PHOENIX ENGINEERING LTD

To : Canadian Natural Resources Ltd
Attention : Howard Keele
Conveyed : e-mail November 9th 2015
Re: Disposal of FFT at CNRL

Dear Mr Keele,

Our response to your Request For Proposal "to get rid of 20 million dry tonnes of fines in a 30 % solids solution by injecting it into other tailings deposits" is attached hereto as a PDF binder entitled "Proposal to CNRL".

Should you have any questions you may reach me directly at: wehodge@shaw.ca

Yours sincerely,

William E Hodge

The attached PDF Binders contain the following:

Text of Response

Figures

Earlier Correspondence
- WEH to COSIA June 16th 2015
- WEH to COSIA July 30th 2015

WebPages Cited
- Trident Unit
- Strata Mixer.

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Attention : Howard Keele
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Re: Disposal of FFT at CNRL

This is our response to your Request For Proposal [hereinafter "RFP"] from Phoenix Engineering Ltd [hereinafter "PEL"] to "to get rid of 20 million dry tonnes of fines in a 30 % solids solution by injecting it into other tailings deposits." That request was conveyed in an e-mail from Howard Keele dated October 8th 2015.

PREAMBLE

Because the method and means by which we intend to pursue a solution to this unique problem have not been employed anywhere before we feel it is in the best interests of all concerned to tackle this matter in stages, rather than as a single commitment. In this way the knowledge gained during each stage can be used either to direct the way forward, or, to reassess the prospects of success.

SCOPE

In this spirit we suggest the following stages:

Stage 1: Collection & Assessment of Available Data

a. A site visit by PEL is a prerequisite in order to get a down-to-earth appreciation of the magnitude/geometry of the undertaking, and to get a hands-on feel for the materials involved. Of course this would best be done before the snow flies &/or freeze-up, nevertheless, in order to move the project forward, a visit under winter conditions would be of some use: This, would need to be supplemented later by a summer visit.

b. We understand from COSIA that the University of Alberta is the repository of the technical data related to the disposal of Canadian Oil Sands' tailing. PEL should visit this institution and become acquainted with that data.

c. Interview well established research institutions such as the Hydraulics Laboratory at NRC, Ottawa and its equivalents to select a working partner for the next stage.

d. Building a team for the successful completion of the whole project is something that has been substantially accomplished already.

Stage 2: Laboratory & 2-Dimensional Model Test

a. At the selected laboratory, using an apparatus custom designed by PEL of the type sketched in Figure 1, perform 1-dimensional tests to determine the Drag Coefficients appropriate to flow of FFT through the coarse tailings. In addition PEL would determine the hydrodynamic affects on flow rates of various gradients and ambient temperatures. Furthermore, we would explore the possible physiochemical advantage that might accrue from cathion exchange.

b. At the selected laboratory, using an apparatus custom designed by PEL of the type sketched in Figure 2, perform 2-dimensional model tests so that the rate at which the FFT permeates the coarser tailing by transfusion can be watched through the transparent sides. Other than, we hope, witnessing the process of infusion in action, the influence of the lateral drainage on the shape of the FFT plume can be examined. Also, by assiduous placement and monitoring of piezometer throughout the model, and by watching the stability of the surface grains we may come to decide the optimum ratio of injection pressure to drainage suction.

It is important to note that the above tests involve full-scale modelling of the two material sizes involved, and consequently, there will be no need to manipulate the results with "modelling factors". It's a simple case of "what you see is what you get."

c. On the basis of this work it will be possible for PEL to decide which of its two machines, the Trident Unit or the Strata Mixer, should be taken into the next stage. The Trident Unit is sketched in Figure 3 and its functionality is explained on our website page: http://www.phoenix-hodge.com/trident.html. Similarly, the Strata Mixer is shown as a sketch on Figure 4 and its attributes are explained at: http://www.phoenix-hodge.com/stratum%20mixer.html. PDFs of both these web pages are attached for ease of reference.

The sketches for both machines depict deployment over water/fluid, this being the more difficult task; deployment on dry land by means of a tractor-mounted rig is illustrated on the Trident Unit web page.

Stage 3: Field Test of the Phoenix™ Hardware

a. An instance of the chosen machine would be designed by PEL. This prototype would be full-sized, but would be a stripped-down (minimal) version, and be comprised of some elements which were field adjustable.

b. A machine shop would be selected by PEL to make shop-drawings from the PEL design drawings.

c. Following discussions, that, or another machine shop would be given the task of building and bench-testing the prototype.

d. The prototype would be shipped to the mine site.

e. A geotechnical contractor would be selected by PEL to carry out a program of field trials at locations within the tailings pond. This work would involve the contractor moving the prototype to various locations, both on dry ground and afloat, then activating the machine so as to inject FFT into the interstices between the grains of coarse tailings.

f. The performance of the prototype would be monitored and recorded by an independent geotechnical consulting firm chosen by CNRL. PEL would have full access to those records.

Stage 4: Disposal of FFT

Pending successful testing, PEL would manage the disposal of the FFT. PEL would provide CNRL with the Technical Specification section to be used in the Bidding/Tender documents to be offered by PEL to selected Geotechnical contractors for the implementation of the Work.

SCHEDULE

We believe the following schedule is attainable for testing and evaluation:

Stage 1: start November 23rd 2015, finish January 15th 2016.

Stage 2: start January 18th 2016, finish July 15th 2016.

Stage 3: start July 18th 2016, finish December 23rd 2016.

BUDGET

Because of the nature of this project it is only possible to provide a budget estimate for one Stage at a time.

Stage 1 anticipated costs:

Hodge fees (200 hours @ $375/hr)	$ 75,000
Subcontractors	$ 7,500
Flights (from YVR to YMM*2, YOW, YEG)	$ 5,000
Travel expenses (10 days @ $350/day)	$ 3,500
Contingency allowance*	$ 31,850
Total estimate	$122,850

* As befits a project of such novelty we have increased by 35% the identifiable costs in order to cover unforeseeable necessary spending.

On the basis of this computation it is advised/appropriate that a budget allocation of $125,000 for Stage 1 be secured before advancing further.

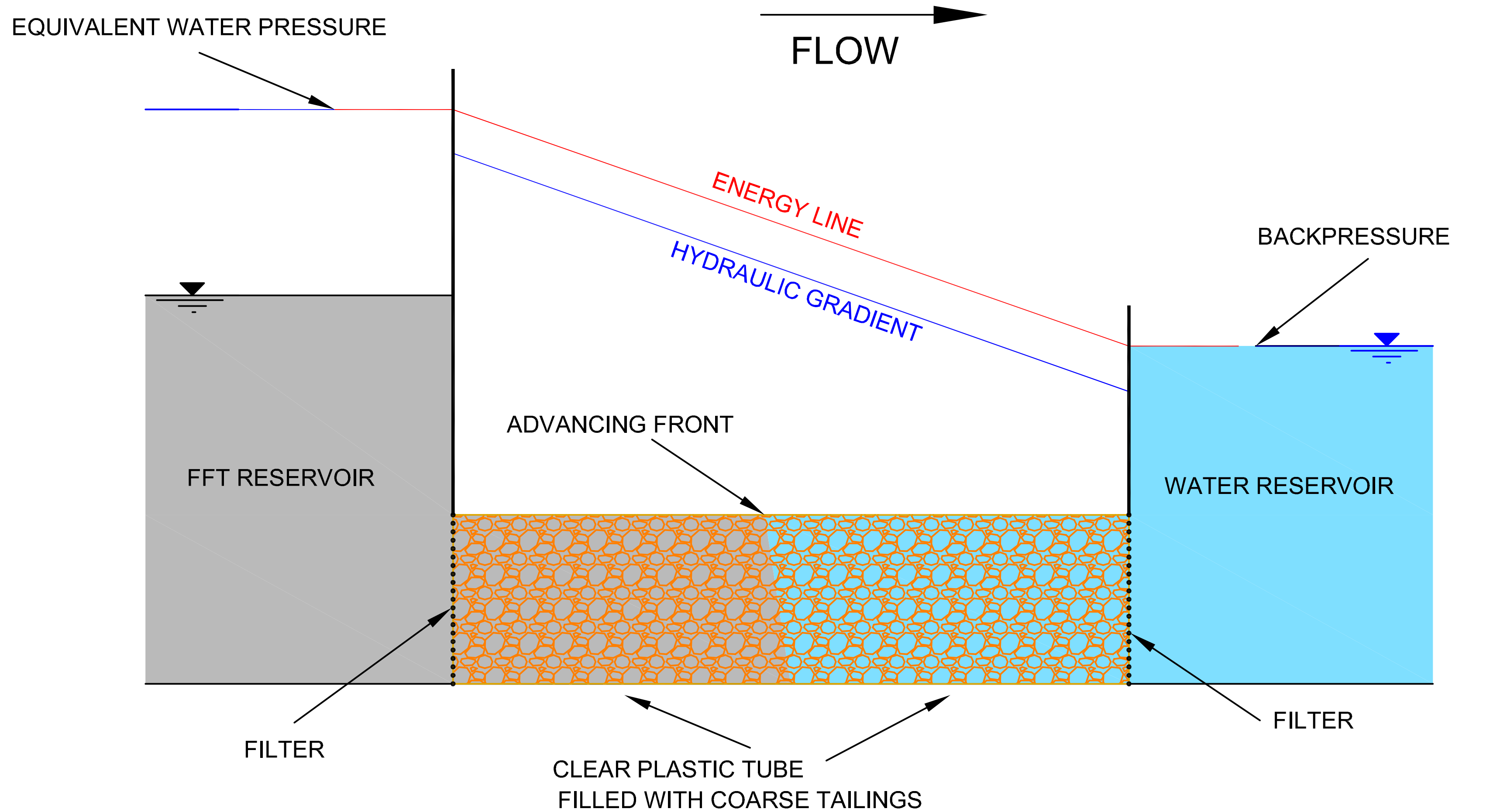
CONCLUSION

Should CNRL conclude that PEL's proposed solution to the FFT problem was viable, PEL will pursue the task of "get rid of 20 million dry tonnes of fines in a 30 % solids solution by injecting it into other tailings deposits" by the manner and means outlined herein. To accomplish this, PEL would design and build one or more machines and select a geotechnical contractor to whom these machines would be leased for the specific purpose of doing this Work.

This response to your RFP has been prepared for PEL by William E Hodge.

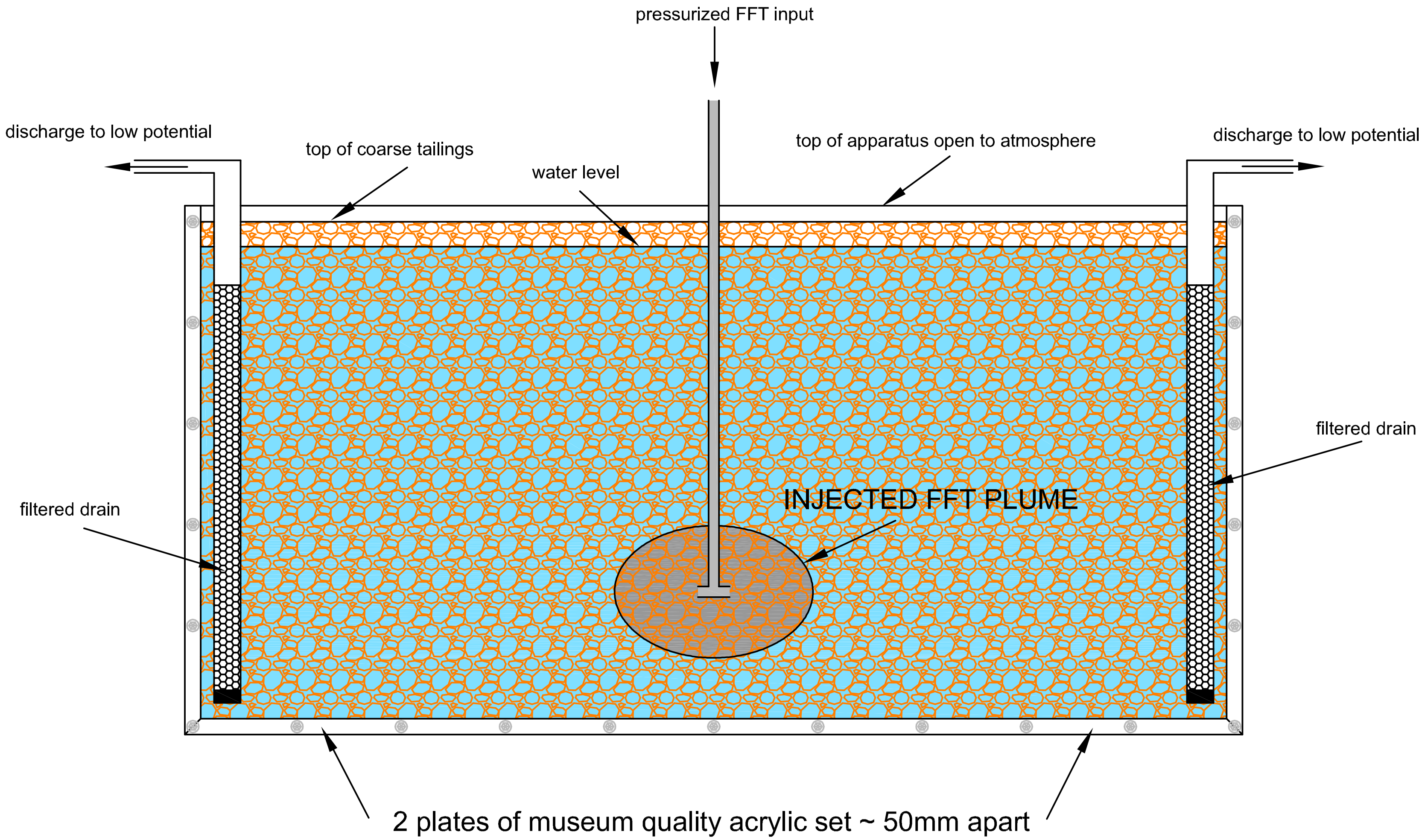
Original signed by: William E Hodge

Dated: November 9th 2015



1 - Dimensional Model

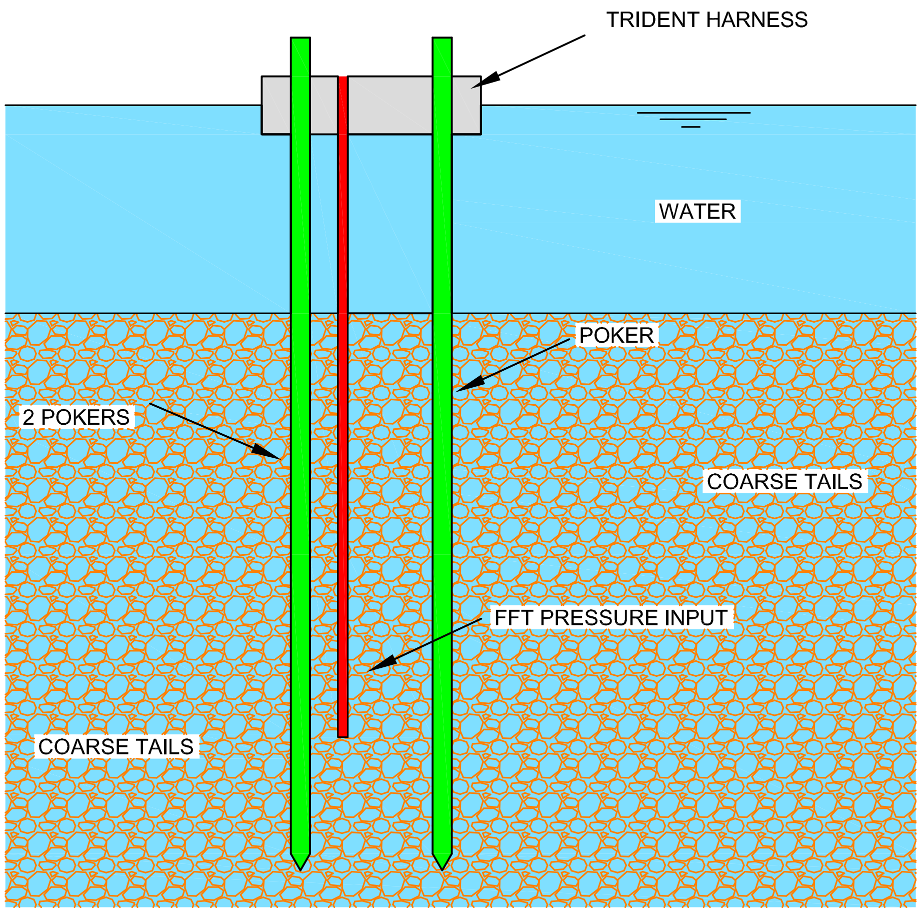
Figure 1

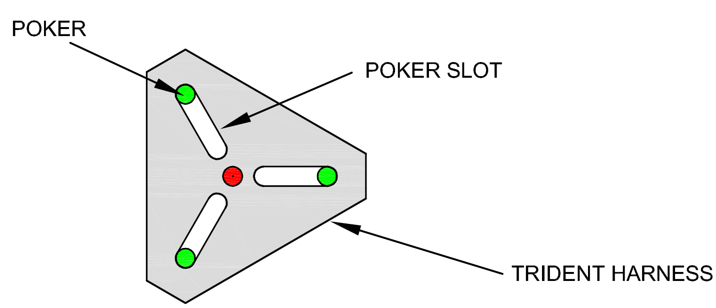


2 - Dimensional Model

Figure 2

POKERS CONTAIN SELECTED PHOENIX™ MODULES

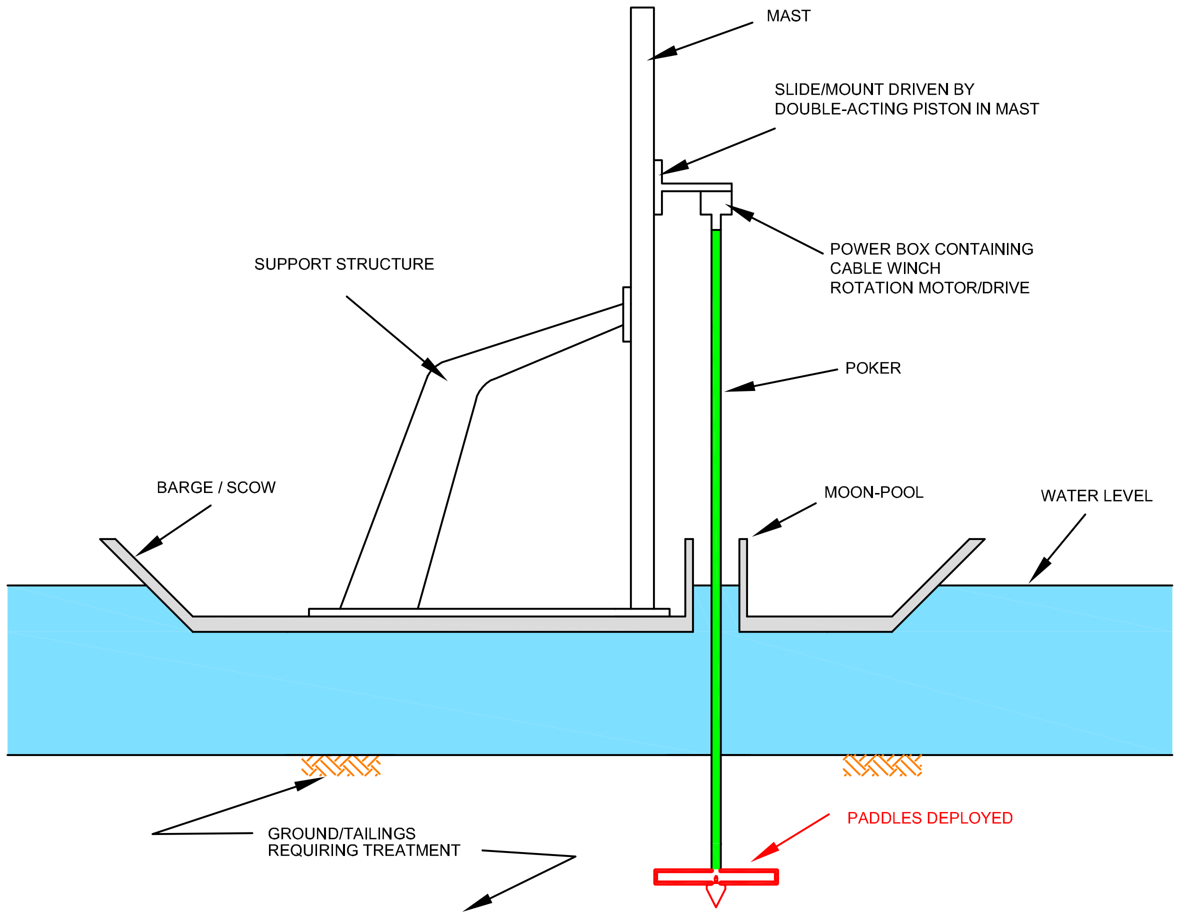


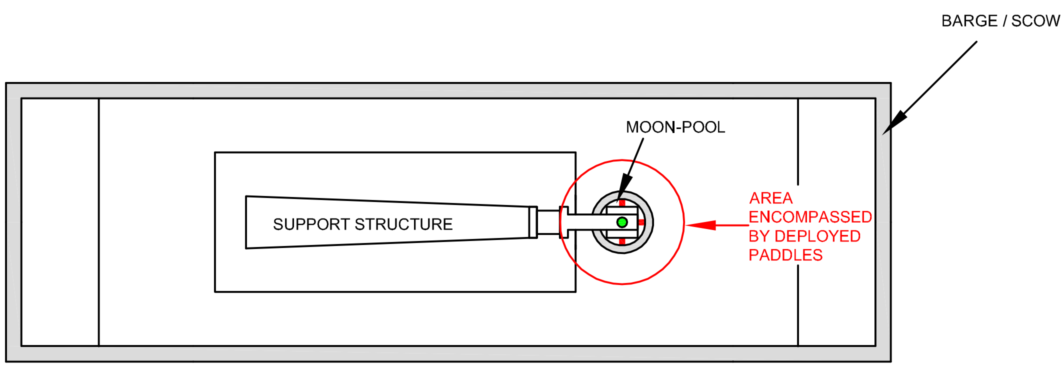


PLAN VIEW OF ABOVE ELEVATION

Trident Unit

Figure 3





PLAN VIEW OF ABOVE ELEVATION

Strata Mixer

Figure 4

Brian, please forward these notes to you contacts at COSIA

COSIA and Phoenix Engineering Ltd (PEL)

I write this as a response to Jonathan Matthews' e-mail communication with Brian Couch on June 3rd 2015.

PEL's use of the Phoenix™ Machine (PM) heretofore has been to increase the strength of sands &/or silts; the attendant volume reduction being of little interest other than suggesting the lateral extent of the area affected by the densification. In consequence, good/reliable determination of ground settlements were not recorded. Theoretically, when a granular material of uniform gradation is brought from minimum to maximum density, the reduction in volume is 29%.

For Gulf's Molikpaq structure we used our patented hydrodynamic compactor, which we refer to as the "Phoenix™ Machine". Its performance capability demonstrated beneath this steel platform may be seen from the CPT traces shown at our webpage http://www.phoenix-hodge.com/Molikpaq.html
Soil strength increases with soil density increase, that is, with volume-reduction. The evidence of having attained such extremely high strengths at Molikpaq is indicative that the Phoenix™ hardware actually reduced the volume of those sands to the extreme lower limit physically possible. I am not aware of any other GI contractor who can make such a claim.

Incidentally, at this high state of density a tailings mass is as strong as it can get and forms a highly competent foundation stratum for any structure; consequently, this concomitant attribute to minimum volume, makes "upstream construction" of tailings dam lifts entirely viable and assuredly safe.

Photo 1 shows cylindrical depressions in the fine (95%<#200) gold mine tailing at Blackdome. These holes indicate volume contractions of about 30%.

Photo 2 is of the test pad at the Myra Falls (MF) mine. Because of the soupy consistency of these tailings it was necessary to construct a trafficable earthfill underlain by geogrid (geotextile mat). In consequence, the settlements attending PM insertions were ameliorated by the tensile strength of the mat and showed up as a dish-shaped concave depression. Because open voids were noticed beneath the geogrid any attempt at determining the volume-reduction per PM axis would have been a crude underestimation of benefits.

Had I known beforehand the clay/silt nature of the materials to be treated at MF I would not have attempted to undertake this field trial; I had been shown samples of medium to coarse sand sizes. As it turned out in the end backing out would have been a shame – I learned a lot there, but not until a long time later.

In an attempt to try and explain to myself the physics behind volume-reduction of a clay/silt material by lateral vibrations I started writing a monograph (so as to insist on logical argument). That little book is reproduced at http://www.phoenix-hodge.com/monograph.html

That in turn lead me to develop a fresh appreciation of how geotechnical materials actually behave. My new hydrodynamic hypothesis can be found at http://www.phoenix-hodge.com/GN%20SIX.html

Because of its serious implications to Civil Engineering this hypothesis is just now been examined by ASCE.

This is also how/why the Strata Mixer concept occurred to me. Now I realize that the volume-reduction achieved at Myra Falls would have been more easily and effectively attained by the Strata Mixer rather than the hydrodynamic compactive action/energy of the PM. And this is why I believe it could be adapted for use at the mines COSIA is engaged in helping.

The fact of the matter is that I cannot offer you reliable values for volume-reduction attainable using Phoenix™ hardware without first undertaking field trials in the particular material shape and state of your tailings deposits. However, on the basis of what I have witnessed elsewhere I believe it is reasonable to expect volume-reductions of about 20% to 25% using the PM, and about 25% to 35% using the Strata Mixer (SM). There is reasonable evidence for the former; the latter is merely my best intuition.

With regard to using the SM for "losing" the FFT (fluid fine tailings) within the water-filled voids of the coarse tailings, all that may be said at this time is that within each 1m^3 of loose tailings there is room (theoretically) to store about ½m^3 of FFT, and that is without any increase in the original 1m^3 volume. During this injection (ingestion) process 500 litres the pre-existing void water could be recovered for reuse. The last time I was on-site (designing the triangular d/s dam drainage system for Syncrude) I got a good feel for the coarse tails but was not aware of the FFT, so I really shouldn't speculate further in that regard.

And in order to provide the client with the factual basis for rational economical choices a field trial of hardware performance working in/on their particular tailings is unavoidable.

If I were asked to suggest a viable approach to dealing with the ever-increasing expanse of the Oil Sands' tailings I would think in terms of using our technology and hardware, and setting a goal whereby daily volume-reduction of old tailings would exceed the rate at which new tailings were being discharged into the ponds. To accomplish this, we first need to find out what the PM spacing, and its withdrawal rate, should be at each treatment axes required to attain the optimum level of compaction. From this we can figure out the number of PM units working 24/7 needed to keep ahead of the incoming tailings flow.

The volume reduction will be greatest where the current density of the tailings is lowest, if that current density is high, further densification will/can yield little benefit. What is necessary is to seek out areas of minimum density so that any work done will yield the highest return on energy investment.

We have at our disposal all the proprietary modules needed to fine tune a custom designed machine to optimise the tailings response to match the priority desires of the mining people. It should be noted that while it is within our capability to achieve extreme densification (volume-reduction) the mine's needs may be attainable at less ambitious levels of effort: higher densities come at a cost of time and work/energy.

I expect the PM/SM and it's carrier can be robotized to work 24/7, with performance data transmitted to remote computers to allow pre-assigned task to be monitored and assessed, and overridden if advantageous. It is likely that after the operation became routine the mine tailings management staff could take over this task itself.

Volume reduction &/or fluid absorption benefits are immediate and require no maintenance to persist.

Any "projected costs for delivery of a prototype for field deployment to assess feasibility in targeted Oil Sands applications" needs to wait until after a PEL site visit and examination of the documents available at U of A by myself.

I hope these notes will be helpful in your deliberations.

William E Hodge
Phoenix Engineering Ltd
owner

June 16th 2015

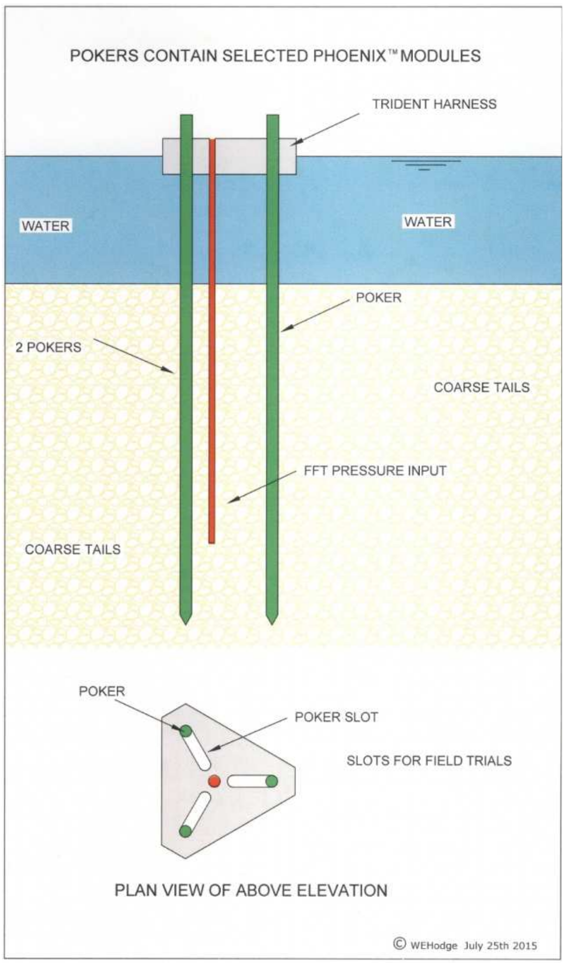
Photos on following two pages.

Photo 1 - Black Dome cylindrical-shaped settlements

Photo 2 - Myra Falls dish-shaped concave general settlement

Phoenix™ Ideas for solving the Oil Sands' FFT problem

The sketch below shows an embodiment of our Trident Unit (US Patent 8,419,316) convenient to this occasion.



The following is how we envision our ground improvement tool being used for this specific task:

With the pokers and pressure input pipe in their withdrawn positions, the buoyant Trident harness would be floated over a location selected for being underlain by coarse tailings in a loose state. The pokers and pressure pipe would then be deployed to a predetermined depth.

The pokers would be activated as drains and remain extended while the pressure pipe would extrude FFT into the surrounding coarse tails. The discharge level of the pressure pipe would be withdrawn at a specified rate till it approached the surface of the tails.

It is very important to keep in mind that introducing high pressure at a point within a tailings pond, where the surrounding slope is only marginally stable, could trigger a regional slope failure. In this proposal that fear is eliminated because such a pressure point is safely encompassed within a drainage system (pokers) which can easily overpower it. So, at no time would this process endanger surrounding tailings slopes.

Following the FFT extrusion process, and the removal of the pressure pipe, the vibratory modules of the pokers would be activated while they were being gradually withdrawn. The increase in soil-structure compaction of the coarse tails thereby attained would result in bringing the pressure of those solid particles to bear on the FFT within the former voids of the host material. Any prospect of promoting consolidation of the entrained FFT would thereby have been given an opportunity to help.

This two-staged process is designed to have two separate & complimentary beneficial affects:

1. Getting rid of the FFT, essentially just by putting it back again where it came from . . .

2. Recovering the water entombed in the voids of the coarse tailings.

William E. Hodge
July 30th 2015