BARRICK

**TO:** [redacted]
**FROM:** [redacted]
**DATE:** June 28, 2010
**SUBJECT:** Recommended Spray Evaporative Operation at [redacted] Project

| | Temperature at 2 m (°C) | Rainfall (mm) |
|---|---|---|

## Objectives

Instead of using a water treatment plant to treat and discharge the mine water at the marine terminal [redacted] at a rate of [redacted] m$^3$/h (:: gpm) as currently proposed, this memo investigates an alternative of using an enhanced evaporation approach.

## Working Principle of Enhanced Evaporation

The principle behind enhanced (spray) evaporation technology is to reduce the particle size of a water droplet and propelling it into the air, thus increasing the surface area of the water droplet exposed to air, consequently accelerating the process of evaporation. The speed of this evaporation process is affected by relative humidity (RH), temperature, and wind speed. Generally speaking; the smaller the droplet of water, the faster the evaporation. However, smaller droplets will travel further when propelled in the air. This is not favorable when attempting to contain the effects of propelling tailings water in the air; this is especially true when complicated by wind effects. So the primary design consideration with these types of sprayers is to balance water droplet size with hang time, or propelled distance.

There are two major manufacturers of this type of technology in North America: Slimline Manufacturing of British Columbia, which makes the TurboMist Evaporator (http://www.turbomisters.com/); and SMI Evaporative Solutions of Michigan, which makes the SMI Polecat Evaporator (http://www.evapor.com/). These technologies have been used at various sites around the continent for dewatering large and small pond areas for agricultural, mining, and industrial applications. Based on our experiences, we recommend using Slimline technology as it has been used at several Barrick sites, such as Grants, Mercur, Nickel Plate and McLaughlin.

Figures 1 and 2 illustrate TurboMist applications at the McLaughlin site.

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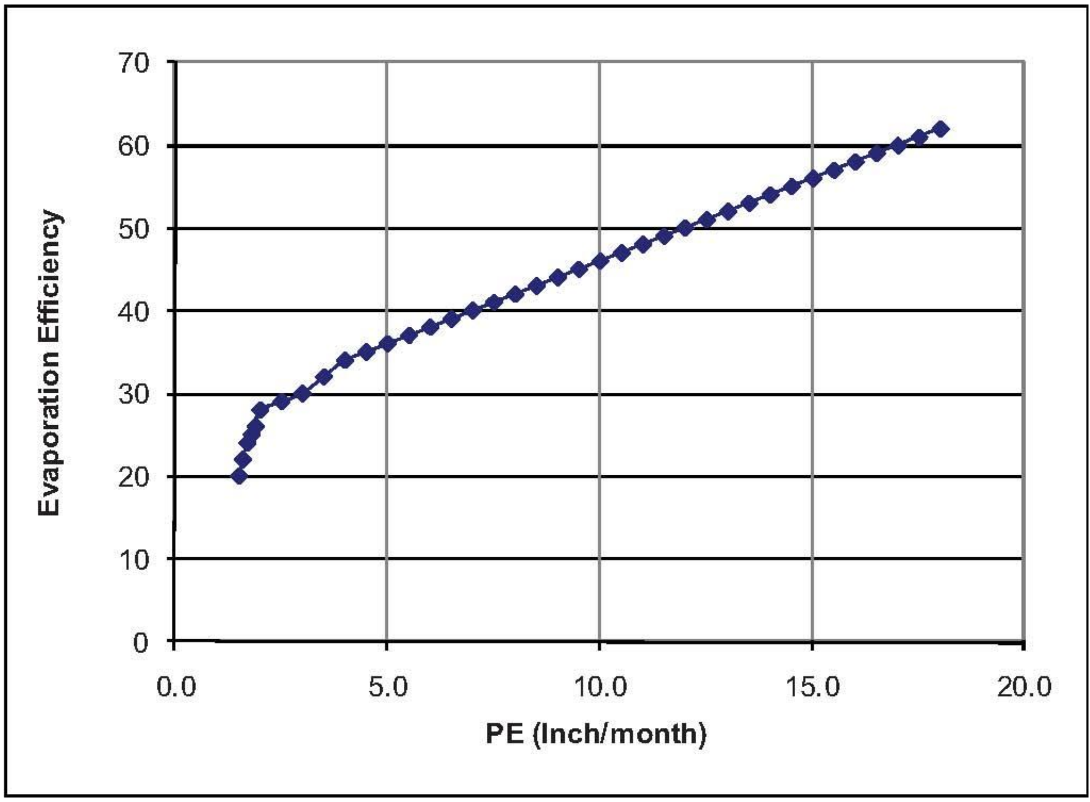
Figure 1. Turbomist units (two dual-pack units) used in the McLaughlin mine.

Figure 2. “McLaughlin waterfall”.

## Evaporation Efficiency vs. Potential Evaporation

Evaporation efficiency is directly related to the potential evaporation (PE). Based on the guideline provided by the manufacture and our experiences gained from other Barrick sites, the relationship between evaporation efficiency and PE is shown on Fig 3 (Slimline, personal communication).

Figure 3. Suggested evaporation efficiency of the TurboMist



## Potential Evaporation at the [redacted]

PE is defined as the amount of evaporation from a large uniform land surface with adequate moisture, such that available energy is the limiting factor. However, most methods compute evapotranspiration using meteorological data. To provide an estimate of reference (or potential) evapotranspiration ($ET_o$), potential evapotranspiration is calculated assuming a hypothetical grass crop with specified characteristics such as an albedo of 0.23, crop depth of 12 cm, and bulk surface resistivity of 70 s/m. Evaporation reported by automatic weather stations is usually $ET_o$ calculated using the Penman-Monteith-FAO method (FAO, 1998).

In most cases, $ET_o$ values can be considered equal to PE. To overcome the ambiguity between $ET_o$ and PE, which mostly originates from biological control of transpiration, this memo adopts the notion that the two are nearly equivalent.

Based on the ESIA document (Table 5.23, SRK and Hagler Bailly, 2010), the climate information for the [redacted] is listed in Table 1. Only seven monthly $ET_o$ were reported with large variation.

Table 1. Climate data for [redacted] Coastguard Station)

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| Months | Temperature at 2 m (°C) | | | Rainfall (mm) | **Calculated monthly total evapotranspiration $ET_0$(mm)** |
|---|---|---|---|---|---|
| | Min | Avg | Max | | |
| January 2009 | 9.8 | 18.3 | 26.6 | 133.8 | 99.8 |
| February 2009 | 10.3 | 20.9 | 31.5 | 0.4 | 104.6 |
| March 2009 | 13.3 | 23.5 | 34.2 | 2.3 | 143.6 |
| April 2009 | 17.3 | 25.1 | 36.3 | 8.7 | 172.2 |
| May 2009 | 19.7 | 28.5 | 42.0 | 0.0 | 192.8 |
| June 2009 | 23.5 | 28.8 | 36.0 | 0.0 | 91.7 |
| July 2009 | 25.7 | 29.2 | 31.6 | 0.0 | 88.5 |
| August 2009 | 24.9 | 27.8 | 30.9 | 0.1 | n/a |
| September 2009 | 20.9 | 26.5 | 31.4 | 0.2 | n/a |
| October 2009 | 15.9 | 24.9 | 31.6 | 0.6 | n/a |
| November 2009 | 8.7 | 22.5 | 33.1 | 0.3 | n/a |
| December 2009 | 10.2 | 21.3 | 29.1 | 25.8 | n/a |
| Annual Total | | | | 172.2 | 893.2 |

| | Estimated $ET_0$ | Measured $ET_0$ in 2009 |
|---|---|---|
| January | **109.1** | 99.8 |
| February | **114.3** | 104.6 |

It is widely believed that there is a direct correlation between temperature and potential evaporation (PE or $ET_0$). Given the short records and high fluctuation of $ET_0$ listed in Table 1, long–term $ET_0$ was calculated with the Blaney-Criddle method (Blaney and Criddle, 1950) based on the monthly average temperature. The calculated $ET_0$ from B-C method is 1,960 mm/y.

The major regional met station at the study area is [redacted] (WMO ID 417560). It was reported that the annual PE at this station is 1,750 mm/y ([redacted] 1977), about 89% of the B-C estimate. By multiplying the B-C calculations with a factor of 0.89, the estimated monthly $ET_0$ at [redacted] are listed in Table 2. As a comparison, the recorded 2009 $ET_0$ values at [redacted] Coastguard Station are also given in Table 2.

The estimates are in close agreement of global PE estimation data (Figure 4) (Ahn and Tateishi, 1994).

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Table 2. Estimated $ET_0$ at [redacted] coastguard station)

Figure 4. Estimated Global potential evaporation.

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| Months | Temperature at 2 m (°C) | | | Rainfall (mm) | **Calc** |
|---|---|---|---|---|---|
| | Min | | | | **evap** |
| January 2009 | 9.8 | 18.3 | 26.6 | 133.8 | |
| February 2009 | 10.3 | 20.9 | 31.5 | 0.4 | |
| March 2009 | 13.3 | 23.5 | 34.2 | 2.3 | |
| April 2009 | 17.3 | 25.1 | 36.3 | 8.7 | |
| May 2009 | 19.7 | 28.5 | 42.0 | 0.0 | |
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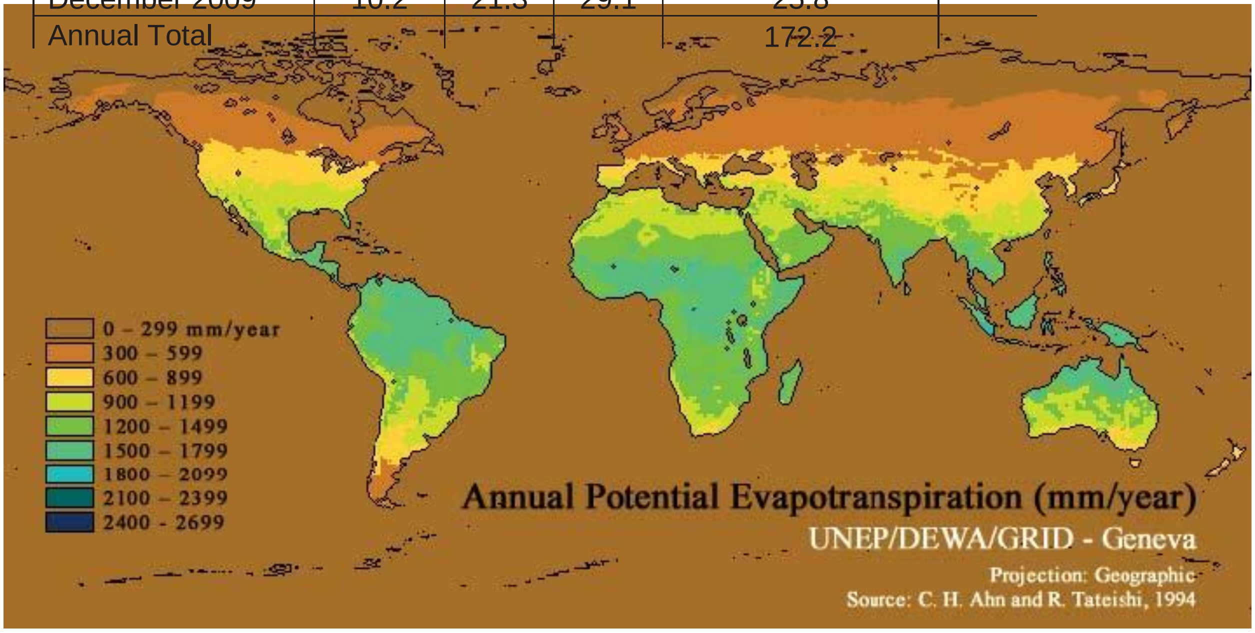
| December 2009 | 10.2 | 21.3 | 29.1 | 25.8 | |
| Annual Total | | | | 172.2 | |



Annual Potential Evapotranspiration (mm/year)

UNEP/DEWA/GRID - Geneva

Projection: Geographic

Source: C. H. Ahn and R. Tateishi, 1994

## Recommended Turbomist

We recommend that Turbomist S30P be used for the project. S30P unit has 30 nozzles and operated under 150 psi with a rate of 80 gpm. Based on the estimated PE at site (Table 2) and corresponding evaporation efficiency (Figure 3), it is estimated that a single unit of Turbomist S30P can evaporate about 58,000 $m^3$ of water, assuming 24 hours per day, 12 months per year (Table 3), which is equivalent to 13.2 $m^3$/hr.

Table 3. Expected evaporation of Turbomist S30P at the [redacted]

**TO:** [redacted]
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[redacted] Project

| Months | Temperature at 2 m (°C) | | | Rainfall (mm) | **Calculated monthly total evapotranspiration $ET_0$(mm)** | |
|---|---|---|---|---|---|---|
| | Min | | | | | Avg |
| January 2009 | 9.8 | 18.3 | 26.6 | 133.8 | 99.8 | |
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As indicated in the web site (http://www.turbomisters.com/models/index.php), cost of a basic model is about CAD$36,500 per unit (without pump), or CAD$67,000 for trailer model with a pump. If no pump is available at the mine site and we have to buy a trailer model, we would strongly recommend purchasing a model called "dual-packs". A "dual-packs" has two units that share one common pump, including a 50ft hose to connect the second unit to the pump on the first unit (means it could sit 50ft away). A 30hp pump is used to feed the two units (160 gpm - 80gpm each evaporator). As a comparison, a 20 hp pump has to be used to feed one unit, which takes 13 kwatts/hr whereas a 30hp pump only takes 17kwatts to feed 2 units (Slimline, personal communication), so "dual-packs" saves electrical costs. A dual-packs unit with 30hp pump costs about $96,000.

## Capital and Operational Costs

Based on the assumptions listed in Table 4, **six** dual-packs are required. The total capital cost and annual operational power costs are estimated to be $576,000, and $80,000, respectively.

It should be indicated that evaporation loss from the pond itself is not included in the calculation. Given a PE of 1,750 mm/y, the evaporation capacity of the pond will be about 2 $m^3$/h or 9 gpm per hectare.

Should you have any questions about this memo, please contact [redacted].

Table 4. Assumptions, capital and operational power cost

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| June 2009 | 23.5 | 28.8 | 36.0 | 0.0 | 91.7 | |
| July 2009 | 25.7 | 29.2 | 31.6 | 0.0 | 88.5 | |

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FAO (1998) Crop evapotranspiration – guidelines for computing crop water requirements – FAO Irrigation and Drainage Paper 56, FAO online document, viewed on 28 June 2010, http://www.fao.org/docrep/X0490E/X0490E00.htm

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References to location, people and projects have been blacked out for privacy purposes