SO2 concentrations greater than the NWT ambient air quality standards for each development case. Predicted SO2 concentrations are more than double the 1-hour and 24-hour standards.

In the next set of model scenarios, all emissions were removed except for the low pressure flare and line heater at the Application Case gas well F-38. The height of the line heater stack was reduced from the height of 19m, used in the DAR (Table III-14 in the DAR), to the standard height of 6.1m at 1m increments. A sample of the predicted SO2 concentrations is provided in Table 2. Using the line heater stack height from the DAR (19m), the maximum predicted 1-hour SO2 concentration is 95% of the NWT ambient standard. Reducing the line heater stack height increases predicted SO2 concentrations. At a stack height of 18m, 1m less than the stack height used in the DAR, SO2 concentrations are predicted to exceed the 1-hour ambient standard. At the standard stack height of 6m, the maximum SO2 concentration is predicted to be almost 50% greater than the ambient standard.

Table 2: Maximum SO2 concentration (ug/m3) assuming different stack heights for line heater F-38. Percentage of NWT ambient standard is given in parentheses.

Stack Height (m)	Max 1hour SO2
19 (used in the DAR)	428 (95%)
18	457 (102%)
17	485 (108%)
16	513 (114%)
15	540 (120%)
6	645 (143%)

In the Baseline Case and Application Case, SO2 emissions are mitigated by using propane in certain equipment at the facility. For both development cases, the thermo-electric generators (54W) and building heaters (48,000Btu/hr), DAR Tables III-7 and III-13, are listed as using propane fuel. In addition, the Baseline Case pumpjack D-78 is listed as using sweet fuel, DAR Table III-9, and the Application Case line heater G-48 is listed as using propane, DAR Table III-13. Using propane and sweet fuel reduces the SO2 emissions to negligible levels.

To investigate the sensitivity of fuel type on the SO2 ambient predictions, the Application Case model run was redone assuming that D-78 and G-48 were using well gas instead of propane. This model scenario is referred to as 2C. Only the SO2 emissions for D-78 and G-78 have been changed, see Table 3. All other model inputs, including stack heights, are the same as those supplied by the Proponent and used to predict values presented in the DAR.

The results from 2C are provided in Table 4. Changing from propane to well gas in pumpjack D-78 and line heater G-48 results in predicted ground-level SO2 concentrations much greater than the NWT ambient standards.

Table 3: SO2 emission (t/d) changes for model run 2C.

Description	DAR	RUN 2C*
Pumpjack D-78	0	.0094
Line heater G-48	**0**	**.03**

** Emissions for D-78 and G-48 were set to equal the emissions for similar equipment in DAR Tables III-9 and III-13.*

Table 4: Maximum SO2 concentration (ug/m3) assuming well gas is used in D-78 and G-48. Percentage of NWT ambient standard is given in parentheses.

Run	Description	1-Hour	24-hour	Annual
Application Case				
2A	DAR*	444 (98.6%)	148 (98.7%)	20 (66.7%)
2C	D-78 & G-48 using well gas.**	**2210 (491%)**	**796 (530%)**	**53 (177%)**
	NWT Ambient Air Quality	*450*	*150*	*30*

** Model predictions using the input files provided by the Proponent. The model results are the same as those presented in the DAR.*
*** Emission changes from model run 2A are listed in Table 2.*

In the Planned Development Case, the Proponent proposed using sweetened fuel from an on-site amine sweetening unit to reduce SO2 emissions at the battery. The next set of model runs are designed to investigate the affect on predicted SO2 concentrations if the battery equipment used well gas instead of sweetened fuel. Model scenario 3A is the same as what was presented in the DAR for the Planned Development Case. Model scenario 3C is the same as 3A except most of the battery equipment was assumed to be using well gas instead of sweetened gas, see Table 5. Model scenario 3D uses the same battery emissions as 3A but all other emissions are removed. Model scenario 3E is the same as 3D except the battery equipment was assumed to be using well gas, see Table 5.

Table 5: Modified battery emissions (t/d) for the Planned Development Case.

Description	DAR	RUN 3C and 3E
Modified Emissions – Used emission rates from Baseline Case		
Treater Unit	0.000018	.034
2 x Compressors	**.00004**	**.16**
Heat Medium Heater	**0**	**0.011**
3 x Water Tank Heaters	**0**	**0.00677**
Unchanged emissions		
Low Pressure Flare	**.0265**	**0.265**

Generator (650kW)	**0.0001**	**0.0001**

In the well gas scenarios, 3C and 3E, ground-level SO2 concentrations are predicted exceed the 1-hour ambient standard, see Table 6. The maximum SO2 concentrations appear to be caused by emissions from the 2 compressors. Note that in model scenarios 3C and 3E, the 650kW generator is assumed to be using sweetened fuel. However, if the amine sweetening unit is not installed, this generator would likely use well gas resulting in greater SO2 emissions. Therefore the model results for 3C and 3E may be underpredicted. In the sweet gas model scenario, 3D, emissions from the battery result in maximum SO2 concentrations well below ambient standards.

Table 6: Maximum SO2 concentration (ug/m3) for sweet and well gas scenarios for the Planned Development Case. Percentage of NWT ambient standard is given in parentheses.

Run	Description	1-Hour	24-hour	Annual
3A	DAR	448.4 (99.6%)	149.5 (99.7%)	20.4 (68%)
3C	Battery Emissions using well gas plus all other emissions	495 (110%)	150 (100%)	25 (83%)
3D	Battery Emissions only with Sweet Fuel	38 (8%)	13 (8%)	2 (7%)
3E	Battery Emissions only with well gas	**464 (103%)**	**140 (93%)**	**16 (53%)**
	NWT Ambient Air Quality	*450*	*150*	*30*

This analysis demonstrates the sensitivity of model predictions to model inputs. Reducing stack heights and changing fuel types resulted in predicted SO2 concentrations in exceedance of the NWT ambient air quality standards. The air quality predictions presented in the DAR are only valid for the proposed development cases described in the DAR. Any changes in development plans, such as lowering stack heights or using well gas instead of sweetened gas, will require new air quality modelling and a new air quality assessment.

Recommendation

Through the model sensitivity tests presented above, Environment Canada has shown that air quality model predictions are very sensitive to changes in stack height and changes in fuel type used at the Cameron Hills facility. Decreasing stack height and changing from sweetened fuel to well gas will increase ground-level SO2 concentration and may cause exceedances of the NWT ambient air quality standards.

Environment Canada recommends that the Proponent conduct a new air assessment including new air quality modelling if stack heights or fuel type are changed from what was proposed in the DAR. This includes any development beyond the Application case without the installation of the amine sweetening unit proposed in the Planned Development Case.