# TECHNICAL MEMORANDUM

**DATE** 13 April 2012 **PROJECT No.** 10-1373-0037

**TO** Rick Schryer
Fortune Minerals Limited

**CC** Jen Gibson (Golder)

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**NICO COBALT-GOLD-BISMUTH-COPPER PROJECT**
**INCORPORATION OF WATER QUALITY PREDICTIONS FOR REVERSE OSMOSIS WATER TREATMENT OPTION INTO HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS**

## 1.0 INTRODUCTION

This technical memorandum was prepared by Golder Associates Ltd. (Golder), on behalf of Fortune Minerals Limited (Fortune), given the recent change to the Project Description for the NICO Cobalt-Gold-Bismuth-Copper Project (the NICO Project). Specifically, the method of water treatment has changed from ion exchange (IX) to reverse osmosis (RO); as a result, the water quality predictions for the 4 receiving waterbodies (i.e., Nico Lake, Peanut Lake, Burke Lake, and the Marian River) have been updated for the operations phase of the NICO Project (Golder 2012a)[1]. Given that these changes to water quality may also result in changes to the risk estimated in the human health, wildlife, and aquatic risk assessments, a comparison of the water quality predictions using both water treatment technologies was undertaken and as appropriate, risks estimates were updated.

One of the main drivers with the change of treatment systems (IX to RO) was to reduce selenium concentrations. It is noted that with the change of treatment systems some parameters increase (i.e., cobalt increases but is still below the site-specific water quality objective) while others decrease; however, it is important to note that with RO, reduced selenium allows for more certainty that the overall risks to the environment will be negligible.

## 2.0 APPROACH

The risk assessment conclusions based on IX technology would only be expected to change if the RO technology resulted in higher concentrations of chemicals in surface water compared to those predicted using IX. Conversely, if the RO water quality predictions are equal to or lower than those using IX, then the risk estimates would be equal to or lower than those calculated in the risk assessment, and there would be no changes to the conclusions of the risk assessment. However, if chemical concentrations using RO were predicted to be higher than those predicted using IX, then those chemicals were screened using the approach applied to identify chemicals of potential concern (CoPCs) that was described in the risk assessments (i.e., comparison to baseline concentrations + 10% and to an appropriate screening guideline). If CoPCs were identified, these CoPCs were carried through the risk assessment.

[1] Golder (Golder Associates Ltd.). 2012a. NICO Project: Update of Receiving Water Quality Predictions for the Operations Period with Revised Effluent Treatment Facility Discharge Quality. Prepared for Fortune Minerals Limited. London, ON. 13 April 2012.

## 3.0 AQUATIC RISK ASSESSMENT

Predicted surface water concentrations for some parameters changed (increased or decreased) in Peanut Lake, Burke Lake, and the Marian River with the change from the IX treatment method to the RO treatment method. As such, the aquatic RA (Golder 2012b)[2] was updated accordingly, including the problem formulation (i.e., identification of CoPCs), exposure assessment (i.e., exposure estimates), and risk characterization (i.e., hazard quotients [HQs]), as provided below. The change in treatment technology did not change water quality predictions for Nico Lake; however, the results for Nico Lake (screening, exposure estimates, and HQs) are provided in all tables for ease of comparison. Water quality predictions were only provided for the operations phase of the NICO Project, and as such, the aquatic RA has been updated with respect to the operations phase only. This is the only phase of the NICO Project during which the RO water treatment plant would be expected to operate and, as such, would only affect water quality during this phase.

The same 2-tiered approach used in the aquatic RA (Golder 2012b) to identify CoPCs in surface water based on the IX water treatment method (Section 5.1.1 of the aquatic RA [Golder 2012b]) was used to identify CoPCs in surface water based on the RO water treatment method. In brief, the water quality predictions for Peanut Lake, Burke Lake, and the Marian River based on RO treatment were compared to applicable guidelines and baseline concentrations.

Parameters were identified as CoPCs if predicted concentrations were greater than guidelines and baseline concentrations. If guidelines were not available, the parameter was identified as a CoPC if the predicted concentration was greater than the baseline concentration. For Peanut Lake, a third tier of screening was conducted in which predicted surface water concentrations were compared to the site-specific water quality objectives developed for Peanut Lake. This was done because the treatment system discharges to Peanut Lake. The screening of parameters included elimination of essential elements that are fundamentally non-toxic substances such as calcium, magnesium, potassium, and sodium.

The detailed screening tables are provided in Tables 3-1 through 3-4 for Nico Lake, Peanut Lake, Burke Lake, and the Marian River, respectively. It should be noted that all parameters are included in these tables and not just those parameters for which water quality predictions changed. The same parameters identified as CoPCs based on the IX water treatment method were identified as CoPCs under the RO treatment method.

The exposure estimates for surface water based on the RO treatment technology, including upper-bound estimates (based on predicted 95$^{th}$ percentile concentrations) and central-tendency estimates are provided in Table 3-5 and Table 3-6, respectively.

The HQs for surface water based on the RO treatment technology are provided in Table 3-7. Of note are the following:

- All HQs were less than one with the exception of the HQs for aluminum and iron, which were greater than one in some waterbodies (i.e., Nico, Peanut, or Burke lakes);
- Relative to the IX treatment method, the following HQs greater than one for aluminum increased under the RO treatment method due to dust deposition:
  - HQ (based on upper-bound estimate of exposure) in Peanut Lake (1.8 under IX and 1.9 under RO);

[2] Golder. 2012b. NICO Cobalt-Gold-Bismuth-Copper Project, Aquatic Risk Assessment. Prepared for Fortune Minerals Limited. London, ON.

- HQ (based on upper-bound estimate of exposure) in Burke Lake (1.2 under IX and 1.3 under RO);
- HQ (based on central tendency estimate of exposure) in Peanut Lake (1.0 under IX and 1.1 under RO); and

- Relative to the IX treatment technology, none of the HQs greater than one for iron increased under the RO treatment method.

**Table 3-1: Comparison of Predicted Chemical Concentrations in Surface Waters of Nico Lake during Operations to Guidelines, Baseline Concentrations, and Site-Specific Water Quality Objectives**

| Nico Lake | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Chemical** | **Units** | **CCME Fresh Water Aquatic Life Guidelines[a]** | **Baseline Concentration** | **+10% Baseline[b]** | **Site Specific Water Quality Objectives[c]** | **Predicted Concentration Operations Phase[d]** | **CoPC?[e]** | **Rationale[f]** |
| **Nutrients** | | | | | | | | |
| Ammonia | mg-N/L | 1.1[k] | 0.0541 | 0.0595 | 4.16 | 0.65 | no | <G |
| Nitrate and Nitrite | mg-N/L | 2.93[g] | 0.0916 | 0.1008 | 30 | 0.68 | no | <G |
| Total Kjeldahl Nitrogen | mg-N/L | | 0.8079 | 0.8887 | | 1.28 | no | See note [m] |
| Total Phosphorus | mg-P/L | Guidance Framework | 0.0225 | 0.0248 | | 0.023 | no | <Trigger range for mesotrophic lakes and rivers and/or <B+50% |
| **Major Ions and TDS** | | | | | | | | |
| Calcium | mg/L | | 8.7641 | 9.6405 | | 8.33 | no | Essential and non-toxic |
| Chloride | mg/L | | 1.1097 | 1.2206 | 353 | 2.07 | no | <SSWQO |
| Magnesium | mg/L | | 3.7994 | 4.1793 | | 4.36 | no | Essential and non-toxic |
| Potassium | mg/L | | 1.0859 | 1.1945 | | 7.56 | no | Essential and non-toxic |
| Sodium | mg/L | | 2.4169 | 2.6586 | | 3.49 | no | Essential and non-toxic |
| Sulphate | mg/L | | 4.0811 | 4.4892 | 500 | 6.40 | no | <SSWQO |
| Total Dissolved Solids | mg/L | 500[o] | 67.2143 | 73.9357 | | 70.6 | no | <G |
| **Total Metals** | | | | | | | | |
| Aluminum (Al) | mg/L | 0.1[l] | 0.0430 | 0.0473 | 0.42 | 1.31 | yes | >SSWQO |
| Antimony (Sb) | mg/L | | 0.0002 | 0.0002 | 0.03 | 0.0013 | no | <SSWQO |
| Arsenic (As) | mg/L | 0.005 | 0.0209 | 0.0230 | 0.05 | 0.044 | no | <SSWQO |
| Barium (Ba) | mg/L | | 0.0083 | 0.0091 | | 0.023 | yes | >B+10% |
| Beryllium (Be) | mg/L | | 0.0005 | 0.0006 | | 0.00011 | no | <B+10% |
| Boron (B) | mg/L | 1.5 | 0.0185 | 0.0204 | | 0.015 | no | <G |
| Cadmium (Cd) | mg/L | 0.000017[i] | 0.0002 | 0.0002 | 0.00015 | 0.000058 | no | <B+10% |
| Chromium (Cr)r | mg/L | 0.001[j] | 0.0013 | 0.0014 | | 0.0018 | no | see note [n] |
| Cobalt (Co) | mg/L | | 0.0009 | 0.0010 | 0.01 | 0.0070 | no | <SSWQO |
| Copper (Cu) | mg/L | 0.002[h] | 0.0017 | 0.0019 | 0.025 | 0.0049 | no | <SSWQO |
| Iron (Fe) | mg/L | 0.3 | 0.6851 | 0.7536 | 1.50 | 3.29 | yes | >SSWQO |
| Lead (Pb) | mg/L | 0.001[h] | 0.0006 | 0.0007 | 0.0076 | 0.00043 | no | <G |

**Table 3-1: Comparison of Predicted Chemical Concentrations in Surface Waters of Nico Lake during Operations to Guidelines, Baseline Concentrations, and Site-Specific Water Quality Objectives (continued)**

| Nico Lake | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Chemical** | **Units** | **CCME Fresh Water Aquatic Life Guidelines[a]** | **Baseline Concentration** | **+10% Baseline[b]** | **Site Specific Water Quality Objectives[c]** | **Predicted Concentration Operations Phase[d]** | **CoPC?[e]** | **Rationale[f]** |
| Manganese (Mn) | mg/L | | 0.0742 | 0.0816 | | 0.048 | no | <B+10% |
| Mercury (Hg) | mg/L | 0.000026 | 0.0001 | 0.0001 | | 0.000015 | no | <G |
| Molybdenum (Mo) | mg/L | 0.073 | 0.0015 | 0.0017 | | 0.0013 | no | <G |
| Nickel (Ni) | mg/L | 0.025[h] | 0.0008 | 0.0009 | | 0.0011 | no | <G |
| Selenium (Se) | mg/L | 0.001 | 0.0002 | 0.0003 | 0.005 | 0.0017 | no | <SSWQO |
| Silver (Ag) | mg/L | 0.0001 | 0.0006 | 0.0007 | | 0.000083 | no | <G |
| Thallium (Tl) | mg/L | 0.0008 | 0.0055 | 0.0061 | | 0.00070 | no | <G |
| Uranium (U) | mg/L | 0.015 | 0.0057 | 0.0063 | 0.027 | 0.0040 | no | <G |
| Vanadium (V) | mg/L | | 0.00041 | 0.0005 | | 0.0012 | yes | >B+10% |
| Zinc (Zn) | mg/L | 0.03 | 0.0026 | 0.0028 | 0.11 | 0.0080 | no | <G |

Note: Shaded chemicals have been identified as chemicals of potential concern (CoPCs).

[a] Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQGs) for the Protection of Aquatic Life.

[b] Mean measured baseline concentration plus 10 percent.

[c] As derived in Section 5.3.1 (Golder 2012b).

[d] Predicted 95$^{th}$ percentile concentration.

[e] Yes = chemical exceeds the CCME CWQG for the Protection of Aquatic Life, is greater than 10% over baseline and is greater than the site-specific water quality objective and, therefore, was retained for assessment; No = chemical did not exceed the CCME CWQG for the Protection of Aquatic Life or/and was less than 10% over baseline or/and was less than the site-specific water quality objective and, therefore, was not retained for assessment.

[f] B = Mean measured baseline concentration plus 10 percent; G = CCME CWQG for the Protection of Aquatic Life; SSWQO = Site Specific Water Quality Objective.

[g] Guideline for nitrate.

[h] The minimum CCME CWQGs for Copper, Lead, and Nickel were used regardless of water hardness.

[i] The CCME CWQG for Cadmium is based on a water hardness of 48.5 mg/L $CaCO_3$.

[j] No CCME CWQG was available for total Chromium, so the value for Chromium VI was used.

[k] The CCME CWQG for Ammonia was derived assuming a temperature of 7$^{o}$C and a pH of 8.

[l] The CCME CWQG for Aluminum is for pH > 6.5.

[m] Total Kjeldahl nitrogen (TKN) is a measure of ammonia and inorganic forms of nitrogen. There is no CCME guideline for TKN for the protection of freshwater aquatic life. Still, potential adverse affects of ammonia on freshwater aquatic life has been addressed through the screening that was completed for ammonia. There is little toxicity information for organic forms of nitrogen; however, these are minor constituents and do not appear to affect water uses (BCMOE 2009). As such, TKN has not been considered further in the aquatic RA.

[n] Chromium was not retained as a COPC as it does not exceed the CCME CWQG for trivalent chromium [Cr(III)] of 0.0089 mg/L. Chromium in surface waters is likely to be present as Cr(III) given that Cr(VI) is reduced to Cr(III) in the presence of natural organic cations (humic and fulvic acids, tannic acids).

[o] CCME CWQG for the Protection of Agricultural Water Uses [(Irrigation, most stringent value (for strawberries, raspberries, beans, and carrots)].

**Table 3-2: Comparison of Predicted Chemical Concentrations in Surface Waters of Peanut Lake during Operations to Guidelines, Baseline Concentrations, and Site-Specific Water Quality Objectives**

| Peanut Lake | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Chemical** | **Units** | **CCME Fresh Water Aquatic Life Guidelines[a]** | **Baseline Concentration** | **+10% Baseline[b]** | **Site Specific Water Quality Objectives[c]** | **Predicted Concentration Operations Phase[d]** | **CoPC?[e]** | **Rationale[f]** |
| **Nutrients** | | | | | | | | |
| Ammonia | mg-N/L | 1.1[k] | 0.0286 | 0.0314 | 4.16 | 0.65 | no | <G |
| Nitrate and Nitrite | mg-N/L | 2.93[g] | 0.0808 | 0.0889 | 30 | 4.15 | no | <SSWQO |
| Total Kjeldahl Nitrogen | mg-N/L | | 0.6270 | 0.6897 | | 1.22 | no | See note [m] |
| Total Phosphorus | mg-P/L | Guidance Framework | 0.0155 | 0.0171 | | 0.023 | no | <Trigger range for mesotrophic lakes and rivers and/or <B+50% |
| **Major Ions and TDS** | | | | | | | | |
| Calcium | mg/L | | 7.6224 | 8.3847 | | 32.8 | no | Essential and non-toxic |
| Chloride | mg/L | | 1.3885 | 1.5273 | 353 | 24.1 | no | <SSWQO |
| Magnesium | mg/L | | 3.5200 | 3.8720 | | 5.32 | no | Essential and non-toxic |
| Potassium | mg/L | | 1.2500 | 1.3750 | | 113 | no | Essential and non-toxic |
| Sodium | mg/L | | 2.7203 | 2.9924 | | 23.1 | no | Essential and non-toxic |
| Sulphate | mg/L | | 1.4128 | 1.5541 | 500 | 61.4 | no | <SSWQO |
| Total Dissolved Solids | mg/L | 500[n] | 61.2500 | 67.3750 | | 289 | no | <G |
| **Total Metals** | | | | | | | | |
| Aluminum (Al) | mg/L | 0.1[l] | 0.1023 | 0.1125 | 0.41 | 0.79 | yes | >SSWQO |
| Antimony (Sb) | mg/L | | 0.0002 | 0.0002 | 0.03 | 0.0021 | no | <SSWQO |
| Arsenic (As) | mg/L | 0.005 | 0.0040 | 0.0044 | 0.05 | 0.027 | no | <SSWQO |
| Barium (Ba) | mg/L | | 0.0102 | 0.0112 | | 0.016 | yes | >B+10% |
| Beryllium (Be) | mg/L | | 0.0005 | 0.0006 | | 0.000048 | no | <B+10% |
| Boron (B) | mg/L | 1.5 | 0.0196 | 0.0215 | | 0.074 | no | <G |
| Cadmium (Cd) | mg/L | 0.000017[i] | 0.0002 | 0.0002 | 0.00015 | 0.000034 | no | <B+10% |
| Chromium (Cr)r | mg/L | 0.001[j] | 0.0014 | 0.0015 | | 0.0012 | no | <B+10% |
| Cobalt (Co) | mg/L | | 0.0006 | 0.0007 | 0.01 | 0.0043 | no | <SSWQO |
| Copper (Cu) | mg/L | 0.002[h] | 0.0010 | 0.0010 | 0.022 | 0.0028 | no | <SSWQO |
| Iron (Fe) | mg/L | 0.3 | 0.3232 | 0.3556 | 1.5 | 1.75 | yes | >SSWQO |
| Lead (Pb) | mg/L | 0.001[h] | 0.0007 | 0.0007 | 0.0076 | 0.00021 | no | <G |

**Table 3-2: Comparison of Predicted Chemical Concentrations in Surface Waters of Peanut Lake during Operations to Guidelines, Baseline Concentrations, and Site-Specific Water Quality Objectives (continued)**

| Peanut Lake | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Chemical** | **Units** | **CCME Fresh Water Aquatic Life Guidelines[a]** | **Baseline Concentration** | **+10% Baseline[b]** | **Site Specific Water Quality Objectives[c]** | **Predicted Concentration Operations Phase[d]** | **CoPC?[e]** | **Rationale[f]** |
| Manganese (Mn) | mg/L | | 0.0388 | 0.0426 | | 0.055 | yes | >B+10% |
| Mercury (Hg) | mg/L | 0.000026 | 0.0001 | 0.0001 | | 0.000014 | no | <G |
| Molybdenum (Mo) | mg/L | 0.073 | 0.0015 | 0.0016 | | 0.0040 | no | <G |
| Nickel (Ni) | mg/L | 0.025[h] | 0.0009 | 0.0010 | | 0.0014 | no | <G |
| Selenium (Se) | mg/L | 0.001 | 0.0003 | 0.0003 | 0.005 | 0.0012 | no | <SSWQO |
| Silver (Ag) | mg/L | 0.0001 | 0.0007 | 0.0007 | | 0.00019 | no | <B+10% |
| Thallium (Tl) | mg/L | 0.0008 | 0.0061 | 0.0067 | | 0.00020 | no | <G |
| Uranium (U) | mg/L | 0.015 | 0.0062 | 0.0068 | 0.027 | 0.0010 | no | <G |
| Vanadium (V) | mg/L | | 0.0004 | 0.0005 | | 0.00092 | yes | >B+10% |
| Zinc (Zn) | mg/L | 0.03 | 0.0037 | 0.0041 | 0.11 | 0.0057 | no | <G |

Shaded chemicals have been identified as chemicals of potential concern (CoPCs).

[a] Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQGs) for the Protection of Aquatic Life.

[b] Mean measured baseline concentration plus 10 percent.

[c] As derived in Section 5.3.1 (Golder 2012b).

[d] Predicted 95$^{th}$ percentile concentration.

[e] Yes = chemical exceeds the CCME CWQG for the Protection of Aquatic Life, is greater than 10% over baseline and is greater than the site-specific water quality objective and, therefore, was retained for assessment; No = chemical did not exceed the CCME CWQG for the Protection of Aquatic Life or/and was less than 10% over baseline or/and was less than the site-specific water quality objective and, therefore, was not retained for assessment.

[f] B = Mean measured baseline concentration plus 10 percent; G = CCME CWQG for the Protection of Aquatic Life; SSWQO = Site Specific Water Quality Objective.

[g] Guideline for nitrate.

[h] The minimum CCME CWQGs for Copper, Lead, and Nickel were used regardless of water hardness.

[i] The CCME CWQG for Cadmium is based on a water hardness of 48.5 mg/L $CaCO_3$.

[j] No CCME CWQG was available for total Chromium, so the value for Chromium VI was used.

[k] The CCME CWQG for Ammonia was derived assuming a temperature of 7$^{o}$C and a pH of 8.

[l] The CCME CWQG for Aluminum is for pH > 6.5.

[m] Total Kjeldahl nitrogen (TKN) is a measure of ammonia and inorganic forms of nitrogen. There is no CCME guideline for TKN for the protection of freshwater aquatic life. Still, potential adverse affects of ammonia on freshwater aquatic life has been addressed through the screening that was completed for ammonia. There is little toxicity information for organic forms of nitrogen; however, these are minor constituents and do not appear to affect water uses (BCMOE 2009). As such, TKN has not been considered further in the aquatic RA.

[n] CCME CWQG for the Protection of Agricultural Water Uses [(Irrigation, most stringent value (for strawberries, raspberries, beans, and carrots)].

**Table 3-3: Comparison of Predicted Chemical Concentrations in Surface Waters of Burke Lake during Operations to Guidelines and Baseline Concentrations**

| Burke Lake | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Chemical** | **Units** | **CCME Fresh Water Aquatic Life Guidelines[a]** | **Baseline Concentration** | **+10% Baseline[b]** | **Predicted Concentration Operations Phase[d]** | **CoPC?[e]** | **Rationale[f]** |
| **Nutrients** | | | | | | | |
| Ammonia | mg-N/L | 1.1[k] | 0.0362 | 0.0398 | 0.27 | no | <G |
| Nitrate and Nitrite | mg-N/L | 2.93[g] | 0.0663 | 0.0729 | 1.64 | no | <G |
| Total Kjeldahl Nitrogen | mg-N/L | | 0.7003 | 0.7704 | 1.01 | no | See note [m] |
| Total Phosphorus | mg-P/L | Guidance Framework | 0.0183 | 0.0201 | 0.019 | no | <B+10% |
| **Major Ions and TDS** | | | | | | | |
| Calcium | mg/L | | 8.1300 | 8.9430 | 18.0 | no | Essential and non-toxic |
| Chloride | mg/L | | 1.7581 | 1.9339 | 9.63 | no | Essential and non-toxic |
| Magnesium | mg/L | | 3.4894 | 3.8383 | 5.24 | no | Essential and non-toxic |
| Potassium | mg/L | | 1.2050 | 1.3255 | 42.7 | no | Essential and non-toxic |
| Sodium | mg/L | | 2.6494 | 2.9143 | 9.82 | no | Essential and non-toxic |
| Sulphate | mg/L | | 1.9914 | 2.1905 | 23.4 | no | Essential and non-toxic |
| Total Dissolved Solids | mg/L | 500[n] | 65.7647 | 72.3412 | 127 | no | <G |
| **Total Metals** | | | | | | | |
| Aluminum (Al) | mg/L | 0.1[l] | 0.0715 | 0.0786 | 0.61 | yes | >B+10% |
| Antimony (Sb) | mg/L | | 0.0003 | 0.0003 | 0.00099 | yes | >B+10% |
| Arsenic (As) | mg/L | 0.005 | 0.0035 | 0.0038 | 0.019 | yes | >B+10% |
| Barium (Ba) | mg/L | | 0.0091 | 0.0100 | 0.015 | yes | >B+10% |
| Beryllium (Be) | mg/L | | 0.0005 | 0.0006 | 0.000035 | no | <B+10% |
| Boron (B) | mg/L | 1.5 | 0.0189 | 0.0208 | 0.030 | no | <G |
| Cadmium (Cd) | mg/L | 0.000017[i] | 0.0002 | 0.0002 | 0.000029 | no | <B+10% |
| Chromium (Cr)r | mg/L | 0.001[j] | 0.0014 | 0.0015 | 0.0011 | no | <B+10% |
| Cobalt (Co) | mg/L | | 0.0007 | 0.0008 | 0.0028 | yes | >B+10% |
| Copper (Cu) | mg/L | 0.002[h] | 0.0013 | 0.0014 | 0.0025 | yes | >B+10% |
| Iron (Fe) | mg/L | 0.3 | 0.6596 | 0.7255 | 1.46 | yes | >B+10% |
| Lead (Pb) | mg/L | 0.001[h] | 0.0008 | 0.0008 | 0.00018 | no | <G |
| Manganese (Mn) | mg/L | | 0.1253 | 0.1378 | 0.051 | no | <B+10% |
| Mercury (Hg) | mg/L | 0.000026 | 0.0001 | 0.0001 | 0.000013 | no | <G |

**Table 3-3: Comparison of Predicted Chemical Concentrations in Surface Waters of Burke Lake during Operations to Guidelines and Baseline Concentrations (continued)**

| Burke Lake | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Chemical** | **Units** | **CCME Fresh Water Aquatic Life Guidelines[a]** | **Baseline Concentration** | **+10% Baseline[b]** | **Predicted Concentration Operations Phase[d]** | **CoPC?[e]** | **Rationale[f]** |
| Molybdenum (Mo) | mg/L | 0.073 | 0.0015 | 0.0016 | 0.0016 | no | <G |
| Nickel (Ni) | mg/L | 0.025[h] | 0.0008 | 0.0009 | 0.0012 | no | <G |
| Selenium (Se) | mg/L | 0.001 | 0.0002 | 0.0003 | 0.00057 | no | <G |
| Silver (Ag) | mg/L | 0.0001 | 0.0007 | 0.0008 | 0.000079 | no | <G |
| Thallium (Tl) | mg/L | 0.0008 | 0.0068 | 0.0075 | 0.00011 | no | <G |
| Uranium (U) | mg/L | 0.015 | 0.0070 | 0.0077 | 0.00068 | no | <G |
| Vanadium (V) | mg/L | | 0.0019 | 0.0021 | 0.00087 | no | <B+10% |
| Zinc (Zn) | mg/L | 0.03 | 0.0049 | 0.0053 | 0.0058 | no | <G |

Shaded chemicals have been identified as chemicals of potential concern (CoPCs).

[a] Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQGs) for the Protection of Aquatic Life.

[b] Mean measured baseline concentration plus 10 percent.

[c] As derived in Section 5.3.1 (Golder 2012b).

[d] Predicted 95$^{th}$ percentile concentration.

[e] Yes = chemical exceeds the CCME CWQG for the Protection of Aquatic Life, is greater than 10% over baseline and is greater than the site-specific water quality objective and, therefore, was retained for assessment; No = chemical did not exceed the CCME CWQG for the Protection of Aquatic Life or/and was less than 10% over baseline or/and was less than the site-specific water quality objective and, therefore, was not retained for assessment.

[f] B = Mean measured baseline concentration plus 10 percent; G = CCME CWQG for the Protection of Aquatic Life; SSWQO = Site Specific Water Quality Objective.

[g] Guideline for nitrate.

[h] The minimum CCME CWQGs for Copper, Lead, and Nickel were used regardless of water hardness.

[i] The CCME CWQG for Cadmium is based on a water hardness of 48.5 mg/L $CaCO_3$.

[j] No CCME CWQG was available for total Chromium, so the value for Chromium VI was used.

[k] The CCME CWQG for Ammonia was derived assuming a temperature of 7$^{o}$C and a pH of 8.

[l] The CCME CWQG for Aluminum is for pH > 6.5.

[m] Total Kjeldahl nitrogen (TKN) is a measure of ammonia and inorganic forms of nitrogen. There is no CCME guideline for TKN for the protection of freshwater aquatic life. Still, potential adverse affects of ammonia on freshwater aquatic life has been addressed through the screening that was completed for ammonia. There is little toxicity information for organic forms of nitrogen; however, these are minor constituents and do not appear to affect water uses (BCMOE 2009). As such, TKN has not been considered further in the aquatic RA.

[n] CCME CWQG for the Protection of Agricultural Water Uses [(Irrigation, most stringent value (for strawberries, raspberries, beans, and carrots)].

**Table 3-4: Comparison of Predicted Chemical Concentrations in Surface Waters of Marian River during Operations to Guidelines and Baseline Concentrations**

| Marian River | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Chemical** | **Units** | **CCME Fresh Water Aquatic Life Guidelines[a]** | **Baseline Concentration** | **+10% Baseline[b]** | **Predicted Concentration Operations Phase[d]** | **CoPC?[e]** | **Rationale[f]** |
| **Nutrients** | | | | | | | |
| Ammonia | mg-N/L | 1.1[k] | 0.0251 | 0.0276 | 0.072 | no | <G |
| Nitrate and Nitrite | mg-N/L | 2.93[g] | 0.0497 | 0.0547 | 0.19 | no | <G |
| Total Kjeldahl Nitrogen | mg-N/L | | 0.6680 | 0.7348 | 1.51 | no | See note [m] |
| Total Phosphorus | mg-P/L | Guidance Framework | 0.0124 | 0.0137 | 0.018 | no | <Trigger range for mesotrophic lakes and rivers and/or <B+50% |
| **Major Ions and TDS** | | | | | | | |
| Calcium | mg/L | | 20.8600 | 22.9460 | 51.0 | no | Essential and non-toxic |
| Chloride | mg/L | | 2.4692 | 2.7161 | 5.49 | no | Essential and non-toxic |
| Magnesium | mg/L | | 9.1088 | 10.0197 | 21.8 | no | Essential and non-toxic |
| Potassium | mg/L | | 1.5908 | 1.7499 | 4.97 | no | Essential and non-toxic |
| Sodium | mg/L | | 3.2540 | 3.5794 | 7.65 | no | Essential and non-toxic |
| Sulphate | mg/L | | 16.7000 | 18.3700 | 42.2 | no | Essential and non-toxic |
| Total Dissolved Solids | mg/L | 500[n] | 120.1818 | 132.2000 | 239 | no | <G |
| **Total Metals** | | | | | | | |
| Aluminum (Al) | mg/L | 0.1[l] | 0.0728 | 0.0801 | 0.104 | yes | >B+10% |
| Antimony (Sb) | mg/L | | 0.0002 | 0.0002 | 0.000076 | no | <B+10% |
| Arsenic (As) | mg/L | 0.005 | 0.0006 | 0.0007 | 0.0017 | no | <G |
| Barium (Ba) | mg/L | | 0.0142 | 0.0157 | 0.030 | yes | >B+10% |
| Beryllium (Be) | mg/L | | 0.0005 | 0.0006 | 0.000032 | no | <B+10% |
| Boron (B) | mg/L | 1.5 | 0.0234 | 0.0257 | 0.036 | no | <G |
| Cadmium (Cd) | mg/L | 0.000017[i] | 0.0001 | 0.0001 | 0.000047 | no | <B+10% |
| Chromium (Cr)r | mg/L | 0.001[j] | 0.0014 | 0.0016 | 0.00077 | no | <G |
| Cobalt (Co) | mg/L | | 0.0006 | 0.0007 | 0.00029 | no | <B+10% |
| Copper (Cu) | mg/L | 0.002[h] | 0.0007 | 0.0008 | 0.0017 | no | <G |
| Iron (Fe) | mg/L | 0.3 | 0.1636 | 0.1799 | 0.31 | yes | >B+10% |
| Lead (Pb) | mg/L | 0.001[h] | 0.0005 | 0.0005 | 0.00029 | no | <G |
| Manganese (Mn) | mg/L | | 0.0246 | 0.0270 | 0.062 | yes | >B+10% |

**Table 3-4: Comparison of Predicted Chemical Concentrations in Surface Waters of Marian River during Operations to Guidelines and Baseline Concentrations (continued)**

| Marian River | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Chemical** | **Units** | **CCME Fresh Water Aquatic Life Guidelines[a]** | **Baseline Concentration** | **+10% Baseline[b]** | **Predicted Concentration Operations Phase[d]** | **CoPC?[e]** | **Rationale[f]** |
| Mercury (Hg) | mg/L | 0.000026 | 0.000036 | 0.00004 | 0.000077 | yes | >B+10% |
| Molybdenum (Mo) | mg/L | 0.073 | 0.0015 | 0.0016 | 0.00046 | no | <G |
| Nickel (Ni) | mg/L | 0.025[h] | 0.0010 | 0.0011 | 0.0020 | no | <G |
| Selenium (Se) | mg/L | 0.001 | 0.0003 | 0.0003 | 0.00070 | no | <G |
| Silver (Ag) | mg/L | 0.0001 | 0.0005 | 0.0005 | 0.000015 | no | <G |
| Thallium (Tl) | mg/L | 0.0008 | 0.0040 | 0.0044 | 0.0000060 | no | <G |
| Uranium (U) | mg/L | 0.015 | 0.0046 | 0.0051 | 0.0017 | no | <G |
| Vanadium (V) | mg/L | | 0.00058 | 0.0006 | 0.0011 | yes | >B+10% |
| Zinc (Zn) | mg/L | 0.03 | 0.0062 | 0.0068 | 0.023 | no | <G |

Shaded chemicals have been identified as chemicals of potential concern (CoPCs).

[a] Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQGs) for the Protection of Aquatic Life.

[b] Mean measured baseline concentration plus 10 percent.

[c] As derived in Section 5.3.1 (Golder 2012b).

[d] Predicted 95$^{th}$ percentile concentration.

[e] Yes = chemical exceeds the CCME CWQG for the Protection of Aquatic Life, is greater than 10% over baseline and is greater than the site-specific water quality objective and, therefore, was retained for assessment; No = chemical did not exceed the CCME CWQG for the Protection of Aquatic Life or/and was less than 10% over baseline or/and was less than the site-specific water quality objective and, therefore, was not retained for assessment.

[f] B = Mean measured baseline concentration plus 10 percent; G = CCME CWQG for the Protection of Aquatic Life; SSWQO = Site Specific Water Quality Objective.

[g] Guideline for nitrate.

[h] The minimum CCME CWQGs for Copper, Lead, and Nickel were used regardless of water hardness.

[i] The CCME CWQG for Cadmium is based on a water hardness of 48.5 mg/L $CaCO_3$.

[j] No CCME CWQG was available for total Chromium, so the value for Chromium VI was used.

[k] The CCME CWQG for Ammonia was derived assuming a temperature of 7$^{o}$C and a pH of 8.

[l] The CCME CWQG for Aluminum is for pH > 6.5

[m] Total Kjeldahl nitrogen (TKN) is a measure of ammonia and inorganic forms of nitrogen. There is no CCME guideline for TKN for the protection of freshwater aquatic life. Still, potential adverse affects of ammonia on freshwater aquatic life has been addressed through the screening that was completed for ammonia. There is little toxicity information for organic forms of nitrogen; however, these are minor constituents and do not appear to affect water uses (BCMOE 2009). As such, TKN has not been considered further in the aquatic RA.

[n] CCME CWQG for the Protection of Agricultural Water Uses [(Irrigation, most stringent value (for strawberries, raspberries, beans, and carrots)]

**Table 3-5: Exposure Point Concentrations for Surface Water during Operations (Upper-Bound Estimate)**

| COPC | Units | Nico Lake | | Peanut Lake | | Burke Lake | | Marian River | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean Baseline Concentration | Predicted Surface Water Concentration[a] | Mean Baseline Concentration | Predicted Surface Water Concentration[a] | Mean Baseline Concentration | Predicted Surface Water Concentration[a] | Mean Baseline Concentration | Predicted Surface Water Concentration[a] |
| Aluminum | mg/L | 0.043 | 1.31 | 0.1023 | 0.79 | 0.0715 | 0.61 | 0.0728 | 0.10 |
| Antimony | mg/L | - | - | - | - | 0.0003 | 0.00099 | - | - |
| Arsenic | mg/L | - | - | - | - | 0.0035 | 0.019 | - | - |
| Barium | mg/L | 0.0083 | 0.023 | 0.0102 | 0.016 | 0.0091 | 0.015 | 0.0142 | 0.030 |
| Cobalt | mg/L | - | - | - | - | 0.0007 | 0.0028 | - | - |
| Copper | mg/L | - | - | - | - | 0.0013 | 0.0025 | - | - |
| Iron | mg/L | 0.6851 | 3.29 | 0.3232 | 1.75 | 0.6596 | 1.46 | 0.1636 | 0.31 |
| Manganese | mg/L | - | - | 0.0388 | 0.055 | - | - | 0.0246 | 0.062 |
| Mercury | mg/L | - | - | - | - | - | - | 0.000036 | 0.000077 |
| Vanadium | mg/L | 0.00041 | 0.0012 | 0.0004 | 0.00092 | - | - | 0.00058 | 0.0011 |

[a] Predicted 95th percentile concentration.

CoPC = chemical of potential concern; mg/L = milligram per litre; '-' = Not a CoPC

**Table 3-6: Exposure Point Concentrations for Surface Water during Operations (Central-Tendancy Estimate)**

| COPC | Units | Nico Lake | | Peanut Lake | | Burke Lake | | Marian River | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean Baseline Concentration | Mean Predicted Surface Water Concentration | Mean Baseline Concentration | Mean Predicted Surface Water Concentration | Mean Baseline Concentration | Mean Predicted Surface Water Concentration | Mean Baseline Concentration | Mean Predicted Surface Water Concentration |
| Aluminum | mg/L | 0.043 | 0.84 | 0.1023 | 0.46 | 0.0715 | 0.35 | 0.0728 | 0.045 |
| Antimony | mg/L | - | - | - | - | 0.0003 | 0.00061 | - | - |
| Arsenic | mg/L | - | - | - | - | 0.0035 | 0.0105 | - | - |
| Barium | mg/L | 0.0083 | 0.018 | 0.0102 | 0.013 | 0.0091 | 0.012 | 0.0142 | 0.015 |
| Cobalt | mg/L | - | - | - | - | 0.0007 | 0.0015 | - | - |
| Copper | mg/L | - | - | - | - | 0.0013 | 0.0018 | - | - |
| Iron | mg/L | 0.6851 | 2.21 | 0.3232 | 1.09 | 0.6596 | 0.93 | 0.1636 | 0.16 |
| Manganese | mg/L | - | - | 0.0388 | 0.027 | - | - | 0.0246 | 0.031 |
| Mercury | mg/L | - | - | - | - | - | - | 0.000036 | 0.000011 |
| Vanadium | mg/L | 0.00041 | 0.00092 | 0.0004 | 0.00059 | - | - | 0.00058 | 0.00042 |

CoPC = chemical of potential concern; mg/L = milligram per litre; '-' = Not a CoPC

**Table 3-7: Hazard Quotients for Surface Water during Operations**

| CoPC | Upper-Bound Estimate[a] | | | | Central-Tendency Estimate[b] | | | |
|---|---|---|---|---|---|---|---|---|
| | Nico Lake | Peanut Lake | Burke Lake | Marian River | Nico Lake | Peanut Lake | Burke Lake | Marian River |
| Aluminum | **2.7** | **1.9** | **1.3** | 0.095 | **1.7** | **1.1** | 0.74 | 0.041 |
| Antimony | - | - | 0.033 | - | - | - | 0.020 | - |
| Arsenic | - | - | 0.39 | - | - | - | 0.21 | - |
| Barium | 0.023 | 0.016 | 0.015 | 0.030 | 0.018 | 0.013 | 0.012 | 0.015 |
| Cobalt | - | - | 0.28 | - | - | - | 0.15 | - |
| Copper | - | - | 0.11 | - | - | - | 0.079 | - |
| Iron | **2.2** | **1.2** | 0.97 | 0.21 | **1.5** | 0.73 | 0.62 | 0.10 |
| Manganese | - | 0.079 | **-** | 0.089 | - | 0.039 | - | 0.045 |
| Mercury | - | - | **-** | 0.30 | - | - | - | 0.042 |
| Vanadium | - | - | **-** | - | - | - | - | - |

[a] 95th percentile.
[b] Average.
- = This parameter was not identified as a CoPC in this waterbody.
Shaded + bold text = hazard quotient > 1.
CoPC = Chemical of potential concern.

Based on the above, the same conclusions as provided based on the IX water treatment method (Golder 2012b) apply under the RO treatment method, as follows:

- Antimony, arsenic, barium, cobalt, copper, manganese, mercury, and vanadium did not exceed target risk levels (i.e., HQs were less than one), indicating negligible risk of adverse effects to aquatic health as a result of the NICO Project.
- Aluminum exceeded target risk levels during operations in Nico, Peanut, and Burke lakes. However, risk from this CoPC is low and likely to be negligible given the degree of conservatism used in the derivation of the risk levels. Of particular note is the conservatism used in the water quality modelling and in the air quality modelling, which fed into the water quality modelling. With respect to the water quality modelling, predicted changes in aluminum concentrations in lakes are considered to be conservative estimates of the maximum predicted changes that could occur during the NICO Project. The predictive air modelling results that fed into the water quality modelling considered that aluminum is adhered to dust (or total suspended particulate), which is generated by the NICO Project through processing and road dust during the operations phase. Most of the total suspended particulate generated during the operations phase is due to road dust rather than processing. The predictive air modelling assumed that dust suppression would only occur during the summer period (i.e., 1 May to 30 September) and that fugitive dust generation is possible during the winter period (i.e., 1 October to 30 April) despite frozen ground conditions and/or snow-covered roads. As a result, much higher concentrations of aluminum were predicted for the winter period compared to the summer period. It is anticipated that road dust would be negligible during the winter period due to snow cover over the roads and the ground being frozen; thus, the predicted concentrations of aluminum used in the water quality modelling and the results of the water quality modelling used in the aquatic RA (Golder 2012b) are associated with a high degree of conservatism. As such, risk to aquatic life from exposure to aluminum has been overestimated and will be re-examined as more information becomes available on winter dust levels at the NICO Project.
- Iron exceeded target risk levels during operations in Nico and Peanut lakes. However, risk from this CoPC is also low and likely to be negligible given the degree of conservatism used in the derivation of the risk levels. The conservatism in the water quality and air quality modelling discussed in the preceding bullet point with respect to aluminum also applies to iron. As such, risk to aquatic life from exposure to iron has also been overestimated.

## 4.0 WILDLIFE RISK ASSESSMENT

Predicted surface water concentrations for some parameters changed (increased or decreased) in Peanut Lake, Burke Lake, and the Marian River with the change from the IX treatment method to the RO treatment method. The change in treatment technology did not change water quality predictions for Nico Lake. The Wildlife Health Risk Assessment (WHRA) (Golder 2012c)[3] used the maximum predicted surface water concentration regardless of when or where it occurred, which was a conservative approach. Therefore the maximum predicted surface water concentrations used in the WHRA are the maximum predicted concentrations in Nico Lake, Peanut Lake, Burke Lake, and the Marian River for each stage of mine operation (i.e., construction, operations, active closure, and post-closure) as well as pit water quality once the pit has filled (~120 years). Table 4-1 summarizes the predicted surface water concentrations used in the WHRA compared to the RO treatment method.

[3] Golder. 2012c. NICO Cobalt-Gold-Bismuth-Copper Project, Wildlife Health Risk Assessment. Prepared for Fortune Minerals Limited. London, ON.

**Table 4-1: Predicted Surface Water Concentrations used in the Wildlife Health Risk Assessment compared to the Predicted Surface Water Concentrations using the RO Treatment Method**

| Chemical | Units | CCME Water Quality Guidelines (mg/L)[a] | Sample et al. 1996 (mg/L)[b] | Concentrations Used in the WHRA[c] | RO Treatment Method[d] |
|---|---|---|---|---|---|
| Aluminum (Al) | mg/L | 5 | NV | 1.31 | 1.31 |
| Antimony (Sb) | mg/L | NV | 0.29 | 0.0080 | 0.0021 |
| Arsenic (As) | mg/L | 0.03 | NV | **0.27** | **0.044** |
| Barium (Ba) | mg/L | NV | 23.1 | 0.084 | 0.030 |
| Beryllium (Be) | mg/L | 0.1 | NV | 0.00015 | 0.00011 |
| Boron (B) | mg/L | 5 | NV | 0.035 | 0.074 |
| Cadmium (Cd) | mg/L | 0.08 | NV | 0.000087 | 0.000058 |
| Chromium (Cr)r | mg/L | 0.05 | NV | 0.0020 | 0.0018 |
| Cobalt (Co) | mg/L | 1 | NV | 0.40 | 0.007 |
| Copper (Cu) | mg/L | 0.5 | NV | 0.012 | 0.0049 |
| Iron (Fe) | mg/L | NV | NV | 4.15 | 3.29 |
| Lead (Pb) | mg/L | 0.1 | NV | 0.0018 | 0.00043 |
| Manganese (Mn) | mg/L | NV | 377 | 0.078 | 0.062 |
| Mercury (Hg) | mg/L | 0.003 | NV | 0.000080 | 0.000077 |
| Molybdenum (Mo) | mg/L | 0.5 | NV | 0.015 | 0.0040 |
| Nickel (Ni) | mg/L | 1 | NV | 0.020 | 0.00198 |
| Selenium (Se) | mg/L | 0.05 | NV | 0.0071 | 0.0017 |
| Silver (Ag) | mg/L | NV | 0.0015 | 0.00013 | 0.00019 |
| Thallium (Tl) | mg/L | NV | 0.032 | 0.00087 | 0.00070 |
| Uranium (U) | mg/L | 0.2 | NV | 0.010 | 0.0040 |
| Vanadium (V) | mg/L | 0.1 | NV | 0.0032 | 0.0012 |
| Zinc (Zn) | mg/L | 50 | NV | 0.056 | 0.023 |

[a] CCME (Canadian Council of Ministers of the Environment) Water Quality Guidelines for Livestock Water.

[b] The value provided is the lowest of the NOAEL-based benchmarks for water provided in Table 12 of Sample et al. (1996) Toxicological Benchmarks for Wildlife, U.S. Department of Energy, ES/ER/TM-86/R3.

[c] Maximum predicted water quality concentrations from Nico Lake, Peanut Lake, Burke Lake, the Marian River, and the flooded pit during construction, operations (IX treatment method), active closure, and post-closure.

[d] Maximum predicted water quality concentrations from Nico Lake, Peanut Lake, Burke Lake, and the Marian River during operations using RO treatment method.

Notes:

NV = No value; mg/L = milligram per litre

Grey Shaded and Bold Cells = Value exceeds screening criteria.

Grey Shaded Cells = Value greater than that used in WHRA but below screening criteria.

With the exception of boron (B) and silver (Ag), the values used in the WHRA were greater than or equal to those predicted using the RO Treatment Method. The predicted boron (B) and silver (Ag) surface water concentrations are below the screening criteria and do not need to be considered further in the WHRA as CoPCs. Therefore, the conclusions of the WHRA (Golder 2012c) are still valid when the RO treatment method is used during mining operations.

## 5.0 HUMAN HEALTH RISK ASSESSMENT

The following are the key assumptions in the Human Health Risk Assessment (HHRA) (Golder 2012d)[4] that pertain to human exposure to surface water:

- The types of human receptors assessed in the HHRA included workers, community residents, and resident/workers (i.e., workers that have a permanent residence at one of the communities within the Regional Study Area as defined in the HHRA).
- Geographic locations considered were the Maximum Point of Impingement (MPOI), the on-site Worker Camp, and at 3 nearby recreational locations (i.e., Hislop Lake, Bea Lake, and the Marian River);
  - The surface water at the MPOI was conservatively represented by the highest water quality predictions from Nico Lake, Peanut Lake, and Burke Lake. The highest predicted chemical concentrations were estimated at Nico Lake; therefore, the HHRA applied these concentrations to estimate risk for receptors at the MPOI;
  - Workers at the Camp were considered to obtain their potable water from Lou Lake, which was unaffected by the NICO Project. Therefore, the Worker Camp location was not considered further; and
  - Water quality at Marian River was adopted for all three recreational locations given that water quality predictions were not available for Hislop Lake or Bea Lake.
- Water quality predictions for the phase of the NICO Project with the highest estimated emissions and/or discharges (i.e., operations) were adopted to represent changes to water quality throughout the course of the NICO Project. The operations phase of the NICO Project consistently had the highest water quality predictions at all assessed waterbodies.
- Water quality predictions for total metals rather than dissolved metals were used in the HHRA given that screening guidelines and toxicity reference values have been derived in terms of total metal concentrations. It should be noted that water quality predictions for nutrients and major ions were not retained for the assessment of health effects to humans given that these measures are applicable for aquatic life.

Given the assumptions above, the following comparisons were carried out:

- The predicted peak 95$^{th}$ percentile concentrations of chemicals using RO for each of the assessed waterbodies were compared to those using IX to determine whether the RO predictions were higher. If predictions are higher for any given chemical, these chemicals were considered further.
- For chemicals for which RO predictions were higher than IX predictions, these chemicals were compared to baseline concentrations + 10% and to the human health-based screening guideline adopted in the HHRA to determine whether it is a CoPC. These CoPCs were then carried through exposure assessment and risk characterization in the HHRA.

As described above, the RO technology did not change predicted water quality in Nico Lake or in the Marian River. However, in some cases total metal concentrations increased in Peanut Lake to concentrations that exceed those predicted for Nico Lake. The metals that were affected are listed below:

[4] Golder. 2012d. Draft: NICO Cobalt-Gold-Bismuth-Copper Project, Human Health Risk Assessment. Prepared for Fortune Minerals Limited. London, ON.

- Antimony (Sb);
- Boron (B);
- Manganese (Mn);
- Molybdenum (Mo);
- Nickel (Ni); and
- Silver (Ag).

As a result, these chemicals were considered further as possible CoPCs for the HHRA.

The predicted concentrations of these chemicals were compared to baseline concentrations + 10% (at Peanut Lake) and to the human health-based screening guideline used in the HHRA (i.e., the Canadian Drinking Water Quality Guidelines). The results of the CoPC screening are shown in Table 5-1 below.

**Table 5-1: Screening of Chemicals of Potential Concern for Human Health**

| Chemical | Units | CDWQ[a] | Potable Ground Water[b] | Peanut Lake Baseline + 10% | Peanut Lake 95th Percentile | CoPC? |
|---|---|---|---|---|---|---|
| Antimony | mg/L | 0.006 | -- | 0.0004 | 0.0021 | No |
| Boron | mg/L | 5.0 | -- | 0.0104 | 0.074 | No |
| Manganese | mg/L | 0.05 | -- | 0.057 | 0.055 | No |
| Molybdenum | mg/L | NG | 0.070 | 0.0003 | 0.0040 | No |
| Nickel | mg/L | NG | -- | 0.0014 | 0.0014 | No |
| Silver | mg/L | NG | 0.0015 | 0.000013 | 0.00019 | No |

[a] CDWG = Canadian Drinking Water Quality Guidelines (Health Canada. 2010. Guidelines for Canadian Drinking Water Quality. Summary Table. Prepared by the Federal-Provincial-Territorial Committee on Drinking Water. December 2010).

[b] Potable Ground Water = Ontario Ministry of the Environment (MOE) Potable Ground Water Standards (MOE. 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act*. PIBS #7382e01, April 15, 2011).

CoPC = chemical of potential concern; NG = no guideline; mg/L = milligram per litre

No further assessment of these chemicals was required because the 95th percentile concentrations were lower than baseline concentrations + 10% or the applicable screening standards. Therefore, the conclusions of the HHRA (Golder 2012d) remain valid when the RO treatment method is applied.

## 6.0 SUMMARY AND CONCLUSIONS

The water quality predictions using RO water treatment technology were assessed with respect to the receptors, pathways, and chemicals identified in the aquatic, wildlife health, and human health risk assessments for the NICO Project. No additional CoPCs were identified for any of the risk assessments compared to those identified under the IX treatment technology, although the estimated HQs for aluminum (Nico, Peanut, and Burke lakes) and iron (Nico and Peanut lakes) for the protection of aquatic life marginally increased. In summary, there were no changes to the CoPCs and conclusions of the risk assessments as a result of changing the water treatment technology during operations from IX to RO.

## 7.0 CLOSURE

We trust that this technical memorandum meets your current requirements. Should you have any questions or comments, please do not hesitate to contact any of the undersigned.

Yours truly,

**GOLDER ASSOCIATES LTD.**

***Original Signed By***

Tammie Morgan-Gray, M.Sc.
Environmental Risk Assessor

***Original Signed By***

Rein Jaagumagi, B.Sc.
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AA/SC/TMG/RJ/TRS/aa

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