REVIEW OF THE SISSON PROJECT BASELINE AQUATIC ENVIRONMENT TECHNICAL REPORT

Context

Fisheries and Oceans Canada's (DFO) Habitat Management Division, Maritimes Region, is reviewing a Baseline Aquatic Environment Technical Report as background information for the Environmental Impact Assessment (EIA) of the Sisson Mine Project to determine if the project is likely to result in negative impacts to fish and fish habitat. The project consists of a conventional open pit tungsten and molybdenum mine, an ore processing plant, and associated facilities and infrastructure located approximately 10 km southwest of the community of Napadogan, New Brunswick.

The specific questions from Habitat Management to DFO Science were:

- Are the baseline studies complete and in particular is there a need for additional surveys to be completed;
- Is there additional information available that should be included / considered in the document; and,
- Are the methodologies used to describe the existing environment appropriate to assess the effects of a mine development on the aquatic environment?

As Habitat Management routinely addresses many aspects of the questions identified for this review and given the relatively quick turnaround for this review, DFO Science sector is focusing this review on non-routine aspects of these questions where credible, timely advice can be provided. In addition, as aspects of this technical report pertain to the mandate of other federal government departments already engaged in the review process, this review focuses on questions relevant to DFO's mandate.

This Science Response report is from the regional Science Special Response Process (SSRP) of July 2012 on the Review of a Baseline Aquatic Environment Technical Report of the Sisson Mine Project. DFO's SSRP was used to review the technical report and provide input due to the short deadline for advice and the fact that the advice will contribute to a broader *Canadian Environmental Assessment Act* process.

As the Baseline Aquatic Environment Technical Report is being prepared as background information for a forthcoming EIA, the DFO Science review of this report is likely the first part of the ongoing review process and additional SSRPs may be completed when the proposed EIA is finalized.

Background

The purpose of the Baseline Aquatic Environment Technical Report is to characterize the aquatic environment presently existing within the Project Development Area (PDA) and in the broader study area and gather baseline data to support the development of a long-term environmental effects monitoring program for the aquatic environment, as may be required to meet follow-up or monitoring commitments. The technical report summarizes the data and other information collected as part of the baseline aquatic environment work carried out for the project. Further analysis and interpretation of the data will be presented in the subsequent EIA Report.

The Canadian Environmental Assessment Registry (project number 63169) includes more information on the proposed development project.

Analysis and Response

Fish Presence/Absence and Abundance Studies

With respect to fish presence/absence and abundance studies, there was good spatial coverage with appropriate consideration given to the various habitat types within each of the affected watersheds. The methodologies and calculations used to estimate fish abundance were scientifically sound. The report was very inclusive as the field sheets were also included in the appendices.

There is one additional report that could be added to the "Information" section for DFO:

> *Francis, A.A. 1980. Densities of juvenile Atlantic salmon and other species, and related data from electroseining studies in the Saint John River system, 1968-78. Can. Data Rep. Fish. Aquat. Sci. No. 178. 102 p.*

Sampling Sites

There seem to be some discrepancies with respect to the location of some sampling sites. Figures 3.3 and 3.4 do not have the same location for the sampling site EBNB. It is possible that the labelling on Figure 3.4 should be site EBNB3 rather than site EBNB1. Figures 3.2 and 3.3 do not have the same location for site B1A5. It is possible that site S3A3 in Figures 3.3 and 3.4 should be labelled as site S3A2 relative to its position in Figure 3.2.

Surface Water and Sediment Quality, Fish Tissue Analysis

The toxicity of metals depends on the form they are present in. If a salt, they are soluble in water, but if under the form of unionized metal (referred to as metal below), they are nearly insoluble. Because this information is widely known, toxicity tests are performed using the more water soluble salts and consider the worst case scenario. All sample analyses tend to be performed by inductively coupled plasma mass spectrometry (ICPMS) because it is relatively cheap, and a series of results can be obtained for numerous metals; however, this approach does not provide any information on the state of ionization of the metals. This makes the interpretation of concentrations provided in studies difficult to explain and can result in some discrepancies between expectations and observations.

There is a limited body of literature on the toxicity of molybdenum and tungsten. Whiting et al. (1994) studied molybdenum and cyanide drained from a mine and found that the levels were not high enough to affect the invertebrate benthic community. Taxa tended to be dominated by pollution tolerant species, being slightly higher in richness and density than at the control site. Sites at 1.5 km were less affected than closer ones. Another relevant study found that a 14 day exposure of earthworms to tungsten at concentration of 6,250 mg/kg arrested reproductive activity (Laura 2006). These animals were chosen because discharged tungsten would be expected to associate with particles and get deposited in sediments, where sediment dwellers would ingest and absorb more material. In another study, 10 species were exposed to sodium molybdate and either growth, reproduction or survival examined as an endpoint (2 to 34 days tests) where the 5% effects level was extrapolated from the data and was represented by 38 mg/L. Fish were more sensitive than invertebrates and plants (De Schamphelaere et al. 2010). Other than this study, there are no other thresholds for lethal or sub-lethal toxicity effects of molybdenum and tungsten on fish and invertebrates.

Surface Water and Sediment Quality

For the water sampled at the 32 qualitative stations, only molybdenum was analyzed, not tungsten. Molybdenum ranged from 0.05 to 23.7 ug/L at M1M2, with some values reaching 6.7, 4.4 and 3.5 ug/L at S2A2, S2A3 and S3A2, respectively. Those 4 sites are within the open pit mine area. Concentrations of 1.9 and 4.4 ug/L were detected at M1N1 and M2E1; these 2 sites are outside the PDA. The rest of the sites ranged from 0.05 to 1 ug/L, with 2 values above 0.4 ug/L and a mean of 0.3 ug/L.

Within the water sampled at 10 quantitative stations, molybdenum displayed the highest concentrations at S2A2 and S3A3 (2.1 and 2.4 ug/L), with the other 8 stations ranging from 0.05 to 0.8 ug/L, with a mean of 0.3 ug/L. Tungsten is listed at 2.5 ug/L, i.e. not detected (ND) at all stations. There is a 3 fold difference in molybdenum concentrations of S2A2 between the 2 sampling times. This variability could be explained by the presence of more or less particles, as well as changes in the depth of water in the stream. By randomly looking at metals in some water samples, iron level can vary from 0.38 to 10.4 ug/L between 2 sampling times of one station (difference of >30 times), cadmium from 0.01 to 0.05 ug/L (5 times), magnesium from 0.49 to 0.74 ug/L (nearly two times).

For the sediment sampled at the 32 qualitative stations, only molybdenum was analyzed, not tungsten. As with the water samples, M1M2 displayed the highest concentration 503 mg/kg followed by S2A3, S2A2, M2E1, M1N1, S3A2 at 31.4, 27.8, 20.5, 13.9, 12.4 mg/kg. The mean of these values is 21.2 mg/kg. M2E1, M1N1 actually fall outside the Project Development Area. Another 10 sites follow with medium values between 1.8 and 6.5 mg/kg, with a mean of 3.2 mg/kg. Another 16 sites display a mean of 0.4 mg/kg.

Within the sediment sampled at the 10 quantitative stations, molybdenum had the highest concentrations at the same 2 stations described for water, S2A2 and S3A3 (17.5 and 6.8 mg/kg). The other 8 sites ranged from 0.05 to 4.7, with a mean of 1.5 mg/kg. Tungsten was at 2.5 mg/kg (ND) at 8 sites and highest at the same 2 sites as above, S2A2 and S3A3, with concentrations of 17 and 20 mg/kg. Values for molybdenum were 15.7 and 19.2 in a duplicate analysis of sediment at S2A2. Among 3 analyses and 2 sampling occasions, sediment concentrations at S2A2 varied by a factor of 2.

Regarding other elements, there seems to be wide variability yet there is no discussion of differences in concentrations observed between sampling times. For example, were the outliers at the same identical site over the 2 sampling times, or observed on one sampling occasion and not the next one? There is also no mention of the usefulness of the Nashwaak River reference site. There are no values given for the expected National Institute of Standards and Technology (NIST) reference material versus values provided after the sediment analysis.

By just randomly looking at metals in some water samples, iron can vary from 0.38 to 10.4 ug/L (difference of >30 times) between 2 sampling times at one station, cadmium from 0.01 to 0.05 ug/L (5 times), magnesium from 0.49 to 0.74 ug/L (nearly two times). By just randomly looking at metals in some sediments samples, chromium can vary from 251 to 4920 mg/kg (difference of 20 times) between two sampling times at one station, cadmium from 0.55 to 1.38 mg/kg (2-3 times), molybdenum from 6.8 to 27.8 mg/kg (4 times). So, overall there is a lot of variability, either analytical or environmental. Analytical variability is reflected by the duplicate analyses (one sample divided in two on several occasions) and the comparison of NIST reference results (obtained versus expected, not listed).

In order for the large number of analyzed metals to be useful for further monitoring, there should be at minimum two figures displaying the results in terms of Principal Component Analysis (PCA). The PCA should examine the metal distribution per site for one sampling time, for metals where all levels are above the limit of quantification, with sites labelled in the PCA and two tables with linear regressions between the metals. Because of the high variability, even then, it will be extremely difficult to interpret changes in the concentration of elements other than molybdenum and tungsten in future monitoring.

Overall, the results for water and sediment concentrations are sufficient. However, they do not reflect the bioaccessibility and bioavailability of contaminants which will in turn determine potential health effects. However, there is little information on the toxicity of these two elements (Whiting et al. 1994, Laura 2006, De Schamphelaere et al. 2010).

Fish Tissues

Concentrations of tungsten in liver are mainly 0.01 mg/g. Two composites at B3A9 show 0.1 and 0.5 mg/kg, and fish livers from S2A2 and S3A3 are between 0.01 and 0.06 mg/kg, with one fish liver at 0.11 and another at 0.9 mg/kg (W4A17). Concentrations of molybdenum are between 0.2-0.9 mg/kg and varying between fish of a site, with most samples between 0.2-0.4 mg/kg.

For the carcasses, molybdenum varies between 0.002 and 0.02 mg/kg with a fair amount of variability between fish within sites, with many of these values representing undetected amounts. Tungsten varies between 0.003 and 0.07 mg/kg, with a fair amount of variability between fish within site, with many of these values representing undetected amounts. The high variability is also observed for all the metal concentrations.

Viscera display slightly higher concentrations but with a high variability as well, with molybdenum ranging from 0.02 to 0.7 mg/kg and tungsten from 0.01 to 0.2 mg/kg and two samples at 1.3 and 1.1 mg/kg, each. Hence, the detected molybdenum and tungsten are likely due to the consumption of particles. A PCA analysis of results might indicate a similarity in the fingerprint of the sediment and visceral content. Overall, it can be concluded that the detection of molybdenum and tungsten is likely due to the consumption of particles.

Given that trout are not abundant enough to be used for future monitoring, a thorough analysis of the monitoring results should have been conducted. Concentrations vary with fish size and sex, and the 20 male and 20 female mature fish per site were not obtained for statistical analyses. This watershed has recreational fisheries and, as mentioned in the report, the collection of more fish would not be sustainable, so expecting to collect 100 fish per site at either 10 or 32 stations covering a 12 km^2 area is not very realistic. Given the need for meaningful and scientifically defensible baseline monitoring data, an alternate approach should be developed. Examining the abundance and diversity of the benthic community for monitoring purpose is likely environmentally and financially costly and, therefore, undesirable.

It seems reasonable to suggest that the approach that should be adopted in future monitoring of environmental quality in the vicinity of the Sisson mine is to use three toxicity tests: one of an aquatic plant, one of an invertebrate, and one of a fish species. This should be done with chemical analyses of sediments and biota, if possible. Acquired data would increase the knowledge base and help in additional monitoring. A stepwise approach could be followed with less than 10 stations likely a sufficient sample size.

Conclusions

With respect to fish presence/absence and abundance studies, there was good spatial coverage with appropriate consideration given to the various habitat types within each of the affected watersheds. The methodologies and calculations used to estimate fish abundance were scientifically sound.

A PCA analysis of results might indicate a similarity in the fingerprint of the sediment and visceral content; however, given the extent of the observed variability in results, it may not show a significant difference.

Overall, the results for water and sediment quality are sufficient. However, they do not reflect the bioaccessibility and bioavailability of contaminants which will in turn determine potential health effects.

Given that trout are not abundant enough to be used for future monitoring and the need for meaningful and scientifically defensible baseline monitoring data, an alternate approach to monitoring should be developed. An approach that could be adopted in future monitoring would be to conduct three toxicity tests: one of an aquatic plant, one of an invertebrate, and one of a fish species. This is Environment Canada’s area of expertise.

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Date: January 11, 2013

Sources of Information

De Schamphelaere, K.A.C., Stubblefield, W., Rodriguez, P., Vleminckx, K., and Janssen, C.R. 2010. The chronic toxicity of molybdate to freshwater organisms. I. Generating reliable effects data. Science of the Total Environment 408: 5362-537.

Francis, A.A. 1980. Densities of juvenile Atlantic salmon and other species, and related data from electroseining studies in the Saint John River system, 1968-78. Canadian Data Report of Fisheries and Aquatic Sciences 178. 102 p.

Laura, S. 2006. Tungsten effects on survival, growth, and reproduction in the earthworm, *Eisenia fetida*. Environmental Toxicology and Chemistry 25: 763-768.

Whiting, E.R., Mathieu, S, and Parker, D.W. 1994. Effects of drainage from a molybdenum mine and mill on stream macroinvertebrate communities. Journal of Freshwater Ecology 9: 299-311.

This Report is Available from the

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ISSN 1919-3769 (Online)

La version française est disponible à l'adresse ci-dessus.

Correct Citation for this Publication

DFO. 2013. Review of the Sisson Project Baseline Aquatic Environment Technical Report. DFO Can. Sci. Advis. Sec. Sci. Resp. 2013/002.