A TETRA TECH COMPANY

April 22, 2013

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EBA FILE: V15101062.700
Via E-mail: dwatt@natlc.ca

North American Tungsten Corp.
Cantung Mine Site
Box 848
Watson Lake, YK Y0L 1CO

Attention: Mr. Doug Watt
Environmental Superintendent

MV2015L2-0003

Dear Mr. Watt:

Subject: Plume Delineation Study Design

1.0 INTRODUCTION

This letter report, prepared by EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) for North American Tungsten Corporation Ltd (NATCL), describes the field method to be employed for effluent plume delineation on the Flat River. This report has been revised to address comments in the Mackenzie Valley Land and Water Board (MVLWB) staff report dated March 18, 2013.

NATCL is presently commissioning a temporary Waste Water Treatment Facility (WWTF) to treat tailings pond water for discharge to the environment. As required by the Water License (WL), NATCL is required to submit by January 31, 2013 a Plume Delineation Study Design for the effluent discharged from the WWTF. A plume mixing numerical model completed by Wenck Associates Inc. using the Cormix model indicated that complete mixing of the effluent would occur 376 metres downstream of the outfall and that the maximum attainable dilution is approximately 5:1, or 20%, at an effluent flow rate of 3,500 m^3/day with a low river flow condition of 17,280 m^3/day. The purpose of the field study is to validate the results of the numerical model and to determine the distance downstream of the discharge where 1% and 0.1% (1 ppm) concentration of the effluent is achieved and/or the distance to complete mixing; where complete mixing is defined as the maximum attainable dilution on the day of the survey based on the effluent and river discharge.

The maximum obtainable dilution will likely be in the range of 20% to 25%. Once complete mixing occurs, further dilution is only possible via additional downstream tributary inflows. The fact that the 0.1% and 1% contour can likely not be mapped locally is ameliorated by the fact that the treated effluent will have parameter concentrations below the effluent quality criteria specified in the water licence for all compliance (specified) parameters. In addition many of the parameters in the effluent will be below CCME criteria for the protection of aquatic life in the receiving environment (Flat River)

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2.0 FIELD PROGRAM

2.1 Theory

The following are excerpts from Environment Canada's 'Technical Guidance - How to Conduct Effluent Plume Delineation':

> *Effluent plume delineation is required in the design phase of the Environmental Effects Monitoring (EEM) program. The objective of plume delineation is to understand how effluent from the mine behaves in the receiving environment and to identify effluent boundaries describing exposure areas and reference areas within which to establish sampling locations.*
>
> *The exposure area for EEM studies is the area where the effluent concentration is 1% or greater. It is important to understand the spatial distribution of effluent in the water column to determine areas for fish collection, as well as to understand where the effluent comes in contact with the bottom substrate to determine areas for sampling the benthic invertebrate community. This is particularly important for effluent that may not exhibit complete vertical or horizontal mixing throughout the receiving environment.*
>
> *Selection of sampling locations within the reference area for EEM studies requires an understanding of the extended dilution of effluent beyond the 0.1% (1:1000 dilution) effluent concentration limit.*
>
> *It is recommended that the effluent exposure zone be predicted for the:*
>
> - *maximum extent, reflecting the zone within which effluent is periodically detectable at a concentration of 1% or greater; and*
> - *long-term average conditions, reflecting the zones within which effluent concentrations of 1% or greater, and 0.1% or greater would be regularly detectable.*

Delineation of effluent plumes will involve a field study to track plume movement during a single time period, coupled with the use of numerical modeling.

The field program will be designed to determine the 1% and 0.1% concentration contours and/or the distance to complete mixing as well as provide an indication of plume behavior in the Flat River, downstream of the outfall discharge point.

2.2 Construction of the Mariotte Bottle

Environment Canada recommends a continuous flow-rate injection system, making field measurements more reliable. A Mariotte bottle provides a simple method for injecting tracer at a constant rate. A simple Mariotte bottle can be constructed from a 10 ℓ carboy fitted with a spigot, which can easily be transported to site. To construct the Mariotte bottle, the screw-on cap is replaced by a size 13½ one-hole rubber stopper with a length of Plexiglas tube inserted to a level about 10 cm higher than the spigot level, cut on a bevel on its lower end (Figure 1). The tube should be inserted such that it remains below the surface of the tracer fluid throughout the measurement period, otherwise, the tracer solution will not discharge at a constant rate. The spigot is fitted with a tubing connector and pipette tip with the end cut off.

The non-tapered end of the tubing connector fits snugly into the spout of the carboy, and the pipette tip is slid over the tapered end of the connector. It is important that the outflow be a continuous stream rather than discrete drips. If the water drips out, air will enter and create an inconsistent outflow rate.

The Mariotte bottle is set up on a square of plywood fixed to the top of a tripod, to provide a stable base for the bottle. When the spigot is first opened, the injection rate will be higher than the ultimate steady-state rate until air begins bubbling, detected by the distinctive “gurgling” sound that occurs every few seconds, through the air entry tube. Once “bubbling” begins, the injection rate will be constant. A bucket should be used to catch the injection solution until constant flow is established.

2.3 Field Sampling Program - Dye Injection

The effluent plume will be traced using Rhodamine WT, which is Environment Canada’s preferred dye tracer in plume delineation studies. It is non-toxic when handled with care and most environments typically have a near-zero background level. The WWTP effluent flows into Stinky Pond, and reaches the Flat River through a culvert underneath the mine road and then a ~20 m ditch (Figure 2).

The Rhodamine solution will be injected into the effluent stream as far upstream in the outlet channel as possible to achieve complete mixing before discharging into the Flat River, tentatively determined as the upstream end of the culvert at the mine road (Figure 2). The Rhodamine will be a visible as a pink plume as it enters the Flat River, and the plume will be initiated at a concentrations such that it dilutes below its visibility threshold of approximately 10 ppb once complete mixing in the Flat River is achieved (5:1).

The Rhodamine concentration in the Mariotte bottle will be known from the amount of dye mixed in the bottle. This concentration will be verified prior to injection using the field fluorometer. Additionally, the effluent stream will be measured above the confluence for at least 15 minutes once injection has been started to determine whether the dye injection and flow are both constant and that complete (or near-complete) mixing of the dye is occurring.

The required tracer quantity can be calculated as follows:

$$M = C_x \text{ x } q_{eff} \text{ x } T \text{ x } \%eff \text{ x } 3{,}600 \text{ sec/hour}$$

Where:

- M = amount of tracer required for the test (kg)
- C_x = tracer detection limit concentration ($1x10^{-8}$ kg/ℓ or 10 ppb – visibility threshold)
- q_{eff} = effluent flow rate (40 ℓ/sec – 3500 m^3/day from Wenck Associates Inc.)
- T = duration of the test (assume a maximum test duration of 6 hours)
- %eff = dilution limit of the plume in % effluent concentration (20%).

In this case, M = .17 kg. The injection rate (kg/hr) is obtained by dividing the amount of tracer required by the duration of the test (.028 kg/hr or approximately 8 mg/sec).

The concentration of the tracer in the injection mixture (typically 20% by weight) does not have to be considered in the calculation, since the detection limit is based on the diluted initial mixture. Should the standards be prepared by volume, the correct specific gravity of the tracer should be applied. The specific gravity of Rhodamine WT is in the range of 1.15 to 1.2, and typically 1.19.

This calculation will be repeated based on the effluent and Flat River discharges on the day of the test. The field study will be conducted at near minimum late summer/early fall flow when effluent dilution will be low relative to other times of the year, but ice cover will not be present which would complicate the study. For the Flat River, the study should take place in late summer or early fall. The study design assumes that the flows are low enough to safely traverse the river in chest waders.

2.4 Field Sampling Program - Dye Measurement

Once the dye injection system is operating and the dye concentration in the ditch just upstream of the Flat River is constant, the field plume delineation survey will begin. A YSI 6130 Rhodamine Sensor will be used to conduct the dye study. This fluorometer is specifically calibrated to detect Rhodamine WT, which absorbs light at one frequency and fluoresces at another. A site specific calibration will be conducted to account for any background concentration.

A series of closely-spaced cross sections near the confluence of the effluent ditch with the Flat River will be measured with the fluorometer to characterize both the horizontal and vertical variability of dye concentration near the confluence. The plume may be highly variable at this location so at least one duplicate cross-section will be completed downstream of the confluence. The river should also be flow-gauged at this location prior to the dye injection setup, and again during the plume delineation, and as well the flow from the WWTF and culvert will be recorded. The velocity profile of the river will aid in understanding mixing and the multiple flow gauging transects will confirm that the discharge of the river is stationary. Flow gauging will be completed with a wading rod, such as a Swoffer meter, and will provide information on the river bathymetry, velocity profiles, and discharge which will allow calculation of the maximum possible dilution. Complete vertical mixing occurs quickly in rivers compared to across-channel mixing. Once the initial vertical mixing is complete, as determined by the dye distribution, the plume continues to spread horizontally and can be measured at a single depth.

After the initial cross-sections are completed at the confluence, the dye concentration in the ditch will be measured once more to confirm that the inflowing concentration remains constant. Then, a series of cross-sections downstream of the confluence will be measured for dye concentration at a constant depth, as shown in Figure 2. The cross-section locations will be logged with a handheld GPS and staked for future reference. The Wenck Associates mixing study indicates that seven transects spaced 50 metres apart will be sufficient to measure the plume until it reaches complete mixing. Complete mixing will be determined when the dye concentration varies by less than 10% across the transect, and additional transects will be completed at 50-metre intervals as necessary. A confirmatory cross-section and flow measurement at the point of complete mixing will be conducted.

2.5 Analysis of Data

The field concentration data will be normalized to dilutions based on the effluent dye concentrations by dividing the initial effluent dye concentration by the field concentrations. The dilutions will be plotted and contoured on a map. This map will be compared with model results to validate the modelling study. The horizontal rate of diffusion will be calculated for this river flow level and compared with values available in the literature for streams and rivers of similar size and slope. The return period of the Flat River discharge during the field study will also be statistically evaluated to confirm that low-flow conditions were measured. The plume delineation study cannot be conducted during the exact same low-flow level as the modelling study, but the results should still be related. NATCL may also choose to refine the modelling study with the same flows as the field study.

3.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of North American Tungsten Corporation and their agents. EBA Engineering Consultants Ltd. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than North American Tungsten Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in EBA's Services Agreement. EBA's General Conditions are provided in Appendix A of this report.

4.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Sincerely,
EBA Engineering Consultants Ltd.

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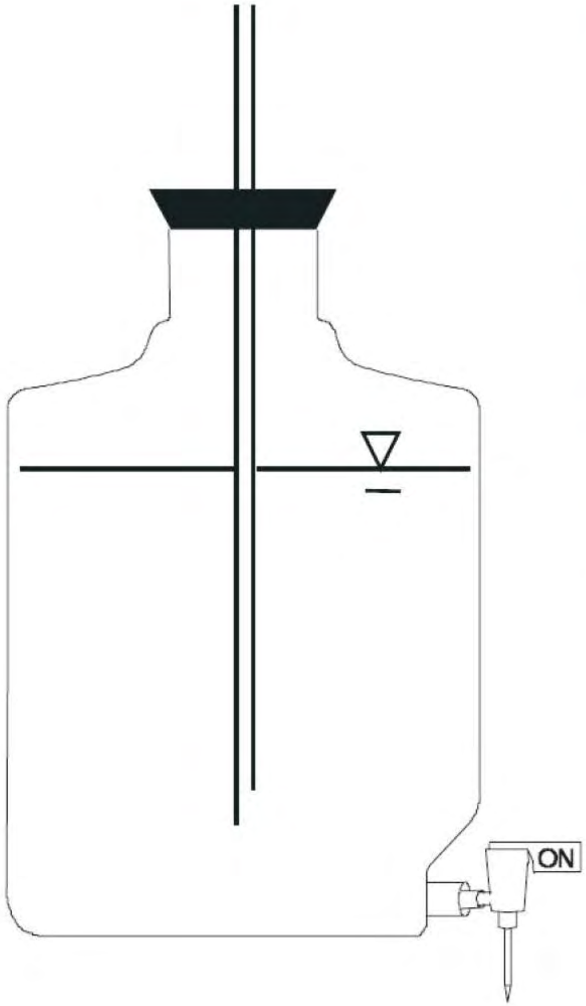
REFERENCES

Environment Canada (EC). 'Technical Guidance - How to Conduct Effluent Plume Delineation'. Revised.

Moore, R.D. 2004. 'Construction of a Mariotte Bottle for Constant-rate Tracer Injection into Small Streams'. Streamline Watershed Management Bulletin Vol. 8/No. 1 Fall 2004.

FIGURES



Mariotte Bottle Schematic

YSI 6600 Sonde with Fluorometer

Rhodamine Dye, ~500 PPB

NOTES

Mariotte Bottle Schematic from Moore, R.D. (2004) Construction of a Mariotte Bottle for Constant-rate Tracer Injection into Small Streams, Streamline Watershet Mgmt. 2004

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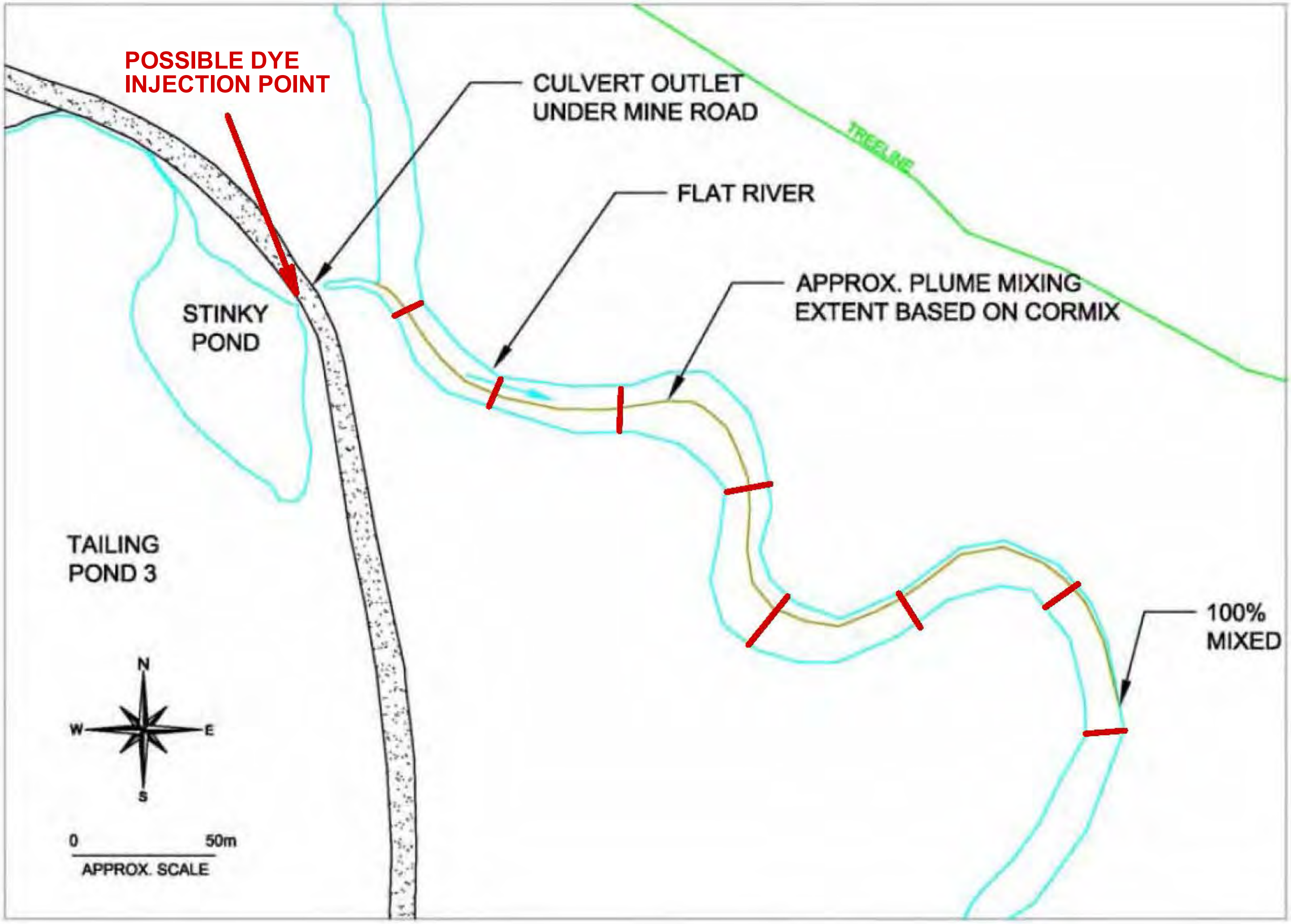
CANTUNG FLAT RIVER PLUME DELINEATION STUDY DESIGN

Mariotte Bottle Schematic and Dye Tracing Instrumentation

PROJECT NO.	DWN	CKD	APVD	REV
V15101062.700	JMR	TM	JAS	0

OFFICE	DATE
EBA-VANC	January 1, 2010

Figure 1



NOTES

Map adapted from Wenck Associates Inc. Mixing Zone Analysis August 16, 2012

Transect Location

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CANTUNG FLAT RIVER PLUME DELINEATION STUDY DESIGN

Schematic Map of Plume Delineation Study

PROJECT NO.	DWN	CKD	APVD	REV
V15101062.700	JMR	TM	JAS	0

OFFICE: EBA-VANC
DATE: January 1, 2010

Figure 2

APPENDIX A

EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

DESIGN REPORT

This Design Report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This Design Report pertains to a specific site, a specific development, and a specific scope of work. The Design Report may include plans, drawings, profiles and other support documents that collectively constitute the Design Report. The Report and all supporting documents are intended for the sole use of EBA’s Client. EBA does not accept any responsibility for the accuracy of any of the data, analyses or other contents of the Design Report when it is used or relied upon by any party other than EBA’s Client, unless authorized in writing by EBA. Any unauthorized use of the Design Report is at the sole risk of the user.

All reports, plans, and data generated by EBA during the performance of the work and other documents prepared by EBA are considered its professional work product and shall remain the copyright property of EBA.

2.0 ALTERNATIVE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. EBA’s instruments of professional service will be used only and exactly as submitted by EBA.

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless so stipulated in the Design Report, EBA was not retained to investigate, address or consider, and has not investigated, addressed or considered any environmental or regulatory issues associated with the project specific design.

4.0 CALCULATIONS AND DESIGNS

EBA has undertaken design calculations and has prepared project specific designs in accordance with terms of reference that were previously set out in consultation with, and agreement of, EBA’s client. These designs have been prepared to a standard that is consistent with industry practice. Notwithstanding, if any error or omission is detected by EBA’s Client or any party that is authorized to use the Design Report, the error or omission should be immediately drawn to the attention of EBA.

5.0 GEOTECHNICAL CONDITIONS

A Geotechnical Report is commonly the basis upon which the specific project design has been completed. It is incumbent upon EBA’s Client, and any other authorized party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the geotechnical information that was reasonably acquired to facilitate completion of the design.

If a Geotechnical Report was prepared for the project by EBA, it will be included in the Design Report. The Geotechnical Report contains General Conditions that should be read in conjunction with these General Conditions for the Design Report.

6.0 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.