SURFACE WATER ARSENIC CONCENTRATION AND LOADING TRENDS IN THE HISTORIC COBALT MINING CAMP, NORTHEASTERN ONTARIO

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Key Words: Farr Creek, watershed, rehabilitation, reclamation

Introduction

Since 2013, Agnico Eagle Mines Limited (Agnico Eagle) and Story Environmental Inc. (SEI) have monitored surface water in the historic Cobalt/Coleman Mining Area. This study focuses on arsenic concentrations and loadings in the 60 square kilometre Farr Creek watershed. Numerous historic mining properties, not all owned by Agnico Eagle, contribute arsenic loadings to the watershed.

The Cobalt/Coleman Mining Area is considered the birthplace of mining in Ontario, with the first silver veins discovered in 1903. By the 1970s, most mining operations had shut down, with some activity continuing in the Cart Lake and Cobalt Lake sub-watershed into the 1980s. In 1989, all mining and milling in the Farr Creek watershed ceased. Rehabilitation work on Agnico Eagle's properties took place in the 1990s, as part of approved closure plans.

Arsenic Concentration Trend

Multi-decade time series of total arsenic concentrations were compiled from Farr Creek sites near the watershed outlet. Data sources included the SEI monitoring campaigns, previous consulting studies (Beak, 2002 and LGL, 2010), and historic data from the Ontario Ministry of Environment (MOE, 1968 to 1996).

The MOE's historic water sampling site on Farr Creek was located in North Cobalt (Provincial Water Quality Monitoring Network station 18737000102). This is the same location as SEI's site CR-10. Site CR-10 is approximately 2 kilometres downstream of site CR-9, which has been sampled more routinely in recent consulting studies (e.g., Beak, 2002). However, both sampling sites are downstream of all former mining sites in the watershed. Sampling in 2013 indicated similar concentrations at both locations.

Near the outflow of the Farr Creek watershed, average total arsenic concentrations have declined at a rate of about 0.01 mg/L per year since the mid-1970s (Figure 1). Average total arsenic concentrations in the creek declined from 0.66 milligrams per litre (mg/L) in 1976-1980 to <0.3 mg/L in 2013-2015.

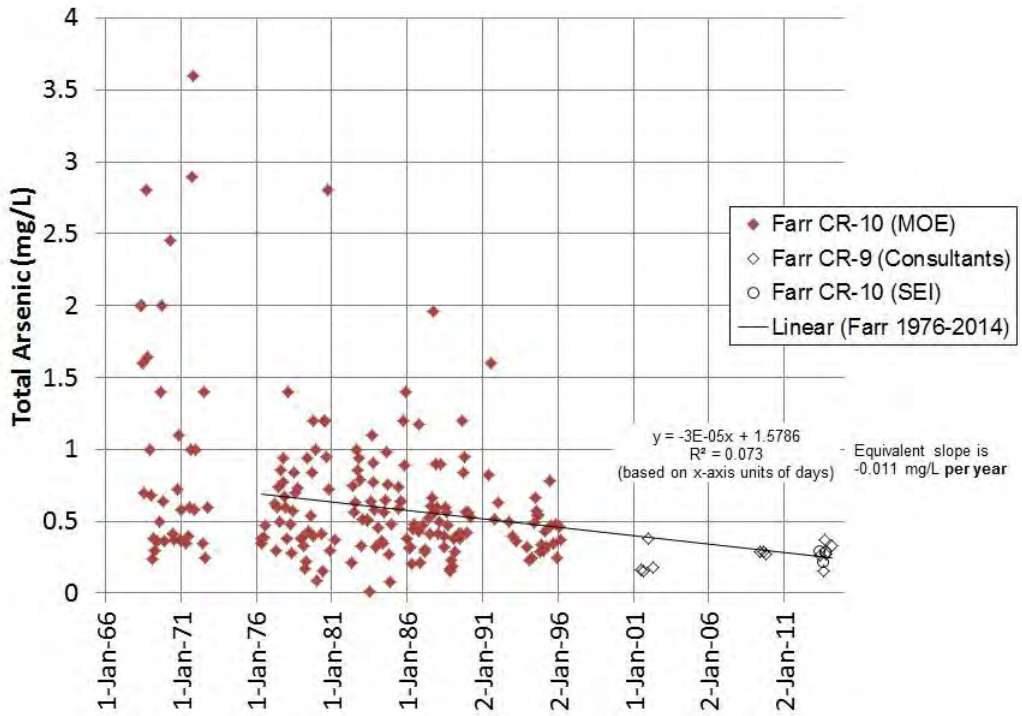

Figure 1 Total Arsenic Concentrations in Farr Creek, 1968-2014

Arsenic Loading

Historical Water Survey of Canada (WSC) flow data for the 1972-1982 period and MOE arsenic data for the 1976-1996 period were used to calculate a flow-weighted historical average annual arsenic loading for Farr Creek (Figure 2). This approach indicated an average total arsenic loading during 1976-1996 of approximately 9700 kg/year (Table 1). Results showed that 48% of the annual arsenic loading occurred in the months of April and May (Figure 2).

Arsenic loadings for the 2013-2015 period were based on 24 data points from site CR-9. Consistent with the historic loading results shown in Figure 2C, 46% of these data (11 of 24) were collected in the important high flow months of April and May. A statistical model of total arsenic concentration based on instantaneous flow in Farr Creek was developed to calculate loadings for 2013-2015. The coefficient of determination (r^2) of the fitted regression model is 0.48.

Applying the regression model to the historic WSC continuous flow records on a daily basis indicated an average annual loading of 4414 kg/year. In other words, assuming that the 11-year record of flow in Farr Creek from 1972-1982 is representative of current flows, a current loading of approximately 4414 kg/year is expected. A plausible upper bound on this mid-range arsenic loading is 5000 kg/year (the 65th percentile of the modelled 2013-2015 annual loadings).

The average total arsenic loading in recent years (2013-2015) has declined by 50% from approximately 9700 kg/year for the 1976-1996 period (Table 1).

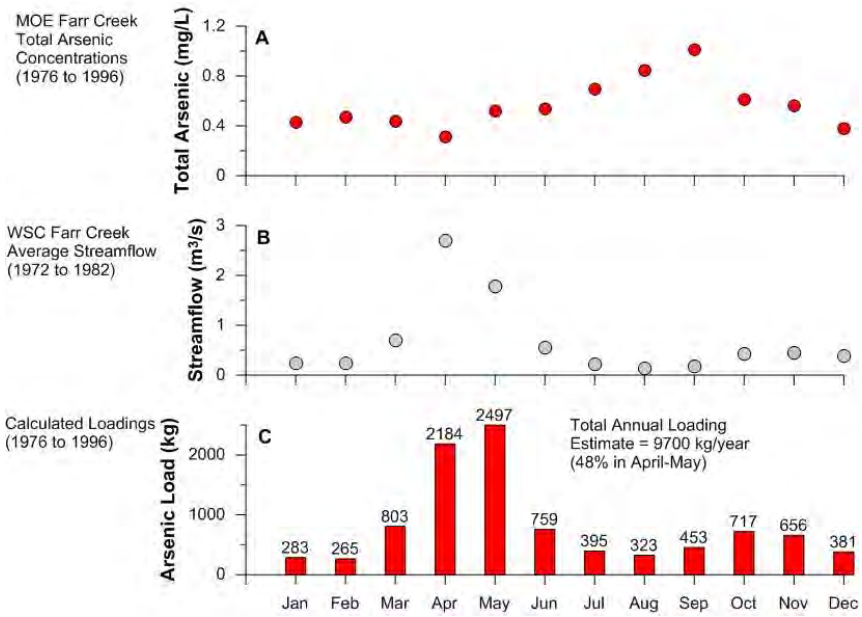

Figure 2 Calculated Monthly Arsenic Loadings in Farr Creek, 1976-1996

Table 1 Farr Creek Annual Arsenic Loadings Estimates

Source	Period	Arsenic Loading Estimate (kg/year)	Notes
SEI (2015)	1976-1996	9700	Flow-weighted load (see Figure 2 above)
SEI (2016)	2013-2015	4400-5000	Flow-weighted load, based on 24 sampling days in 2013-2015, combined with 1972-1982 WSC flow data

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