

Memorandum



Date: April 24, 2018

To: Oliver Curran, TMAC Resources Inc.

From: ERM Consultants Canada Ltd.

CC: Nicole Bishop, ERM

Subject: TMAC Resources Inc. – Technical Comments received from Health Canada regarding the Madrid-Boston Final Environmental Impact Statement

INTRODUCTION

This memorandum responds to Technical Comment HC-4.2.2 provided by Health Canada (HC) in March 2018 with respect to TMAC Resources Inc.'s (TMAC) Final Environmental Impact Statement (FEIS) for the Madrid-Boston Project (the Project). Provided below is technical comment HC-4.2.2 followed by TMAC's response.

HEALTH CANADA TECHNICAL COMMENT HC-4.2.2:

SUBJECT/TOPIC

Human Health Risk Assessment – Short-term/intermittent Exposures

REFERENCES

FEIS, Volume 6, Section 5.3.2.1, page 5-21

SUMMARY

The HHRA may underestimate risk to off-duty workers as a result of dose-averaging and intermittent exposures. The proponent is being asked to consider the potential of dose averaging on the risk to human health.

DISCUSSION

Importance of Issue to the Impact Assessment Process

Potential risk to human health.

Detailed Review Comment

The HHRA appears to have assessed the chronic health effects alone by dose-averaging the intermittent exposures of the off-duty workers (i.e. 2 weeks / 4 weeks, 26 weeks/year for 14 years). The following issues should be considered with regards to dose averaging (or dose amortization) practice (Health Canada 2013).

- i) There is a potential for underestimating chronic health risks for both cancer and non-cancer risk assessments.
- ii) The possibilities of acute/subchronic non-cancer effects due to elevated exposures that exceed chronic TRVs have not been considered.
- iii) Considerations should be given to assessing the potential acute/subchronic/chronic health effects noted above. To this end, Health Canada has developed specific guidance (Health Canada 2016) that can be employed to assess risks associated with short- and/or intermittent duration exposure scenarios. Alternatively, an uncertainty analysis can be conducted in order to determine how representative the risk assessment is of actual site conditions, and how sensitive the risk estimates are to changes in any or all of the assumptions used in this risk assessment. Such analysis would allow for mitigative measures to be designed accordingly.

RECOMMENDATION/REQUEST

- a) Provide rationale for dose-averaging the intermittent exposures off-duty workers.
- b) Assess risks associated with short- and/or intermittent duration exposure scenarios or alternatively an uncertainty analysis can be conducted in order to determine how representative the risk assessment is of actual site conditions, and how sensitive the risk estimates are to changes in any or all of the assumptions used in this risk assessment.

TMAC RESPONSE:

INTRODUCTION

TMAC has reviewed the Health Canada (2016) *Primer for Evaluating Human Health Risks at Contaminated Sites for Chronic and Less-than-chronic Exposures to Chemicals*, which was referenced in comment HC-4.2.2. TMAC reiterates that this guidance document was not previously provided to TMAC, nor were any comments received on the dose-averaging methodology used to estimate health risks for off-duty workers during the review of the DEIS in 2017.

Health Canada's Federal Contaminated Sites Action Plan (FCSAP) guidance documents (Health Canada 2010a, b, c, d, e; Health Canada 2011) were used in the FEIS to estimate potential human health risks from the Project. TMAC understands that Health Canada (2016) was developed to support FCSAP guidance and, although the proposed Project is not a contaminated site, TMAC has taken this primer into consideration. The risk estimates to off-duty workers from exposure to metals (all pathways) and risk estimates for inhalation of criteria air contaminants (CACs) were re-evaluated (see sections below). As described below, the risk re-evaluations indicate that removing dose-averaging from the risk estimates does not change the outcome of the human health risk assessment provided in the FEIS, and that there is no change in risk to off-duty worker health as a result of the Project.

RE-EVALUATION OF RISK DUE TO EXPOSURE TO METALS

Non-carcinogenic Risk

TMAC has applied the tiered approach to evaluate non-carcinogenic risks to off-duty workers from less-than-chronic exposures to metals in air, soil, and surface water (Health Canada 2016). The tiered approach applies an initial screening step to assess chemicals with non-carcinogenic effects by using an unadjusted daily exposure (i.e., without dose averaging) to the chronic Toxicity Reference Value (TRV; Health Canada 2010b).

To calculate an unadjusted daily exposure, TMAC has assumed that the duration terms are equal to "1", that is $D1 = 24$ hours per day, $D2 = 7$ days per week, and $D3 = 52$ weeks per year exposed. Thus the unadjusted daily exposures provide a worst-case exposure scenario where health effects are not anticipated if the target risk level (or hazard quotient; HQ) of 0.2 is not exceeded. This approach "ignores" any time periods that a worker will spend away from the Project during off-shift rotation and does not average the dose between on-shift and off-shift periods that the off-duty worker would receive.

The unadjusted estimated daily dose (or intake; EDI) of metals via inhalation, soil ingestion, dermal exposure to soil, and drinking water ingestion is calculated using Equations 1 to 4 described in Section 5.3.3 of Volume 6 of the FEIS. Table 1 lists the unadjusted EDI and the resulting HQs for metals from all exposure pathways and at different receptor locations for the Project's Construction and Operational phases. Please note that other changes to risk calculations made in response to comments during the FEIS review period have not been included in the EDIs and HQs in Table 1 to facilitate a direct comparison to results provided in the FEIS.

To calculate the HQ, the unadjusted EDI from each pathway were summed (as per Equation 6 in Section 5.3.5.2 of Volume 6 of the FEIS) and then the summed EDI of each

metal was then divided by the TRV (in mg/kg BW/day) to obtain the unadjusted HQ (See Equation 7 in Section 5.3.5.2 of Volume 6 of the FEIS).

Table 2 compares the HQs calculated for dose-averaged exposures presented in the FEIS with the new unadjusted HQs. Results in Tables 1 and 2 illustrate that when exposures are not dose-averaged, but rather calculated as a daily exposure, HQs for off-duty workers remain below the target risk level of 0.2. Therefore, there are no unacceptable health risks to off-duty workers from exposure to Project-related metals.

The assumptions adopted in this memo to satisfy comment HC-4.2.2 do not meet the occupational health and safety requirements that TMAC must adhere to, as it required assuming that a worker is on shift for 24 hours a day for 14 years, continuously. The FEIS contains many conservative assumptions including maximum or 95th percentile predicted concentrations of metals in various environmental media and shift rotations that do not take in to account holiday time or sick time. Thus the re-calculated risk estimates are not reasonably realistic. However, despite these ultra-conservative and unrealistic conditions, no unacceptable risks were identified to off-duty Worker health.

Carcinogenic Risk

In the FEIS, the evaluation of carcinogenic risk for off-duty workers included the calculation of a lifetime average daily dose (i.e., the dose received averaged over a lifetime) in accordance with the Health Canada (2013, 2016) guidance documents. Age-dependent adjustment factors for different life stages does not apply to off-duty workers as only adults will be working at the Project site. Therefore, the carcinogenic risk calculations do not require re-evaluation.

RE-EVALUATION OF RISK DUE TO INHALATION OF CRITERIA AIR CONTAMINANTS

In response to comment HC-4.2.2, TMAC has also reviewed the HQs calculated for off-duty workers from inhalation exposure to CACs. The HQs for CACs are based on the maximum concentrations for the averaging periods provided by the air quality model for two different model cases. Maximum concentrations were not dose-averaged and were compared directly to the Ambient Air Quality Criteria for the applicable averaging periods (i.e., 1-hour, 24-hour, and annual criteria; Table 5.4-18 of Volume 6 of the FEIS). Thus, the risk calculations for CACs do not require re-evaluation.

Table 1. Risk Characterization for Off-duty Workers during the Construction and Operational Phases using Less-than-chronic Exposure and Risk Evaluation

COPC	Toxicity Reference Value (mg/kg BW/day)	Construction Phase - Off-Duty Workers													Hazard Quotient for Off-Duty Workers			
		Estimated Daily Intake (mg/kg BW/day)											Total for Boston Operational Camp (All Exposure Routes)	Total for Quarry D Camp (All Exposure Routes)	Hazard Quotient for Doris Camp	Hazard Quotient for Boston Exploration Camp	Hazard Quotient for Boston Operational Camp	Hazard Quotient for Quarry D Camp
		Inhalation at Doris Camp	Inhalation at Boston Exploration Camp	Inhalation at Boston Operational Camp	Inhalation at Quarry D Camp	Drinking Water	Soil Ingestion	Dermal Contact With Soil	Total for Doris Camp (All Exposure Routes)	Total for Boston Exploration Camp (All Exposure Routes)	Total for Boston Operational Camp (All Exposure Routes)	Total for Quarry D Camp (All Exposure Routes)						
Arsenic	0.0003	2.24E-09	1.44E-09	7.56E-09	4.99E-09	6.72E-06	7.73E-08	2.67E-09	6.80E-06	6.80E-06	6.80E-06	6.80E-06	6.80E-06	0.023	0.023	0.023	0.023	
Cadmium	0.001	4.48E-10	2.87E-10	1.51E-09	9.98E-10	1.54E-07	5.23E-09	6.03E-11	1.60E-07	1.60E-07	1.60E-07	1.60E-07	1.60E-07	0.00016	0.00016	0.00016	0.00016	
Chromium	0.001	6.71E-07	4.31E-07	2.27E-06	1.50E-06	1.21E-05	1.37E-06	1.58E-07	1.38E-05	1.38E-05	1.42E-05	1.40E-05	1.40E-05	0.014	0.014	0.014	0.015	
Copper	0.141	4.92E-07	3.16E-07	1.66E-06	1.10E-06	3.34E-05	7.93E-07	5.49E-08	3.44E-05	3.44E-05	3.47E-05	3.46E-05	3.46E-05	0.00025	0.00025	0.00026	0.00025	
Lead	0.0013	2.69E-09	1.72E-09	9.07E-09	5.99E-09	1.21E-06	3.14E-07	3.62E-07	1.89E-06	1.89E-06	1.89E-06	1.89E-06	1.89E-06	0.0015	0.0015	0.0015	0.0015	
Manganese	0.156	4.16E-06	2.67E-06	1.41E-05	9.28E-06	4.86E-04	7.72E-06	8.90E-06	5.04E-04	5.04E-04	5.06E-04	5.05E-04	5.05E-04	0.0033	0.0032	0.0033	0.0033	
Mercury	0.0003	4.48E-11	2.87E-11	1.51E-10	9.98E-11	6.76E-08	1.04E-09	1.20E-09	6.99E-08	6.99E-08	6.99E-08	6.99E-08	6.99E-08	0.00023	0.00023	0.00023	0.00023	
Nickel	0.011	3.22E-07	2.07E-07	1.09E-06	7.19E-07	1.29E-05	7.26E-07	7.61E-08	1.38E-05	1.37E-05	1.39E-05	1.39E-05	1.39E-05	0.0013	0.0013	0.0013	0.0013	
Selenium	0.0057	2.24E-09	1.44E-09	7.56E-09	4.99E-09	5.71E-06	5.24E-09	6.04E-11	5.71E-06	5.71E-06	5.71E-06	5.71E-06	5.71E-06	0.0010	0.0010	0.0010	0.0010	
Thallium	0.00007	4.48E-10	2.87E-10	1.51E-09	9.98E-10	1.32E-07	1.05E-08	1.21E-08	1.55E-07	1.55E-07	1.55E-07	1.55E-07	1.55E-07	0.0022	0.0022	0.0022	0.0022	
Zinc	0.57	2.64E-07	1.69E-07	8.92E-07	5.89E-07	7.27E-05	1.24E-06	1.43E-07	7.42E-05	7.41E-05	7.43E-05	7.42E-05	7.42E-05	0.00013	0.00013	0.00013	0.00013	
COPC	Toxicity Reference Value (mg/kg BW/day)	Operational Phase - Off-Duty Workers													Hazard Quotient for Off-Duty Workers			
		Estimated Daily Intake (mg/kg BW/day)											Total for Boston Operational Camp (All Exposure Routes)	Total for Quarry D Camp (All Exposure Routes)	Hazard Quotient for Doris Camp	Hazard Quotient for Boston Exploration Camp	Hazard Quotient for Boston Operational Camp	Hazard Quotient for Quarry D Camp
		Inhalation at Doris Camp	Inhalation at Boston Exploration Camp	Inhalation at Boston Operational Camp	Inhalation at Quarry D Camp	Drinking Water	Soil Ingestion	Dermal Contact With Soil	Total for Doris Camp (All Exposure Routes)	Total for Boston Exploration Camp (All Exposure Routes)	Total for Boston Operational Camp (All Exposure Routes)	Total for Quarry D Camp (All Exposure Routes)						
Arsenic	0.0003	1.30E-09	2.69E-09	8.80E-09	2.03E-09	6.79E-06	7.73E-08	2.67E-09	6.87E-06	6.87E-06	6.88E-06	6.87E-06	6.87E-06	0.023	0.023	0.023	0.023	
Cadmium	0.001	2.59E-10	5.38E-10	1.76E-09	4.07E-10	1.55E-07	5.23E-09	6.03E-11	1.60E-07	1.60E-07	1.60E-07	1.60E-07	1.60E-07	0.00016	0.00016	0.00016	0.00016	
Chromium	0.001	3.89E-07	8.06E-07	2.64E-06	6.10E-07	1.22E-05	1.37E-06	1.58E-07	1.39E-05	1.40E-05	1.44E-05	1.39E-05	1.39E-05	0.014	0.015	0.016	0.014	
Copper	0.141	2.85E-07	5.91E-07	1.94E-06	4.47E-07	3.38E-05	7.95E-07	5.50E-08	3.47E-05	3.48E-05	3.52E-05	3.48E-05	3.48E-05	0.00025	0.00025	0.00026	0.00025	
Lead	0.0013	1.56E-09	3.23E-09	1.06E-08	2.44E-09	1.22E-06	3.14E-07	3.62E-07	1.90E-06	1.90E-06	1.90E-06	1.90E-06	1.90E-06	0.0015	0.0015	0.0015	0.0015	
Manganese	0.156	2.41E-06	5.00E-06	1.64E-05	3.78E-06	4.91E-04	7.73E-06	8.90E-06	5.08E-04	5.09E-04	5.12E-04	5.09E-04	5.09E-04	0.0033	0.0033	0.0034	0.0033	
Mercury	0.0003	2.59E-11	5.38E-11	1.76E-10	4.07E-11	6.90E-08	1.04E-09	1.20E-09	7.13E-08	7.13E-08	7.13E-08	7.13E-08	7.13E-08	0.00024	0.00024	0.00024	0.00024	
Nickel	0.011	1.87E-07	3.87E-07	1.27E-06	2.93E-07	1.30E-05	7.26E-07	7.61E-08	1.38E-05	1.39E-05	1.41E-05	1.39E-05	1.39E-05	0.0013	0.0013	0.0014	0.0013	
Selenium	0.0057	1.30E-09	2.69E-09	8.80E-09	2.03E-09	5.72E-06	5.25E-09	6.05E-11	5.72E-06	5.72E-06	5.72E-06	5.72E-06	5.72E-06	0.0010	0.0010	0.0010	0.0010	
Thallium	0.00007	2.59E-10	5.38E-10	1.76E-09	4.07E-10	1.32E-07	1.05E-08	1.21E-08	1.55E-07	1.55E-07	1.55E-07	1.55E-07	1.55E-07	0.0022	0.0022	0.0022	0.0022	
Zinc	0.57	1.53E-07	3.17E-07	1.04E-06	2.40E-07	7.33E-05	1.24E-06	1.43E-07	7.47E-05	7.48E-05	7.50E-05	7.48E-05	7.48E-05	0.00013	0.00013	0.00013	0.00013	

Notes:

COPC = contaminant of potential concern

BW = body weight

Table 2. Comparison of Dose-averaged Hazard Quotients from the FEIS with Unadjusted Hazard Quotients using a Tiered Approach¹

COPC	Construction Phase - Off-Duty Workers								Operational Phase - Off-Duty Workers							
	FEIS (time- and dose-averaged)				Un-adjusted				FEIS (time- and dose-averaged)				Un-adjusted			
	Hazard Quotient for Off-Duty Workers		Hazard Quotient for Off-Duty Workers		Hazard Quotient for Off-Duty Workers		Hazard Quotient for Off-Duty Workers		Hazard Quotient for Off-Duty Workers		Hazard Quotient for Off-Duty Workers		Hazard Quotient for Off-Duty Workers		Hazard Quotient for Off-Duty Workers	
	Hazard Quotient for Doris Camp	Hazard Quotient for Boston Exploration Camp	Hazard Quotient for Boston Operational Camp	Hazard Quotient for Quarry D Camp	Hazard Quotient for Doris Camp	Hazard Quotient for Boston Exploration Camp	Hazard Quotient for Boston Operational Camp	Hazard Quotient for Quarry D Camp	Hazard Quotient for Doris Camp	Hazard Quotient for Boston Exploration Camp	Hazard Quotient for Boston Operational Camp	Hazard Quotient for Quarry D Camp	Hazard Quotient for Doris Camp	Hazard Quotient for Boston Exploration Camp	Hazard Quotient for Boston Operational Camp	Hazard Quotient for Quarry D Camp
Arsenic	0.011	0.011	0.011	0.011	0.023	0.023	0.023	0.023	0.011	0.011	0.011	0.011	0.023	0.023	0.023	0.023
Cadmium	0.000079	0.000079	0.000079	0.000079	0.00016	0.00016	0.00016	0.00016	0.000079	0.000079	0.000079	0.000079	0.00016	0.00016	0.00016	0.00016
Chromium	0.0067	0.0066	0.0071	0.0069	0.014	0.014	0.016	0.015	0.0066	0.0067	0.0072	0.0067	0.014	0.015	0.016	0.014
Copper	0.00012	0.00012	0.00012	0.00012	0.00025	0.00025	0.00026	0.00025	0.00012	0.00012	0.00012	0.00012	0.00025	0.00025	0.00026	0.00025
Lead	0.00067	0.00067	0.00067	0.00067	0.0015	0.0015	0.0015	0.0015	0.00067	0.00067	0.00067	0.00067	0.0015	0.0015	0.0015	0.0015
Manganese	0.0016	0.0016	0.0016	0.0016	0.0033	0.0032	0.0033	0.0033	0.0016	0.0016	0.0016	0.0016	0.0033	0.0033	0.0034	0.0033
Mercury	0.00012	0.00012	0.00012	0.00012	0.00023	0.00023	0.00023	0.00023	0.00012	0.00012	0.00012	0.00012	0.00024	0.00024	0.00024	0.00024
Nickel	0.00061	0.00061	0.00063	0.00062	0.0013	0.0013	0.0013	0.0013	0.00061	0.00062	0.00064	0.00062	0.0013	0.0013	0.0014	0.0013
Selenium	0.00050	0.00050	0.00050	0.00050	0.0010	0.0010	0.0010	0.0010	0.00050	0.00050	0.00050	0.00050	0.0010	0.0010	0.0010	0.0010
Thallium	0.0011	0.0011	0.0011	0.0011	0.0022	0.0022	0.0022	0.0022	0.0011	0.0011	0.0011	0.0011	0.0022	0.0022	0.0022	0.0022
Zinc	0.000065	0.000065	0.000065	0.000065	0.00013	0.00013	0.00013	0.00013	0.000065	0.000065	0.000065	0.000065	0.00013	0.00013	0.00013	0.00013

Notes:

COPC = contaminant of potential concern

¹ Health Canada (2016).

REFERENCES

Health Canada. 2010a. *Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)*. Version 2.0. Revised 2012. Contaminated Sites Division, Safe Environments Directorate: Ottawa, ON.

Health Canada. 2010b. *Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors*. Version 2.0. Contaminated Sites Division, Safe Environments Directorate: Ottawa, ON.

Health Canada. 2010c. *Federal Contaminated Site Risk Assessment in Canada, Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRA_{CHEM})*. Contaminated Sites Division, Safe Environments Directorate: Ottawa, ON.

Health Canada. 2010d. *Federal Contaminated Site Risk Assessment in Canada, Supplemental Guidance on Human Health Risk Assessment for Country Foods (HHRA_{Foods})*. Contaminated Sites Division, Safe Environments Directorate: Ottawa, ON.

Health Canada. 2010e. *Useful Information for Environmental Assessments*. Health Canada, Environmental Assessment Division: Ottawa, ON.

Health Canada. 2011. *Toxicological Reference Values, Estimated Daily Intakes or Dietary Reference Values for Trace Elements*. Obtained from Chemical Health Hazard Revised March 2011, unpublished: Ottawa, ON.

Health Canada. 2013. *Federal Contaminated Site Risk Assessment in Canada, Interim Guidance on Human Health Risk Assessment for Short-Term Exposure to Carcinogens and Contaminated Sites*. Health Canada, Contaminates Sites Division, Safe Environments Directorate: Ottawa, ON.

Health Canada. 2016. *Memorandum: A Primer for Evaluating Human Health Risk at Contaminated Sites for Chronic and Less-than Chronic Exposures to Chemicals*. October 2016.