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# AIR DISPERSION MODELLING
# OF ROASTER STACK EMISSIONS
# ROYAL OAKS GIANT YELLOWKNIFE MINE
# YELLOWKNIFE, NORTHWEST TERRITORIES

MARCH 1995

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# 1.0 INTRODUCTION

Ore mined at the Giant Yellowknife Mine contains several gold carrier minerals, such as arsenopyrite, pyrite, and other metallic sulfides. These minerals are crushed and ground to produce a bulk gold sulfide concentrate that is passed through a two stage fluosolids roaster. In addition to the main discharge, this roasting process produces off gas rich in sulfur dioxide and arsenic trioxide which is passed through cyclones, Cottrell precipitators, and a baghouse prior to discharge to the atmosphere via the roaster stack.

The air dispersion modelling of sulfur dioxide and arsenic emissions from the Giant Yellowknife Mine roaster stack is outlined in this report. It is submitted in execution of the project initiated by request for proposals, dated August 23, 1994, jointly by the Northwest Territories Department of Renewable Resources and Royal Oak Mines, Inc.. Project objectives are to both model the atmospheric dispersion of sulfur dioxide and arsenic emitted from the gold roaster stack using an appropriate USEPA dispersion model and to assess the effectiveness of emission control options in reducing ambient concentrations of emmitted pollutants.

Background information about the site, the emission source, and local meteorology is summarized in Section 2. Model selection, the configuration of selected model runs, and baseline modeling results are described in Section 3. Modeling results are evaluated by comparison with ambient monitoring results in Section 4. In Section 5, the ability to reduce ambient air concentrations of $SO_2$ is evaluated in a sensitivity analysis. Conclusions and recommendations are provided in Section 6.

# 2.0 BACKGROUND INFORMATION REVIEW

## 2.1 SITE DATA

Information regarding roaster stack emissions, site bluiding and stack geometry, ground level and upper air meteorological data, and local topography were gathered to develop proper input files for execution of the desired modelling runs. Information on the gold roasting process, inplace emission control technologies, stack testing results, site building and stack dimensions, and ambient air monitoring results were provided by Royal Oak Mines Inc. and the GNWT Department of Renewable Resources. Surface and upper air meteorological data were purchased on disk from the Atmospheric Environment Service, Canadian Climate Centre in Downsview, Ontario.

## 2.2 EMISSION SOURCE DATA

Historical roaster stack test results have been reviewed and emission parameter values needed as model inputs have been calculated. Emission parameters, which include mass emission rates for both arsenic and sulfur dioxide as well as mean exit gas velocity and temperature, have been calculated from stack test data provided and are summarized in Table 2-1.

While the mass emission rate for arsenic was said to vary from 20 to 30 kg/day, measured values from sampling in 1991 and 1993, as shown in Table 2-1 were chosen for model runs. The mass emission rate for sulfur dioxide, which reportedly ranges in value from 30 to 65 x $10^3$ kg/day, was set at its lower value of 30 x $10^3$ kg/day for initial model runs. Mean values of exit gas velocity and temperature were determined as the arithmetic average of traverse point values measured during 1991 and 1993 stack sampling, as shown in Table 2-1.

## 2.3 SITE BUILDING AND STACK DATA

A detailed minesite layout showing building locations and dimensions was reviewed to determine if the roaster stack was located within the building wake area of influence of any nearby structures. While the stack was found to be within the influence areas of the two roaster buildings, the Cottrell precipitator and baghouse buildings, and the arsenic loadout building, none of the buildings were tall enough to produce a turbulent wake cavity high enough to intercept a portion of the roaster stack plume. It was concluded that building wake effects did not exert an influence on the dispersion of roaster stack emissions.

Topographic maps of the minesite and surrounding area were reviewed to classify the terrain within the modelled area for use with either a simple or complex terrain dispersion model. Simple terrain models are meant to model dispersion over flat or rolling terrain where elevation differences within the model domain are less than or equal to one stack height (150 ft.). It was concluded from this review that an area

**TABLE 2-1 ROASTER STACK EMISSION PARAMETER VALUES**

| Source Parameter | Stack Test Results October 14, 1993 | Stack Test Results June 24, 1991 |
|---|---|---|
| Arsenic Emission Rate Total (g/s) | 0.306 | .167 |
| Sulfur Dioxide Emission Rate Gas Phase (g/s) | 315.7[1] | 315.7[1] |
| Exit Gas Temperature (°K) | 385.2 | 352.9 |
| Exit Gas Velocity (m/s) | 2.70 | 2.45 |
| Volumetric Flow Rate ($10^3$ $m^3$/hr) | 39.95 | 38.72 |

1. Estimated value equal to 30 x $10^3$ kg/day, not measured during stack test.

extending 7 km north of the stack, 7 km west of the stack, 7 km east of the stack, and 8 km south of the stack could be modelled with a simple terrain model.

## 2.4 METEOROLOGICAL DATA

Meteorological data, provided by the Canadian Climate Centre of AES, included three years (1991, 1992, and 1993) of hourly surface meteorological data from the AES monitoring station at the Yellowknife Airport and three years of twice daily upper air soundings from the AES station at Fort Smith, which is the nearest upper air monitoring station. 1994 data was not yet available on disk from AES at that time. Surface data included hourly average air temperature, windspeed, wind direction, ceiling height, cloud cover, and daily snow cover. The twice daily upper air soundings give air temperature at elevations ranging from the ground surface (1000 mb) up to about 3000 m. (700 mb). This upper air data was used to calculate mixing heights. These data were processed through the PCRAMMET meteorological data processor to produce model input meteorological data sets.