TETRA TECH EBA

TECHNICAL MEMO

MV2005L2-0015

To:	Patrick Kramers, De Beers Canada Inc.	**Date:**	November 25, 2015
C:	Sarah McLean, De Beers Canada Inc.	**Memo No.:**	
From:	Bill Horne, Tetra Tech EBA Inc.	**File:**	E14103040-11.015
Subject:	Total Suspended Solids - Turbidity Relationship Technical Memo Gahcho Kué Project, NT, Canada		

1.0 INTRODUCTION

DeBeers Canada Inc. (DeBeers), has retained Tetra Tech EBA Inc. (Tetra Tech EBA) to provide a relationship between Total Suspended Solids (TSS) and Turbidity for use during the construction monitoring of the dykes at the Gahcho Kué Project situated in the Northwest Territories. The correlation was originally developed in October 2014 for Dyke A construction. Since that time additional data has been obtained during the construction of Dyke J, Dyke I, and the Mine Rock Causeway. The correlation has been updated taking into account the additional site data.

2.0 METHODS

Due to the site-specific nature of TSS-turbidity relationships, it is necessary to obtain a unique relationship between TSS and turbidity specific to the waterbody and sediment in question. A site visit to the Gahcho Kue project on October 3, 2014 was conducted by Tetra Tech EBA environment staff to obtain appropriate sediment and water samples to develop the TSS-turbidity relationship. Water from the proposed Dyke A location was collected in one pail and sediment and crushed rock was collected in another. The sediment and the crushed rock from in and around the proposed Dyke A location are expected to be the materials potentially released into the waterbody during dyke construction and thus, the original TSS-turbidity relationship was established using these materials.

The 2014 sampling program was based on 20 samples obtained by combining the water and sediment to produce turbidity values over a range of levels. A sample of background conditions (no additional sediment added) was also collected.

Turbidity values were measured in the field using an Oakton turbidity meter for each sample location and the bottles were sent to ALS Environmental Laboratory in Yellowknife for their corresponding TSS analysis.

TSS levels were analyzed by ALS using procedures adapted from the American Public Health Association (APHA) Method 2540 “Solids”. TSS was measured in milligrams/litre and was determined by a system of filtering water through glass fibre filters and drying the sediment sample at 104°C.

During the construction of Dykes I, J, and the Mine Rock Causeway, De Beers site personnel were measuring turbidity with a YSI Exo 1 multi-parameter water quality meter, with turbidity probe and collecting TSS samples for submittal to an offsite laboratory. The samples were collected nearby the active construction areas according the constructive management plans.

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3.0 RESULTS

Turbidity and the corresponding TSS values from the 2014 program are presented in Table 1 and Figures 1 and 2. Turbidity values ranged from 0.92 to 300 NTU with TSS values ranging from 3 to 449 mg/L.

The turbidity and corresponding TSS values obtained during the 2015 dyke construction season are presented in Table 2 and Figures 1 and 2. The 2015 samples had a much smaller range of turbidity and TSS than the 2014 samples. The turbidity ranged from 0.4 to 37 NTU and TSS ranged from 1.0 to 63 mg/L.

Table 1: TSS-Turbidity Values – 2014 Data

Sample ID	Turbidity (NTU)	TSS (mg/L)
TSS-1	0.93	3
TSS-2	10.81	41.8
TSS-3	8.12	16.8
TSS-4	7.53	11.5
TSS-5	24.87	44.9
TSS-6	15.93	23.3
TSS-7	23.97	39.9
TSS-8	44.73	73.3
TSS-9	49.3	71.7
TSS-10	66.9	92
TSS-11	82.3	128
TSS-12	98.3	159
TSS-13	112	222
TSS-14	150	250
TSS-15	130	192
TSS-16	219	449
TSS-17	176	290
TSS-18	192	268
TSS-19	264	398
TSS-20	300	394

Table 2: TSS-Turbidity Values – 2015 Data

Sample Location	Turbidity (NTU)	TSS (mg/L)
WSS05	4.0	3.1
WSS05	2.7	2.5
WSS05	3.8	2.3
WSS05	2.7	2.1
WSS05	0.8	1
WSS05	0.7	1.1
WSS05	1.0	1.7
WSS06A	2.0	2.1
WSS06A	3.5	3.1
WSS06A	48.13	27.3
WSS06A	7.0	5.6
WSS06A	0.4	1.3
WSS06A	0.4	1.1
WSS06A	0.4	1.4
WSS06A	0.4	1.4
WSS06A	0.5	1.7
WSS06A	0.4	1.3
WSS06A	0.7	1.8
WSS06A	0.5	1.4
WSS06A	1.1	1.3
WSS06A	0.6	1.4
WSS06A	0.5	1.3
WSS06A	0.9	2.2
WSS06A	1.0	1.8
WSS06A	7.8	18.4
WSS06A	6.6	7.4
WSS04	4.0	4.8
WSS04	2.1	2.4
WSS04	0.5	1.1
WSS04	0.4	1.1
WSS04	5.2	3.4
WSS04	1.2	1
WSS04	1.8	1.6
WSS04	7.9	4
WSS04	6.1	3.8
WSS04	5.7	3.3
WSS04	2.1	2.1

Table 2: TSS-Turbidity Values – 2015 Data

Sample Location	Turbidity (NTU)	TSS (mg/L)
WSS04	2.7	2
WSS04	1.3	1.7
WSS04	0.7	1.1
WSS04	0.5	1.2
WSS04	0.5	1.1
WSS04	1.6	1.2
WSS04	1.0	1
WSS04	1.1	1.2
WSS04	0.9	1.3
WSS04	1.2	2
WSS04	0.6	2.3
WSS04	0.7	1.6
WSS04	0.7	1.1
WSS04	1.0	1.7
WSS04	0.7	1.4
WSS08	0.8	1.2
WSS08	7.4	4.8
WSS08	2.7	2.9
WSS08	3.0	3.7
WSS08	0.7	1.6
WSS08	2.8	2.6
WSS08	1.5	1.2
WSS08	0.7	7.1
WSS08	8.6	7.9
WSS12	1.8	4.2
WSS12	0.9	1.4
WSS12	2.1	2.2
WSS12	0.4	1.2
WSS12	0.4	1.2
WSS12	0.4	1.3
WSS12	0.4	1.2
WSS12	0.4	1.3
WSS12	0.4	1.1
WSS12	1.3	2
WSS12	0.7	1.2
WSS12	3.4	4.2
WSS13	1.4	1.7

Table 2: TSS-Turbidity Values – 2015 Data

Sample Location	Turbidity (NTU)	TSS (mg/L)
WSS13	25.9	19.2
WSS13	32.0	62.9
WSS13	12.0	10.6
WSS13	4.2	3.4

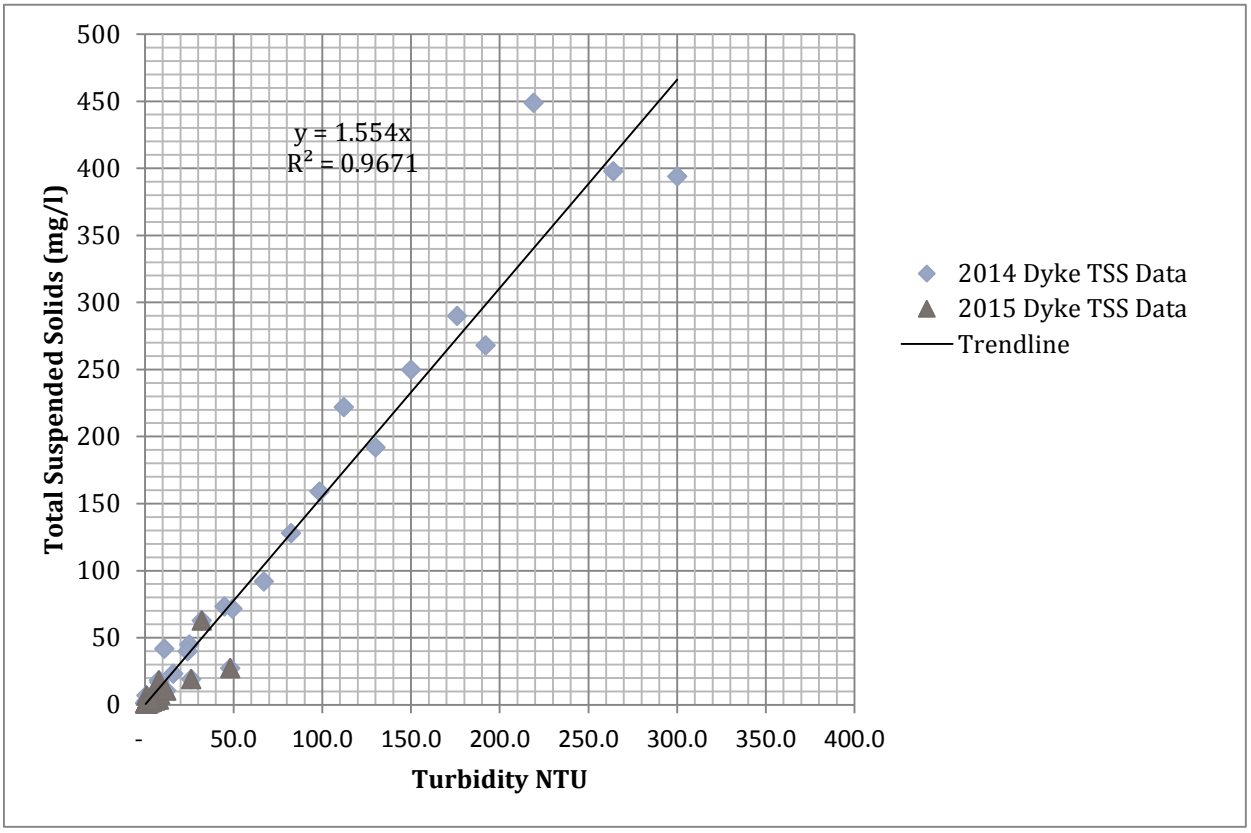


Figure 1: TSS-Turbidity Linear Relationship (all data)

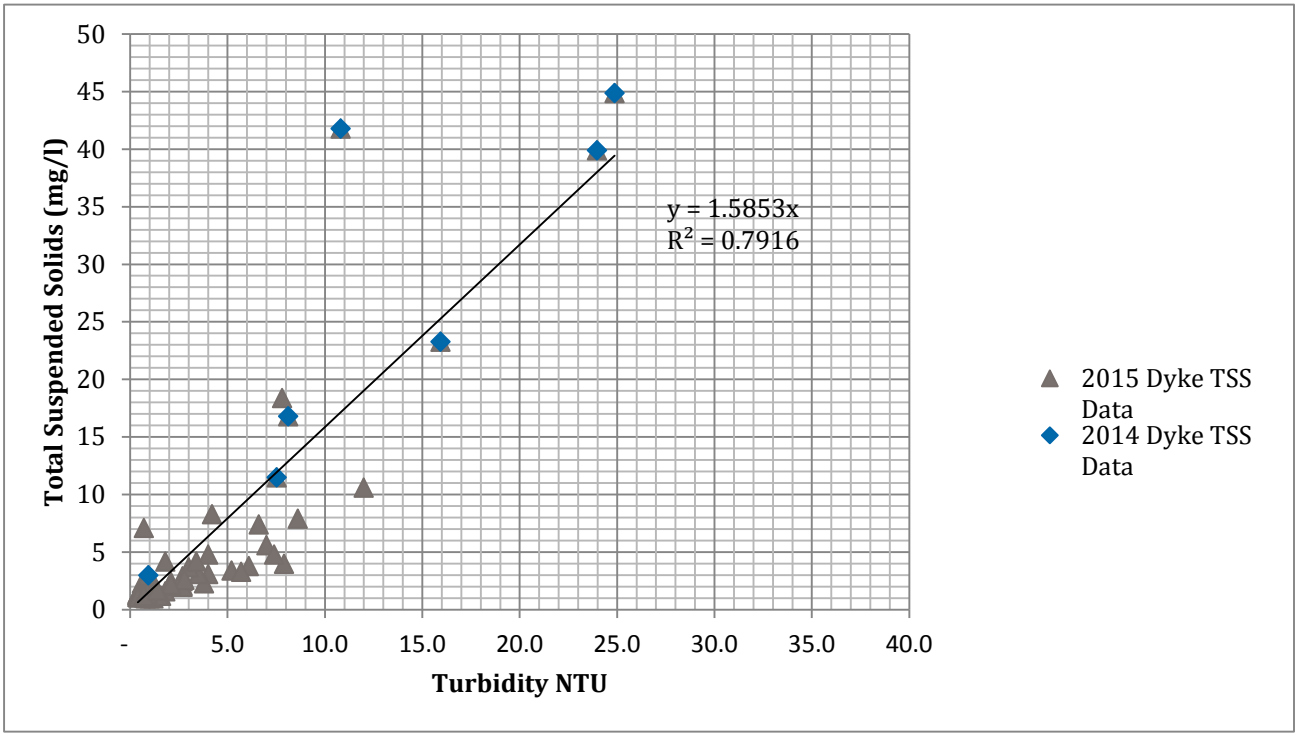


Figure 2: TSS-Turbidity Linear Relationship (<25 NTU)

4.0 DISCUSSION

Turbidity was obtained across a wide range of values because the amount of sediment entering the waterbody from construction activity cannot be predicted. Some variation between the samples obtained and the linear relationship is expected and may be a result of large sediment particles not influencing turbidity values, but still contributing to TSS values. Overall, the linear relationship between TSS and turbidity indicates a good correlation. The relationship is similar over the large range (Figure 1) and small range (<25 NTU) (Figure 2). It is recommended that the correlation be applied as:

TSS = 1.55 * NTU

The correlation above is very similar to that developed in 2014. In the range of 7 to 15 NTU, the estimated TSS is within 1 mg/l of the previous correlation. The TSS values measured in the 2015 construction season generally fall below the new correlation. This provides a conservatively high estimate of the TSS from the turbidity measurements.

The correlation will be updated as the project proceeds, using the additional data collected throughout the construction period.

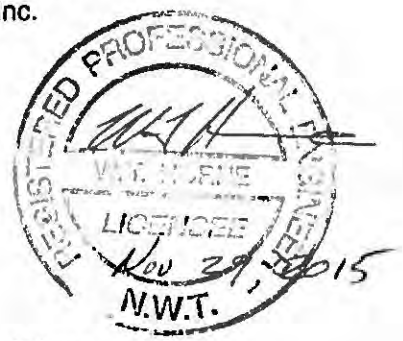
The 2014 calibration was developed with an Oakton T-100 Turbidity Gage. The 2015 turbidity samples were obtained with a YSI Exo 1 multi-parameter water quality meter with turbidity probe.

The turbidity meter should be calibrated on a monthly basis using standards provided by the turbidity gage manufacturer.

5.0 CLOSURE

We trust this memo meets your present requirements. Should you have any questions or comments, please contact the undersigned at your convenience.

Respectfully submitted,
Tetra Tech EBA Inc.



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PERMIT TO PRACTICE
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Signature _____
Date November 29, 2015
PERMIT NUMBER: P245
The Association of Professional Engineers and Geoscientists of Alberta

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Attachments: Appendix A: Tetra Tech EBA's General Conditions

APPENDIX A
TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

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

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of Tetra Tech EBA’s Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Tetra Tech EBA’s Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech 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 Tetra Tech EBA shall be deemed to be the original for the Project.

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

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech 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 stipulated in the report, Tetra Tech EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. Tetra Tech EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of testholes and/or soil/rock exposures. Stratigraphy is known only at the locations of the testhole or exposure. Actual geology and stratigraphy between testholes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. Tetra Tech EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

7.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

11.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

13.0 SAMPLES

Tetra Tech EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

14.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

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