APPENDIX B

Preliminary CDF Geotechnical Assessment

DREDGEATE ASSESSMENT
PEV Bulk Materials Handling Facility
Sydney Harbour, Nova Scotia

Stantec

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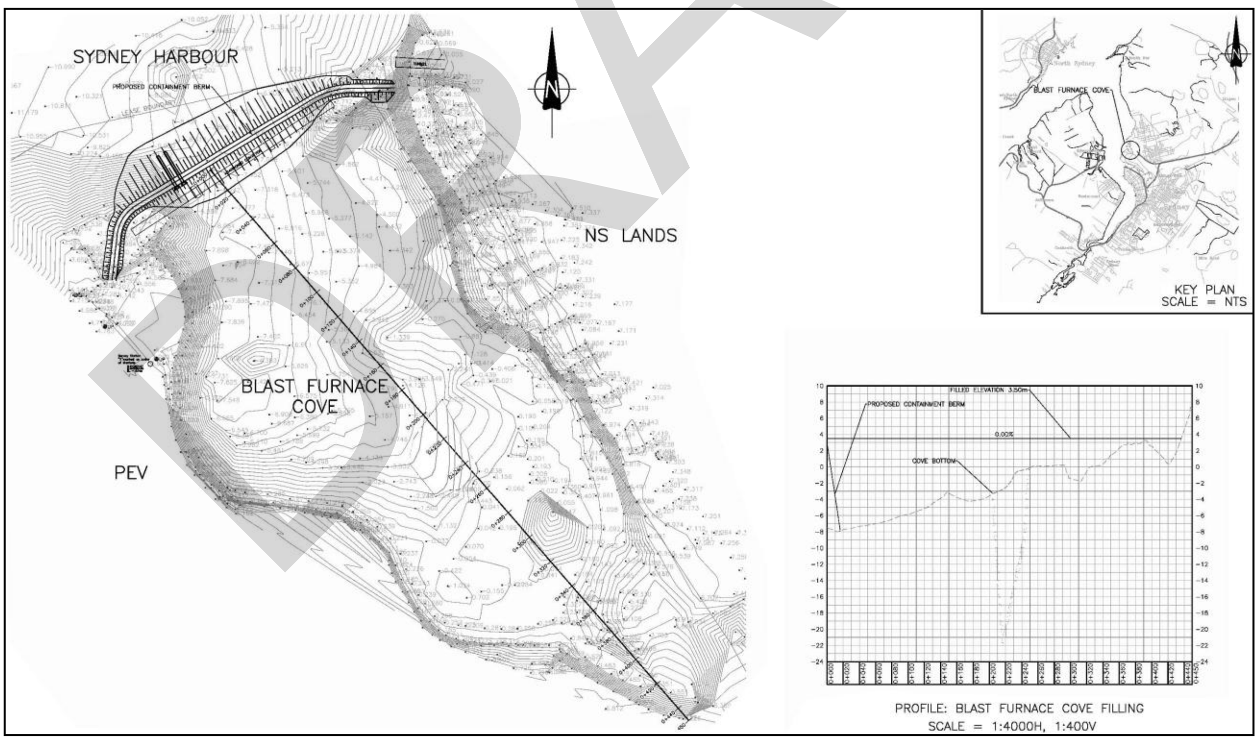
1.0 Introduction

Stantec Consulting Ltd., acting at the request of Mr. Richard Morykot of CBCL Limited, has carried out an assessment of the dredgeate disposal for Provincial Energy Ventures Ltd. The purpose of the work was to review the material properties of the dredgeate to be disposed, describe its likely behavior and provide a discussion on how the site could be developed into a storage area for bulk materials such as mine ores of various types.

The project will consist of extending the newly dredged channel to the PEV current bulk materials handling facility in Sydney Harbour. This project will consist of the removal of 150,000 to 200,000 m^3 of insitu material. At this time it is anticipated that a cutter suction type dredge or a clam would be used. The dredged material is to be disposed of in Blast Furnace Cove. The cove will be developed into a containment area by constructing a berm at the mouth of the cove and around the sides where the current grades are below about el. 4 m. The following Figure 1.1 shows the location of the cove within Sydney Harbour and the proposed containment berms.

FIGURE 1.1 Plan View



2.0 Dredgeate Material and behavior

2.1 DREDGEATE MATERIAL

The following discussion deals with the geotechnical aspects of the materials to be dredged and not the chemical quality or any environmental issues related to the dredgeate.

Stantec Consulting Ltd. (previously Jacques Whitford) has conducted numerous geotechnical investigations in and around Sydney Harbour including work for the recently completed channel dredging project. Based on our in-house information, it is anticipated that the material to be dredged will consist predominantly of organic silt. The organic silt insitu has a very low strength as it has been deposited by settling from the water column to the harbor bottom. The organic silt is comprised of a mixture of sand, silt and clay size particles, as well as a significant organic content. The type of deposition and the constituents give the material a very high natural moisture content and corresponding high compressibility characteristics.

The organic silt, as noted above, has a relatively low undrained strength typically in the order of 5 to 15 kPa. When disturbed from the dredging process, the material will lose most of this strength, depending on the type of dredging carried out.

If suction dredging is used, the material is made into a slurry with no appreciable shear strength. If clammed and dumped, the undrained shear strength would reduce to less than 5 kPa. The strength characteristics and compressibility control the behavior of the material under various loading scenarios. Compressibility is the settlement (consolidation) behavior of the organic silt from applied loads.

For the following discussion on the behavior of the silt, we have selected the following consolidation parameters based on previous work carried out on the organic silt:

Compression Ratio $\frac{C_c}{1+e_o}$	0.19
Time Rate of Consolidation C_v	0.00025 cm^2/s
Coefficient of Secondary Compression $C\alpha$	0.045
Ratio of Undrained Shear Strength to Overburden Pressure $\frac{C_u}{P_o}$	0.3

2.2 DREDGEATE BEHAVIOR

For this discussion, it is assumed that the organic silt will be pumped into the disposal area as a slurry, which may extend above the water level in some areas of the cove and remain below the water level in other areas. The behavior of the near surface material will be affected significantly if it is allowed to undergo some drying, little affect will occur from drying below about 0.5 m from the surface.

When the material is initially pumped into the cove as a slurry, the organic silt will begin to settle and deposit as a semi-solid material, which slowly gains strength as the deposit gets thicker and the unit weight of the material increases as water is released from consolidation (settlement) of the organic silt. The gain in undrained shear strength is a function of time and the unit weight of the material. When unaffected by drying conditions, the undrained shear strength will be zero at the surface of the silt and increase by about 1 to 2 kPa/m of depth when the silt is fully consolidated. As an example, for a 10 m thick layer of silt, the strength will increase from zero at the surface to about 12 kPa at 10 m deep.

There is a significant time component involved with consolidation of the silt and corresponding strength gain. For 90% consolidation to occur, it will take the following approximate times for various layer thicknesses.

Thickness of Organic Silt Layer (m)	Time at U = 90% (years)
1	0.3
2	1.1
5	6.7
10	26.6

As shown, the thickness of the silt has a significant effect on the time it takes to consolidate and gain strength. This becomes important in how loads can be applied over the organic silt without causing shear failures. This would include the initial capping/working surface and the subsequent bulk materials stockpiles.

If the organic silt is capped with a layer of material such as slag, the weight of the slag will cause additional settlement and a proportional strength gain throughout the silt layer equal to about ⅓ of the added soil pressure. Following the example above, if 4 m of slag increased the soil pressure by 70 kPa, the strength at the top of the silt would be approximately 21 kPa and at a depth of 10 m would be approximately 33 kPa.

3.0 Storage Area Construction

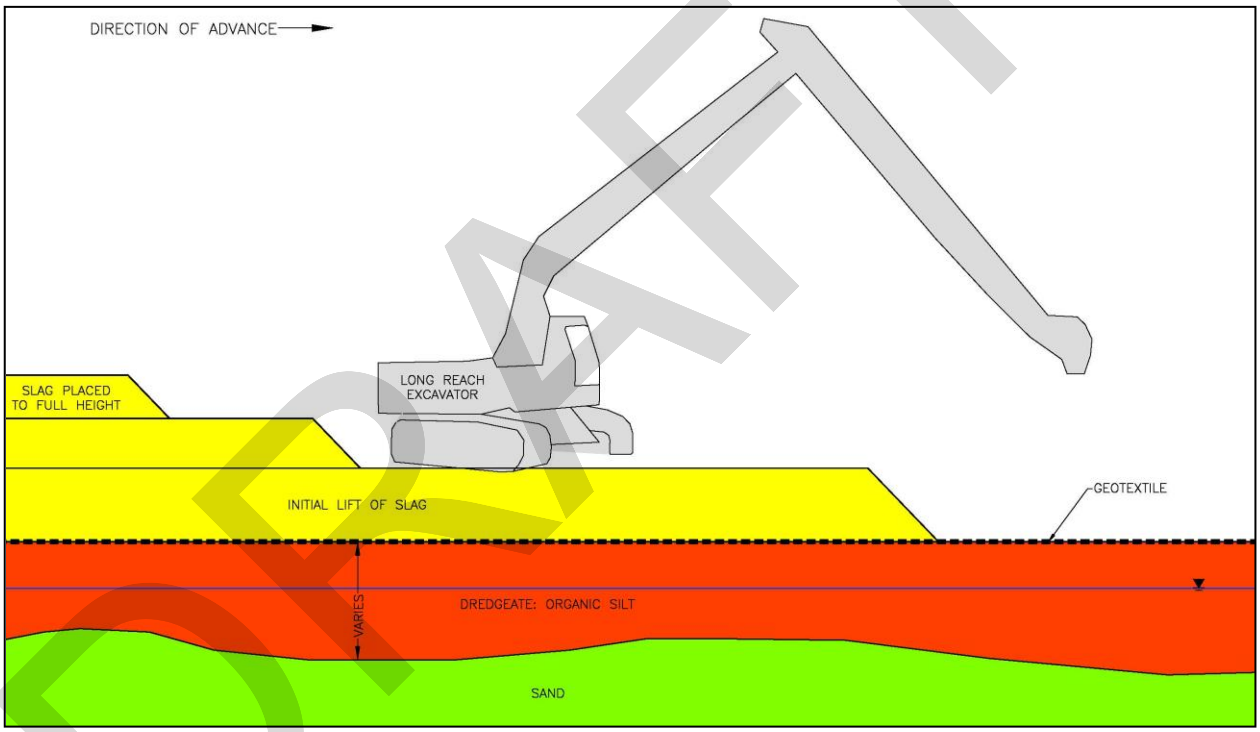
As noted in the preceding section, the silt is expected to be placed above sea level in some areas of the cove and below in others. In order to construct a working surface from which equipment will be involved in placing and moving bulk materials, special procedures will be required. At this time, we have assumed that the final surface at the site will be around el. 4 m and the organic silt will have a blanket of slag of at least 3 m thick over the silt to stabilize the site and allow machinery to work safely. It is also assumed that the dredgeate will have been in place for approximately 1 year prior to attempting to cover the site with the slag material.

To facilitate placement of the capping layers, 2 conditions may occur:

1) Surface of organic silt is above water level.

   This will likely allow some drying of the upper surface forming a relatively shallow crust which may be strong enough to enable geotextiles to be placed over the surface of the silt. The geotextile placement ahead of the slag will enable trucks and excavators to place an initial lift of slag over the geotextile. This initial lift of material should enable subsequent lifts of slag to be placed up to final grade. The following Figure 2.1 illustrates how this could be carried out.

   FIGURE 3.1 Fill Placement Detail

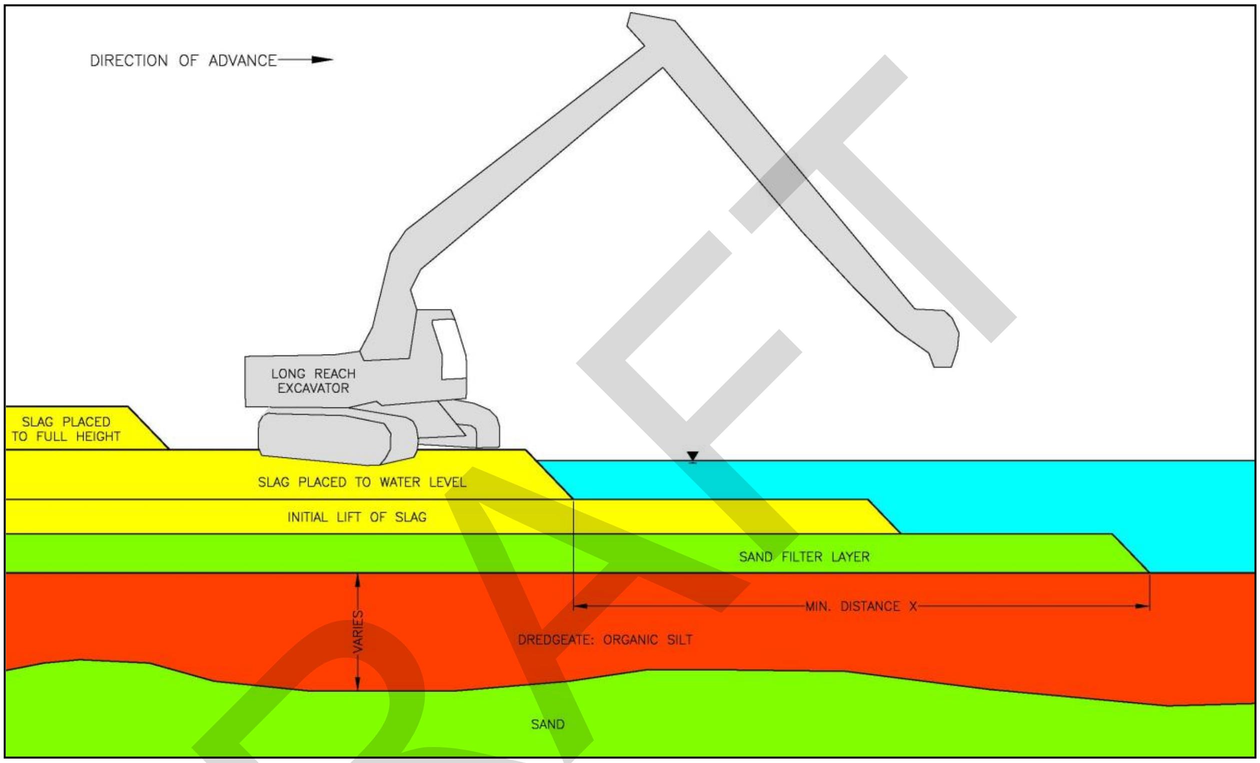


   It will be important not to place lifts too thick especially at the leading edge of the fill as this could lead to slope failures or large mudwaves at the toe of the fill. The use of a long reach excavator or clam would allow the machinery to stay well back from the leading edge of the fill where stability is a concern. Some trial and error will be required to establish the most efficient placement procedures.

2) Surface of organic silt is below water.

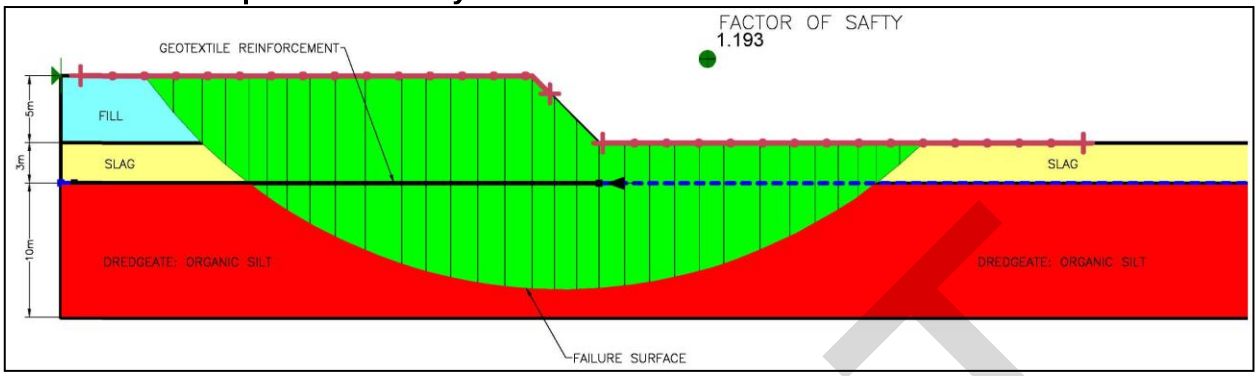
   In this scenario, a similar type of construction could be employed, only the practicality of using geotextile below water is limited, therefore use of a sand to act as a filter between the slag and organic silt could be considered. The sand will help keep the organic silt from migrating into the slag, which can have an effect on the stability of the slag if mixing of the materials occurs. There would not likely be any crust formed on the surface of the silt making it difficult to spread material. Using a long reach excavator would allow placement of material in relatively thin lifts with each lift acting as a berm to stabilize the next lift as illustrated below in Figure 2.2.

FIGURE 3.2 Fill Placement Detail



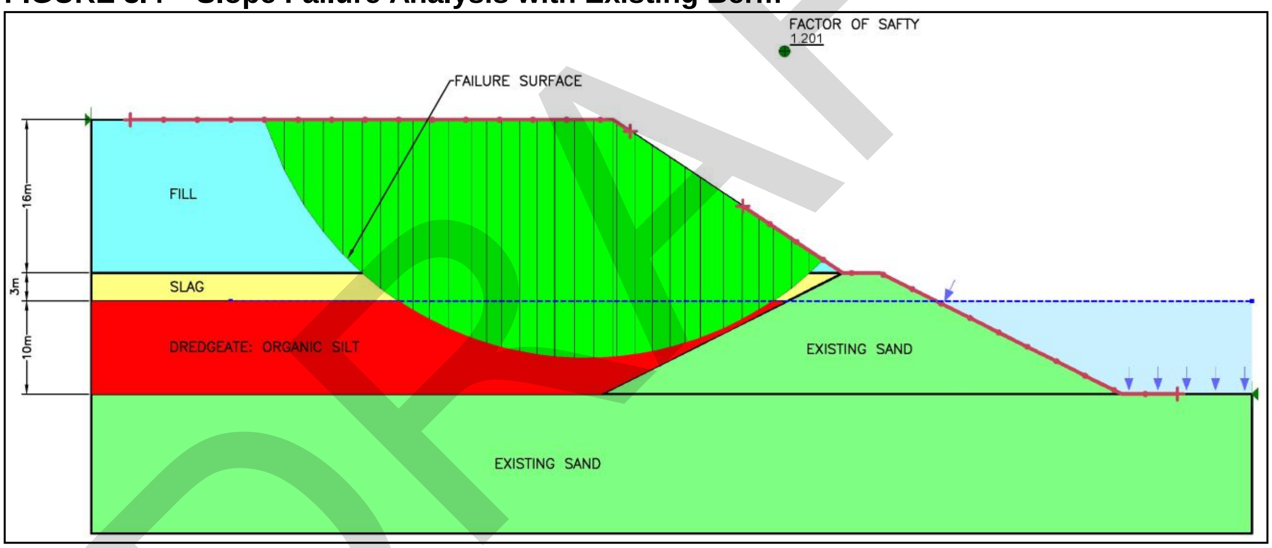
When the capping materials are in place, the final surface would be capable of supporting any machinery loads that may be applied, such as large trucks, loaders, dozers, etc. The ability of the completed surface to support stockpiles of materials is then dependent on the thickness of the capping material, the strength of the underlying silt and the shape/distribution of the stockpile. As an example, the following Figure 2.3 illustrates the safe height of stockpiled material that could be placed shortly after completing the slag placement. In this example we show a 3 m thick layer of slag over the organic silt.

FIGURE 3.3 Slope Failure Analysis with Geotextile Reinforcement



As shown, only about 5 m of material could be placed without initiating a slope failure. If the material were placed to cover the entire footprint of the cove, such that the failure surface has to fail as illustrated below in Figure 2.4, then a much higher stockpile can be constructed.

FIGURE 3.4 Slope Failure Analysis with Existing Berm

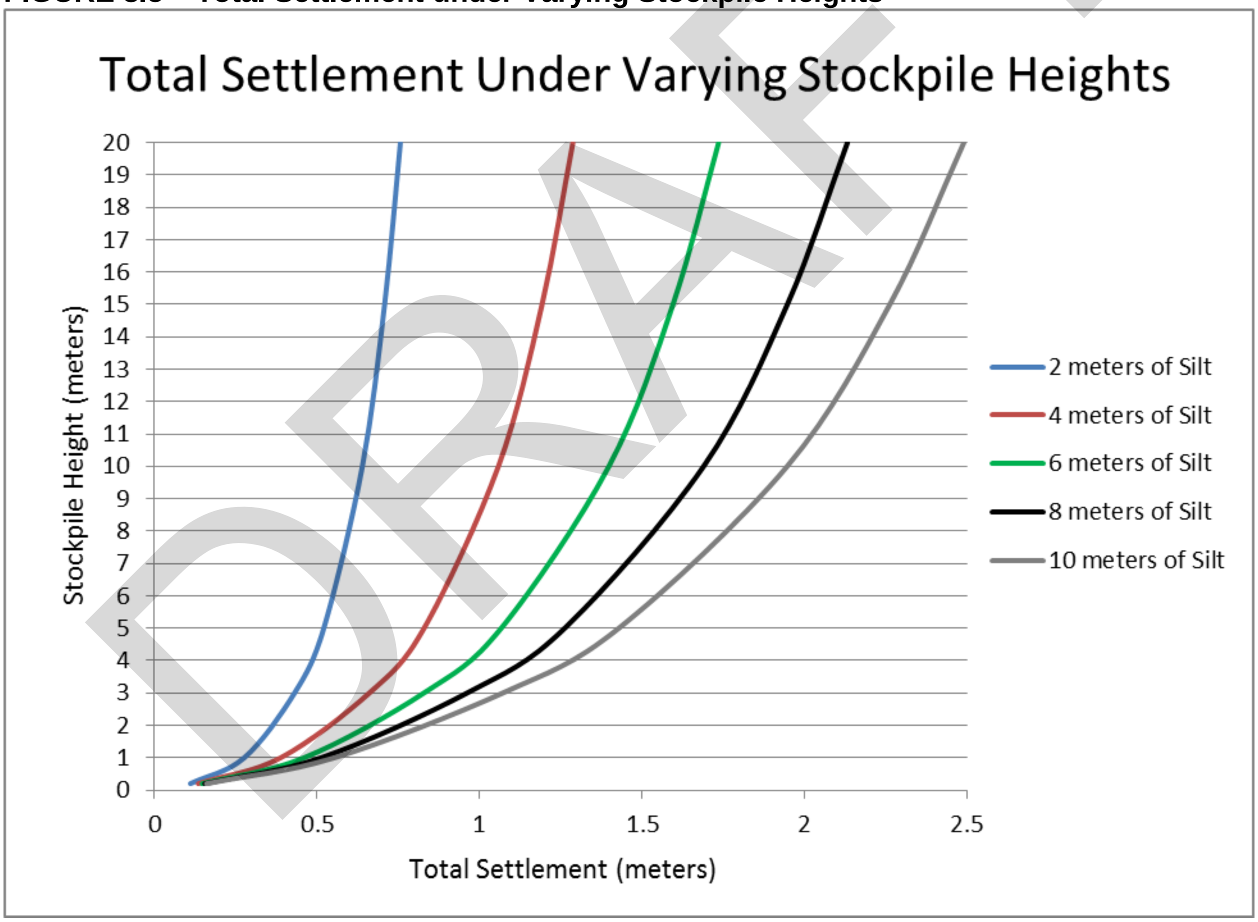


These examples are based on the strength of the organic silt shortly after placement of the slag. As the silt consolidates over time from the added loads, it will gain strength in the manner previously described and with the gain in strength a subsequent increase in load can be realized, i.e., higher stockpiles. The difficulty in this scenario is the time it takes to consolidate the silt. As shown in Section 2.2, for a silt layer 5 m thick, it would take approximately 7 years to achieve most (approximately 90%) of the strength gain.

Consolidation can be sped up by installing wick drains at relatively close spacing (1 to 1.5 m). Wick drains are thin sheets of geotextile drainage material that are driven vertically through the organic silt layer and as load is applied to the silt layer, the excess pore pressures that are developed are able to drain horizontally toward the wick drains as opposed to vertically to the surface slag or underlying native materials. Wick drains can speed the time from several years to around 1 month. Wick drains would be very useful if the operation required high stockpiles that did not cover the entire cove area. They should enable the sites to be preloaded and allowed to consolidate prior to forming a stockpile with actual commercial products. The surcharge would have to be done in multiple stages to allow the silt to consolidate between stages and gain sufficient strength to allow placement of the next lift of surcharge material.

As load is applied to the site, significant settlement of the underlying organic silt will occur. The following Figure 2.5 illustrates the amount of settlement that can be expected from various stockpile heights. It should be noted that the heights given apply to normal granular type products, such as local slag or common borrow materials. Specific ores may have much higher or lower unit weight and the resulting settlement would be proportionally higher or lower than those illustrated. Where significant settlement occurs, the surface may have to be regraded from time to time to re-establish the preferred floor level.

FIGURE 3.5 Total Settlement under Varying Stockpile Heights



Instrumentation of the site will be important to ensure the behavior of the materials are acting as predicted. Typically, this would include settlement plates, piezometers to monitor pore water pressures in the silt and slope indicators to ensure embankment fills are stable. A specific instrumentation plan should be developed concurrent to any proposed loading scenarios proposed for this site.

4.0 Closure

The preceding discussion describes the generalized behavior of the organic silt placed within the cove. Due to the number of variables associated with the behavior of the silt, as plans proceed, additional analysis should be carried out for specific load conditions that the operation proposes to use.

We trust that this is the information you require at this time. If you have any questions please do not hesitate to call.

Yours very truly,

STANTEC CONSULTING LTD.

S. Greg MacNeill, P.Eng.
Principal

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