Information Request 46

Response to Information Request 46

IR 46 – Exclusion of Polycyclic Aromatic Hydrocarbons

References:

EIS Guidelines, Section 2.7.3.3
EIS, Section 2.7.3.3
2009 EIS, Section 6.3.1.6

Related Comments:

CEAR # 265 (Health Canada)

Rationale:

In Section 2.7.3.3, the EIS Guidelines require the Proponent to conduct a human health risk assessment and include consideration of the potential effects for all project phases (*i.e.* construction, operation, closure and post-closure).

In the 2009 EIS (Section 2.1.3, p.2-12), the Proponent identifies measurable variables for the air quality assessment which are subsequently used in predicting project effects on human health. Measurable variables include: respirable particulate matter ($PM_{2.5}$); inhalable particulate matter (PM_{10}), total suspended particulates (TSP); dustfall; oxides of nitrogen (NOx); carbon monoxide (CO); sulphur dioxide (SO_2); lead (Pb); carbon dioxide (CO_2); methane (CH_4); and nitrous oxide (N_2O).

Health Canada noted that the human health impact assessment did not provide information on the potential for the generation of potentially carcinogenic polycyclic aromatic hydrocarbons from heavy equipment activities and associated effects on human health. It was noted that this exclusion could under-estimate cancer causing effects of Project activities.

Information Requested:

With regards to the air quality assessment, the Panel requests that Taseko:

a. Provide an assessment on potentially carcinogenic polycyclic (polynuclear) aromatic hydrocarbons from heavy equipment operations or a rationale as to why these were excluded from the analysis.

b. Provide an assessment of the effects of exposure to potentially carcinogenic polycyclic (polynuclear) aromatic hydrocarbons on the health of identified sensitive receptors.

Information Requests #46a and b

a. Provide an assessment on potentially carcinogenic polycyclic (polynuclear) aromatic hydrocarbons from heavy equipment operations or a rationale as to why these were excluded from the analysis.

b. Provide an assessment of the effects of exposure to potentially carcinogenic polycyclic (polynuclear) aromatic hydrocarbons on the health identified sensitive receptors.

Response Summary for a

Carcinogenic and non-carcinogenic polycyclic (polynuclear) aromatic hydrocarbons were included as a component of the Air Dispersion Modeling. CCME guidance was used to rank the potencies of the individual carcinogenic PAH to determine Potency Equivalencies. The annual average PAH concentrations associated with diesel emissions from the heavy machinery were converted into B[a]P-TPE concentrations for the Construction and Operations phases for various locations at the mine site and regional area.

Response Summary for b

An assessment of the effects of exposure to potentially carcinogenic polycyclic (polynuclear) aromatic hydrobarbons on sensitive receptors is provided in the section below (Discussion). The conclusion of the assessment is that exposure to carcinogenic PAH from the operation of heavy machinery over the lifetime of the mine will not result in exposures that exceed the acceptability limits established by provincial and federal regulatory authorities.

Discussion

Inhalation of polycyclic aromatic hydrocarbons (PAH) in exhaust from heavy equipment represents the primary route of exposure to these compounds for people on site and in the local area around the site. A component of the Air Dispersion Modeling completed for the project includes estimates of the concentrations of individual PAH (both carcinogenic and non-carcinogenic PAH). The modeling provides 1-hour, 24-hour and annual average PAH concentration estimates for several key locations within the local and regional study areas. Health Canada and CCME guidance on estimating lifetime cancer risk for PAH requires that the risk be calculated based on a Benzo[*a*]pyrene Total Potency Equivalents (B[a]P-TPE) (Health Canada 2010b). This approach recognizes that the carcinogenic PAH have the same biological mechanism of action and differ only in their potencies (ability to cause cancer). In recognition of this, CCME has developed an approach that ranks the cancer potencies of the individual carcinogenic PAH to the carcinogenic potency of B[a]P. This approach is similar the approach taken by other regulatory agencies (e.g., US EPA, WHO). Table 46-1 provides the CCME Potency Equivalence factors assigned to the individual carcinogenic PAH. Table 46-1 also provides an example of how these Potency Equivalencies are used to calculate the B[a]P-TPE

that is used to estimate the cancer risk associated with exposures to carcinogenic PAH. Essentially, the reported concentration of the individual PAH are multiplied by the corresponding B[a]P equivalent potency to provide a B[a]P equivalent concentration. For example, benz[a]anthracene has a B[a]P-TPE of 0.1, meaning that the concentration of benz[a]anthracene needs to be 10 times higher than B[a]P to produce the equivalent lifetime cancer risk. This approach is applied to the reported concentrations of each of the carcinogenic PAH and the resulting B[a]P-TPE concentrations are summed to provide concentration which is used in estimating the lifetime cancer risk associated with exposure to the carcinogenic PAH.

Table 46-1. Benzo[a]pyrene Total Potency Equivalence – Sample Calculation

Carcinogenic PAH	B[a]P Equivalent Potency	Example Concentration (µg/m^3)	B[a]P Equivalent Concentrations (µg/m^3)
Benz[a]anthracene	0.1	10	1
Benzo[a]pyrene	1	3	3
Benzo[b]fluoranthene	0.1	20	2
Benzo[ghi]perylene	0.01	7	0.07
Benzo[k]fluoranthene	0.1	7	0.7
Chrysene	0.01	3	0.03
Dibenz[a,h]anthracene	1	7	7
Flouranthenre	0.001	12	0.012
Indeno[1,2,3-cd]pyrene	0.1	12	1.2
Phenanthrene	0.001	90	0.09
Total B[a]P Total Potency Equivalent Concentration (µg/m^3)			**15.102**

* B[a]P Equivalent Potencies – from Health Canada 2010a.

This approach has been used to convert the annual average PAH concentrations predicted to be associated with diesel emissions from the heavy machinery into B[a]P-TPE concentrations for the Construction and Operations phases of the Project (Table 46-2 and Table 46-3 respectively). The B[a]P-TPE concentrations for the construction and operation phases were used to calculate the life-time averaged daily exposures for people at the following locations:

- Camp Location;
- Nemiah Valley;
- Southern Area of Mine Site Footprint;
- Northwest Corner of Mine Site;

- Maximum Point of Impingement;
- Maximum Concentrations on or outside the Disturbance Boundary

Table 46-2. Calculation of B[a]P-TPE: - Construction Phase

Carcinogenic PAH	Predicted Annual Average Concentrations of Carcinogenic PAH (µg/m^3)					
	Camp Location	Nemiah Valley	Southern Area of Minesite Footprint	NW Corner of Mine Site	Maximum Point of Impingement	Maximum on/outside of Disturbance Boundary
Benz[a]anthracene	4.71E-05	8.51E-08	2.51E-07	8.62E-07	6.72E-05	2.88E-05
Benzo[a]pyrene	2.55E-06	4.60E-09	1.36E-08	4.66E-08	3.63E-06	1.56E-06
Benzo[b]fluoranthene	2.14E-05	3.86E-08	1.14E-07	3.91E-07	3.05E-05	1.31E-05
Benzo[ghi]perylene	3.16E-07	5.70E-10	1.68E-09	5.78E-09	4.50E-07	1.93E-07
Benzo[k]fluoranthene	2.43E-06	4.39E-09	1.29E-08	4.45E-08	3.46E-06	1.48E-06
Chrysene	5.30E-05	9.58E-08	2.83E-07	9.70E-07	7.56E-05	3.24E-05
Dibenz[a,h]anthracene	6.68E-06	1.21E-08	3.56E-08	1.22E-07	9.52E-06	4.08E-06
Flouanthene	8.45E-04	1.53E-06	4.51E-06	1.55E-05	1.21E-03	5.17E-04
Indeno[1,2,3-cd]pyrene	4.05E-06	7.31E-09	2.16E-08	7.41E-08	5.77E-06	2.47E-06
Phenanthrene	1.48E-03	2.68E-06	7.91E-06	2.72E-05	2.12E-03	9.07E-04

Carcinogenic PAH	B[a]P-Potency Equivalence	B[a]P-Potency Equivalency Concentrations of Carcinogenic PAH (µg/m^3)					
Benz[a]anthracene	0.1	4.71E-06	8.51E-09	2.51E-08	8.62E-08	6.72E-06	2.88E-06
Benzo[a]pyrene	1	2.55E-06	4.60E-09	1.36E-08	4.66E-08	3.63E-06	1.56E-06
Benzo[b]fluoranthene	0.1	2.14E-06	3.86E-09	1.14E-08	3.91E-08	3.05E-06	1.31E-06
Benzo[ghi]perylene	0.01	3.16E-09	5.70E-12	1.68E-11	5.78E-11	4.50E-09	1.93E-09
Benzo[k]fluoranthene	0.1	2.43E-07	4.39E-10	1.29E-09	4.45E-09	3.46E-07	1.48E-07
Chrysene	0.01	5.30E-07	9.58E-10	2.83E-09	9.70E-09	7.56E-07	3.24E-07
Dibenz[a,h]anthracene	1	6.68E-06	1.21E-08	3.56E-08	1.22E-07	9.52E-06	4.08E-06

Carcinogenic PAH	B[a]P-Potency Equivalence	B[a]P-Potency Equivalency Concentrations of Carcinogenic PAH (µg/m^3)					
Flouranthenre	0.001	8.45E-07	1.53E-09	4.51E-09	1.55E-08	1.21E-06	5.17E-07
Indeno[1,2,3-cd]pyrene	0.1	4.05E-07	7.31E-10	2.16E-09	7.41E-09	5.77E-07	2.47E-07
Phenanthrene	0.001	1.48E-06	2.68E-09	7.91E-09	2.72E-08	2.12E-06	9.07E-07
B[a]P Total Potency Equivalent concentration (µg/m^3)		**1.96E-05**	**3.54E-08**	**1.04E-07**	**3.58E-07**	**2.79E-05**	**1.20E-05**

Table 46-3. Calculation of B[a]P-TPE: - Operations Phase

Carcinogenic PAH	Predicted Annual Average Concentrations of Carcinogenic PAH (µg/m^3)					
	Camp Location	Nemiah Valley	Southern Area of Minesite Footprint	NW Corner of Mine Site	Maximum Point of Impingement	Maximum on/outside of Disturbance Boundary
Benz[a]anthracene	2.58E-05	2.24E-07	6.56E-07	2.24E-07	4.51E-04	9.28E-05
Benzo[a]pyrene	1.39E-06	1.21E-08	3.54E-08	1.21E-08	2.44E-05	5.01E-06
Benzo[b]fluoranthene	1.17E-05	1.02E-07	2.97E-07	1.02E-07	2.04E-04	4.21E-05
Benzo[ghi]perylene	1.73E-07	1.50E-09	4.39E-09	1.50E-09	3.02E-06	6.22E-07
Benzo[k]fluoranthene	1.33E-06	1.15E-08	3.38E-08	1.15E-08	2.33E-05	4.78E-06
Chrysene	2.90E-05	2.52E-07	7.38E-07	2.52E-07	5.08E-04	1.04E-04
Dibenz[a,h]anthracene	3.65E-06	3.17E-08	9.29E-08	3.17E-08	6.39E-05	1.31E-05
Flouanthene	4.62E-04	4.02E-06	1.18E-05	4.02E-06	8.09E-03	1.66E-03
Indeno[1,2,3-cd]pyrene	2.21E-06	1.92E-08	5.64E-08	1.92E-08	3.88E-05	7.97E-06
Phenanthrene	8.11E-04	7.06E-06	2.07E-05	7.06E-06	1.42E-02	2.92E-03
Carcinogenic PAH	**BAP Equivalent Potency**	**B[a]P-Potency Equivalency Concentrations of Carcinogenic PAH (µg/m3)**				
Benz[a]anthracene	0.1	2.58E-06	2.24E-08	6.56E-08	2.24E-08	4.51E-05	9.28E-06
Benzo[a]pyrene	1	1.39E-06	1.21E-08	3.54E-08	1.21E-08	2.44E-05	5.01E-06
Benzo[b]fluoranthene	0.1	1.17E-06	1.02E-08	2.97E-08	1.02E-08	2.04E-05	4.21E-06
Benzo[ghi]perylene	0.01	1.73E-09	1.50E-11	4.39E-11	1.50E-11	3.02E-08	6.22E-09
Benzo[k]fluoranthene	0.1	1.33E-07	1.15E-09	3.38E-09	1.15E-09	2.33E-06	4.78E-07
Chrysene	0.01	2.90E-07	2.52E-09	7.38E-09	2.52E-09	5.08E-06	1.04E-06
Dibenz[a,h]anthracene	1	3.65E-06	3.17E-08	9.29E-08	3.17E-08	6.39E-05	1.31E-05
Carcinogenic PAH	**BAP Equivalent Potency**	**B[a]P-Potency Equivalency Concentrations of Carcinogenic PAH (µg/m3)**				
Flouranthenre	0.001	4.62E-07	4.02E-09	1.18E-08	4.02E-09	8.09E-06	1.66E-06
Indeno[1,2,3-cd]pyrene	0.1	2.21E-07	1.92E-09	5.64E-09	1.92E-09	3.88E-06	7.97E-07
Phenanthrene	0.001	8.11E-07	7.06E-09	2.07E-08	7.06E-09	1.42E-05	2.92E-06
B[a]P Total Potency Equivalent concentration (µg/m^3)		**1.07E-05**	**9.31E-08**	**2.73E-07**	**9.31E-08**	**1.87E-04**	**3.86E-05**

The B[a]P-TPE concentrations from the construction and operations phases were used to calculate the lifetime averaged daily exposures (LADE) for the respective phases in order to facilitate the calculation of the overall incremental lifetime cancer risk (ICLR) associated with exposure to carcinogenic PAH in diesel emissions from heavy machinery. The ICLRs for the various locations have been calculated using the equations recommended by Health Canada (Health Canada 2010a). The general form of the equation is shown in Equation 1.

Eq 1:

$$ICLR_{ih} = AirConcentration(\mu g/m^3) \times Fraction\ of\ Time\ Exposed \times Inhalation\ Unit\ Risk\ (\mu g/m^3)^{-1}$$

Where the fraction of time exposed represents that number of years of exposure that occur over an 80 year lifetime and is calculated as shown in Equation 2:

EQ 2:

$$Fraction\ of\ Time\ Exposed\ (FTE) = \frac{{}^{hours}/_{day} \times {}^{days}/_{year} \times years\ of\ exposure}{24\ {}^{hours}/_{day} \times 365\ {}^{days}/_{year} \times 80\ year\ lifetime}$$

For the purposes of providing a conservative estimate of potential cancer risk, it has been assumed that people within the project study are would be present 24 hours/day 365 days per year over the construction and operational phases of the project. Thus, the frequency of exposure represents the number of expected years of exposure over an 80-year lifetime. The construction phase of the project will last for one year and the operations phase is expected to last for nineteen years. These phase durations have been used in driving the FTE values necessary to estimate overall lifetime cancer risk. The FTE values calculated for the construction and operations phases of the project are shown in Table 46-4.

Table 46-4. Calculation of Fraction of Time Exposed (FTE) for Project Phases

Mine Phases	Duration of Exposure			Lifetime			Fraction of Time Exposed (FTE)
	hours/day	days/year	years	hours/d	days/year	years	
construction	24	365	1	24	365	80	0.0125
operations	24	365	19	24	365	80	0.2375

These FTE values have been used in conjunction with the annual average B[a]P-TPE concentrations for the construction and operations phases of the project to evaluate the potential increase in lifetime cancer risk associated with inhalation exposures to carcinogenic PAH in diesel exhaust from heavy machinery on the mine site. The ILCRs for the construction and operations phases of the project are calculated individually using Equation 1.

The Health Canada Inhalation Unit Risk value (IUR) for benzo[a]pyrene (Health Canada 2010b) was used in the derivation of the ILCR values. Although BC MOE (2012) recommends preferential use of the US EPA: Integrated Risk Information System (IRIS) toxicity reference values in human health risk assessment, US EPA IRIS does not provide a quantitative estimate of carcinogenic health risks from inhalation exposure to B[a]P. The ILCRs for the construction and operations phases for each of the identified receptor locations are provided in Table 46-5.

Table 46-5. Lifetime Cancer Risks Estimates for Exposure to PAH in Project Diesel Emissions

Receptor Location	Project Phase	Annual Average B[a]Peq Concentration ($\mu g/m^3$)	Fraction of Time Exposed (FTE) (unitless)	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Incremental Increase in Lifetime Cancer Risk (unitless)	Total ICLR (unitless)	Health Canada & BC MOE Risk Acceptability Benchmark (unitless)	Estimated Cancer Risk Above the Cancer Risk Benchmark?
Camp Location	Construction	1.96E-05	0.0125	3.10E-05	7.59E-12	8.64E-11	1.00E-05	No
	Operation	1.07E-05	0.2375	3.10E-05	7.88E-11			
Nemiah Valley	Construction	3.54E-08	0.0125	3.10E-05	1.37E-14	6.99E-13	1.00E-05	No
	Operation	9.31E-08	0.2375	3.10E-05	6.85E-13			
Southern Area of Minesite Footprint	Construction	1.04E-07	0.0125	3.10E-05	4.04E-14	2.05E-12	1.00E-05	No
	Operation	2.73E-07	0.2375	3.10E-05	2.01E-12			
NW Corner of Mine Site	Construction	3.58E-07	0.0125	3.10E-05	1.39E-13	8.24E-13	1.00E-05	No
	Operation	9.31E-08	0.2375	3.10E-05	6.85E-13			
Maximum Point of Impingement	Construction	2.79E-05	0.0125	3.10E-05	1.08E-11	1.39E-09	1.00E-05	No
	Operation	1.87E-04	0.2375	3.10E-05	1.38E-09			
Maximum on/outside of Disturbance Boundary	Construction	1.20E-05	0.0125	3.10E-05	4.64E-12	2.89E-10	1.00E-05	No
	Operation	3.86E-05	0.2375	3.10E-05	2.84E-10			

The ILCRs for the construction and operations phases must be combined in order to provide an estimate of the total cancer risk associated with exposure to PAH in diesel emissions over the life of the project. Table 46-5 provides the total ILCR values for each of the receptor locations. Table 46-5 also lists the cancer risk acceptability benchmark established by both Health Canada and the British Columbia Ministry of the Environment. This risk acceptability benchmark represents an increase in overall lifetime cancer risk of 0.00001 for an individual. Estimated cancer risks that fall below this benchmark are considered to be negligible by regulatory agencies and mitigation is not required. The total ILCR values listed in Table 46-5 are well below the risk acceptability benchmark of 1×10^{-5} (0.00001). The largest ILCR (1.39E-09 or 0.00000000139) was calculated for the maximum point of impingement. This is 10,000 times lower than the 0.00001 benchmark. ILCRs for the other locations range between 100,000 and 10,000,000 times lower than the 0.00001 benchmark.

The ILCR for the maximum point of impingement location is based on the conservative assumption that a person would be present at the location where diesel-related PAH concentrations in air are highest, 24 hours per day 365 days per year over the 20 year life of the project. At the maximum point of impingement, the B[a]P-TPE annual average concentrations were higher for the operations phase than the construction phase. To evaluate a maximum upper-bound worst-case estimate of potential cancer risk, the calculations shown above were also run assuming that a person would spend an entire 80-year lifetime at the maximum point of impingement location and that the B[a]P-TEQ annual average concentration would be present in the air for that 80-year lifetime (effectively increasing the value of FTE from 0.2375 to 1 which is equivalent to continuous lifetime exposure). This represents a 4.2-fold increase in FTE. Increasing the FTE value by 4.2-fold, increases the ILCR by the same amount, resulting in a worst-case ILCR value of 5.84E-09 (1.39E-09 x 4.2 = 5.37E-09). Even this worst-case estimate is still well below the ILCR benchmark established by regulatory authorities. Thus, exposure to carcinogenic PAH from the operation of heavy machinery over the lifetime of the mine will not result in exposures that exceed the acceptability limits established by provincial and federal regulatory authorities.

Conclusion

Carcinogenic and non-carcinogenic polycyclic (polynuclear) aromatic hydrocarbons were included as a component of the Air Dispersion Modeling. CCME guidance was used to rank the potencies of the individual carcinogenic PAH to determine Potency Equivalencies. The annual average PAH concentrations associated with diesel emissions from the heavy machinery were converted into B[a]P-TPE concentrations for the Construction and Operations phases for various locations at the mine site and regional area. The assessment of the effects of exposure to potentially carcinogenic polycyclic (polynuclear) aromatic hydrobarbons on sensitive receptors concludes that exposure from the operation of heavy machinery over the lifetime of the mine will not result in exposures that exceed the acceptability limits established by provincial and federal regulatory authorities.

References

British Columbia Ministry of Environment (BC MOE), 2012. Technical Guidance 7 on Contaminated Sites, Supplemental Guidance for Risk Assessments, Version 3.

Health Canada, 2010a: Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2- Federal Contaminated Site Risk Assessment in Canada

Health Canada, 2010b: Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2 – Federal Contaminated Site Risk Assessment in Canada