# GEOTECHNICAL EVALUATION
# TUNNEL MOUNTAIN WASTEWATER LIFT STATION AND FORCE MAIN
# BANFF, ALBERTA

**SUBMITTED TO:**

**MMM Group**
**Calgary, Alberta**

**PREPARED BY:**

**McIntosh•Lalani Engineering Ltd.**
**Calgary, Alberta**

**December, 2009**

**M•L 4534**

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## 1.0 INTRODUCTION

This report presents the results of a geotechnical evaluation conducted by McIntosh•Lalani Engineering Ltd. (M•L) for the proposed Tunnel Mountain Wastewater Lift Station and force main development in Banff, Alberta. This evaluation was undertaken at the request of Mr. Darren Finney, P.Eng. of MMM Group. The objective of this evaluation was to assess the general subsurface soil conditions at the site for the design and construction of the proposed lift station and force main.

This report presents the results of the drilling program and geotechnical recommendations for construction.

## 2.0 PROJECT DETAILS

The project is understood to comprise the design and construction of the proposed Tunnel Mountain Wastewater lift station and associated force main. The structure is to consist of a concrete below grade tanked structure with an above grade building. The tank and building have an approximate 3 metre diameter footprint area. Based on information provided by MMM Group, the tank is to be situated approximately 5.0 metres below existing ground elevation.

## 3.0 SITE DESCRIPTION AND TOPOGRAPHY

The proposed lift station is to be located just northwest of the intersection of Tunnel Mountain Road and the Village 1 access road in the Tunnel Mountain Campground in Banff, Alberta. The lift station is to be located just north of Tunnel Mountain Road and the force main runs along the north side of Tunnel Mountain Road, then transitions to the south side of the Village 2 campground area and ties into the existing sewer system directly to the west of the Village 2 entrance Kiosk. The lift station location is mainly flat and covered in native vegetation consisting of low lying brush and mature trees. The force main alignment is covered in similar native vegetation and varied in topography as it progresses.

## 4.0 FIELD AND LABORATORY WORK

The fieldwork consisted of drilling subsurface investigation boreholes within the proposed lift station area and along the force main alignment using a solid stem auger drill rig contracted from Beck Drilling and Environmental Services Inc. of Calgary.

In all, fourteen (14) boreholes were drilled across the site. One (1) borehole was advanced at the sewage lift station location to a depth of 15.2 metres below existing ground surface. The remaining thirteen (13) boreholes were advanced to depths of 6.1 metres below existing ground surface along the force main alignment. The soil was classified from disturbed samples extracted from the auger flights. Soil consistency was determined using the aid of Standard Penetration Testing (SPT).

Laboratory testing including natural moisture content and soluble sulphate concentrations are being performed on selected soil samples recovered from the boreholes.

## 5.0 SUBSURFACE CONDITIONS

### 5.1 Soils

The general subsurface soil stratigraphy consisted of a organic topsoil overlying silts.

Organic topsoil was initially encountered in all the boreholes with thicknesses ranging from 50 to 100 mm. Beneath the topsoil in Borehole No. 2 a silt fill was encountered which was compact, damp, brown and extended to a depth of 0.5 metres below the existing ground surface.

Beneath the fill in Borehole No. 2, the sandy gravel in Borehole No. 12 and beneath the topsoil in the remaining boreholes a native silt was encountered which extended beyond the maximum depth drilled in all boreholes except Borehole Nos. 1 and 12. This silt was generally compact to dense, damp, medium brown in colour and contained some gravel and traces of sand throughout.

Sandy gravel was encountered with Borehole No. 10, beneath the topsoil and in Borehole Nos. 1 and 12 beneath the silt. This sandy gravel was compact, dry, medium brown and contained silt. In Borehole No. 10 it extended to the silt strata at a depth of 1.7 metres below the existing ground surface while in Borehole Nos. 1 and 12 it was encountered at a depth of 12.5 and 2.3 metres below existing grade respectively and extended beyond the depth of a 5.2 and 6.1 metres drilled within Boreholes No. 1 and 12 respectively.

A more detailed soil description is presented in the attached borehole logs located in Appendix A.

Information on subsurface stratigraphy was available only at discrete borehole locations. Conditions and soil parameters were extrapolated and interpolated from the boreholes logs to develop recommendations. Adequate monitoring should be provided during construction to check that these assumptions are reasonable.

### 5.2 Groundwater

Groundwater seepage was only encountered within Borehole No. 1 upon completion of drilling and the remaining thirteen (13) boreholes were dry upon completion. Groundwater readings were obtained on December 14, 2009 at which time measured groundwater ranged from depth from 4.81 to 13.15 metres below existing ground surface. The measured groundwater depths within the boreholes can be found in Table No. 1.

## 6.0 DISCUSSION AND RECOMMENDATIONS

### 6.1 Foundations

Based on the proposed structure foundation elevations the foundations system should be situated within the dense silt soils. These soils are appropriate for a strip and spread foundation system. Alternatively a mat (raft) foundation system may be used for this project provided certain precautions are taken during construction. Recommendations for each of these options have been provided below.

Should the above grade structure be larger in footprint than the below grade tank, a deep pile foundation would be required for the portion of foundation that extends into the fill zone outside of the tank. Should this be required, M•L will provide pile design parameters.

### 6.2 Strip and Spread Footings

Based on the results of the subsurface investigation, conventional strip and spread foundations are feasible for the proposed structure.

The recommended net allowable static bearing pressure for the design of strip and spread footings on the undisturbed silts soils at the proposed 5.0 metre depth is 200 kPa.

Some degree of groundwater seepage into the foundation excavation should be expected. Recommendations with regard to the groundwater can be found under the heading groundwater considerations.

All bearing surfaces must be inspected by a qualified geotechnical engineer prior to placement of the footing concrete. The silt soils are considered to be susceptible to degradation under exposure to water, construction equipment and meteorologic elements including freezing temperatures. Therefore, the bearing surfaces must be protected against any disturbances by pouring footings as soon as possible once excavated, or by covering and protecting them with lean mix concrete immediately following excavation.

### 6.3 Mat (Raft) Foundation

A mat foundation founded on the silts soils may be designed using a modulus of subgrade reaction of 20 MPa/m.

As with strip and spread footings, the bearing surfaces for mat slabs should be approved by a qualified geotechnical engineer and protected against disturbance and degradation by applying a lean concrete mix over the exposed surface immediately following excavation. Mat slabs should be protected from meteorologic elements including freezing temperatures and water.

### 6.4 Floor Slabs-On-Grade

Slab-on-grade construction is considered feasible provided certain precautions are undertaken. The exposed subgrade materials below the underside of the slabs-on-grade should be inspected by a qualified geotechnical engineer to ensure all loose and soft spots are detected and replaced with general engineered fill compacted as per our specifications contained within this report.

Some relative movement between the floor slabs-on-grade and adjacent walls or foundations and differential movements within the slab should be anticipated. It is also possible that some cracking of the slab may occur. Generally if recommendations outlined in this report are followed the unwanted movements should be acceptably small. The risk of such damage should be weighed against the additional costs associated with alternative slab support systems such as the structurally supported slabs.

### 6.5 Structural Slabs

A structural supported floor slab system may be considered as an alternative to a slab-on-grade if differential movement between the slab and adjacent walls or foundations can not be tolerated.

With any structurally supported floor slab system, there is a risk of movement of the ground beneath the slab relative to the slab. This can lead to problems if piping and other utilities that are connected to the slab are embedded within the ground beneath the slab. All utilities beneath structurally supported ground floor slabs should be protected from the effects of such differential movement. This can be accomplished by placing utilities within ducts suspended from the structural slab.

### 6.6 Lateral Wall Pressures

Permanent and temporary walls should be designed to resist all lateral pressures including those due to soil or backfill, surcharges, water and adjacent footings using the following expressions defined in terms of total and effective stresses:

$P_{lateral\ pressure} = P'_{earth+surcharge} + P_{net\ water} + P'_{adj\ ft}$

where $P_{lateral\ pressure}$ = total lateral pressure at a given depth ($kN/m^2$)

$P'_{earth+surcharge}$ = lateral earth pressure due to soil/bedrock or fill and surcharges at a given depth ($kN/m^2$)
= $K(\gamma h + q)$ above water table or phreatic surface
= $K(\gamma' h + q)$ below water table or phreatic surface

$P_{net\ water}$ = net water pressure on wall at a given depth ($kN/m^2$), calculated by hand drawn flow net or computer solution based on drainage conditions

$P'_{adj\ ft}$ = lateral earth pressure due to adjacent footings at given depth ($kN/m^2$)

$K$ = coefficient of lateral earth pressure, $K_a$, $K_0$, $K_p$ or combination of as noted below

$K_a$ = coefficient of active earth pressure

$K_0$ = coefficient of at-rest earth pressure

$K_p$ = coefficient of passive earth pressure

$\gamma'$ = submerged unit weight of backfill or natural soil or bedrock ($kN/m^3$)

$\gamma'$ = $\gamma_{sat} - \gamma_w$

$\gamma$ = bulk unit weight of backfill or natural soil or bedrock ($kN/m^3$)

$\gamma_w$ = unit weight of water 9.81 $kN/m^3$

$h$ = excavation depth (m)

$q$ = surcharge load ($kN/m^2$)

The following Table presents coefficients of lateral earth pressures and unit weights.

| | Ka | $K_o$ | Kp | $\gamma$ ($kN/m^3$) |
|---|---|---|---|---|
| Fill | 0.36 | 0.6 | --- | 20.5 |
| Native Silt Soils | 0.33 | 0.53 | 2.9 | 19.5 |

## 6.7 Permanent Lateral Wall Pressures

The distribution of soil pressure against a permanent wall may be assumed using the general equation given above with a coefficient of lateral earth pressure equal to the at-rest coefficient of earth pressure, $k = k_0$. Values of $k_0$ are given the above table for fill and native silt soils.

Permanent walls should be designed to resist the maximum possible water pressure subject to drainage conditions determined by design.

Recommendations for permanent anchors are not included in this report. Lateral forces against permanent walls may be resisted by wall section and top and bottom slab support.

### 6.8 Temporary Lateral Wall Pressures

The distribution of soil pressure against a temporary wall may be assumed using the general equation given above and values of K according to deformation restrictions as follows:

- If moderate wall movements can be permitted
  $K=K_a$.

- If foundations of buildings or services exist at a shallow depth, at a distance less than H (height of the wall) behind the top of the wall and not closer than 0.5H

  $K= 0.5 (K_a + K_o)$.

- If foundations or services exist at a shallow depth, at a distance less than 0.5H
  $K=K_o$.

### 6.9 Temporary Passive Wall Resistance

Passive resistance at the base of a temporary wall may be calculated as follows:

$$P'_p = K_p (\gamma' d/1.5)$$

Where $P'_p$ = passive resistance at depth below excavation ($kN/m^2$)
$K_p$ = coefficient of passive earth pressure
$\gamma'$ = submerged unit weight ($kN/m^3$)
$d$ = depth below excavation level (m)

The passive resistance should be taken to act on an area twice the pile diameter below grade.

### 6.10 Site Grading and Drainage

Upon inspection of the underlying native soils present on site by an M•L representative, approved engineered fill soils may be used for site grading in the lift station building area.

It is recommended that final site grading be provided to direct water to areas remote from the proposed structure. Minimum landscape gradients of 1.5 percent are recommended to reduce the risk of run-off ponding in localized areas. Landscaping within a zone of approximately 2 m of the exterior perimeter of the structure should be graded to drain away from the structure at a minimum gradient of 2 percent. Furthermore, downspouts should be positively directed away from the building.

### 6.11 Groundwater Considerations

Groundwater was encountered within Borehole No. 1 located at the lift station site at a depth of 13.15 metres below existing grade and ranged from 4.81 to dry 6.1 metres below existing grade within the boreholes located along the force main alignment. Groundwater levels typically fluctuate seasonally and will vary in elevation depending on the time of the year.

Groundwater seepage should be expected during the excavation works. Based upon groundwater levels and anticipated flow quantities encountered during construction, dewatering using a system of ditches leading to sumps equipped with pumps, will most likely be an adequate method of dewatering the excavations. Dewatering methods and pumping rates are the responsibility of the contractor. For a more accurate pumping rate requirement, a hydrogeologist should be consulted.

Hydrostatic pressures should be considered during the design stages of the below grade structure walls and slabs. More information regarding the pressures to be considered is provided under the heading lateral wall pressures.

Although no groundwater was encountered within 2.1 metres of the anticipated founding depth of the lift station, perched water and surficial water intrusion through the building backfill zone should be anticipated. If the proposed structure is sensitive to any groundwater intrusion, water proofing of the below grade structure should be considered.

### 6.12 Construction Excavations

The composition and consistencies of the soils encountered at the site are such that conventional hydraulic excavators should generally be able to remove these materials. However, fine grain soils at depth were encountered on site. These soils are non-cohesive and susceptible to sloughing upon excavation. M•L should be notified to review the possible presence of sloughing soils in the side slopes upon excavation to ensure the safety of all temporary excavated slopes.

Temporary excavations at the site in excess of 1.5 m should be sloped or shored. For excavations in the silt soils at the site, side slopes of 1 Horizontal to 1 Vertical may be used cuts extending through the sandy gravels will require a 1.5H:1V cut slope. Should steeper slopes be required due to space requirements, trench boxes should be used within deep utility excavations to ensure the

safety of workers within the excavation. Within the boreholes, groundwater was not encountered until a depth of approximately 5 metres, however, this can be variable due to seasonal flotations of up to 1.2 metres vanince as well as climactic fluctuations due to storm events. Should shallow groundwater be encountered, provisions may be required to shore the excavations below the local groundwater level. A concrete lock block or other means may be employed to retain these soils at the toe of the slope within the lift station excavation. Provisions for these possible measures should be considered upon sizing the required excavation.

In addition, protection of adjacent infrastructure during temporary excavations needs to be considered. Also, the length of open trench will need to be minimized in the cohesionless soils. The trench will need to be excavated in short lengths with the backfilling occurring immediately behind the pipe placement. Should sloughing soils become more of a problem, the use of additional washed drainage gravel may be used as backfill to accelerate the backfilling in problematic areas. A geotextile separation will be required between the non cohesive soils and the drain gravel.

### 6.13 Temporary Shoring Walls

Soldier pile and lagging with temporary tiebacks are considered feasible as a temporary shoring system within the lift station excavation only if dewatering is carried out before excavation begins to eliminate the possibility of excessive deformation, loss of ground, heave at the base of the excavation and overall instability. The design and construction of temporary shoring is considered proprietary and the responsibility of the contractor. Adequate drainage and filter media will be require behind the chosen shoring system to prevent piping loss of the silt from the slope. M•L should review the shoring design prior to installation.

The contractor must assess if dewatering is required before excavation begins to eliminate the possibility of excessive deformations, loss of ground, heave at the base of the excavation and overall instability.

Temporary anchor allowable bond values should be determined with a test anchor at the site. For preliminary design, the allowable bond values may be taken as 15 kPa in the silt soils.

### 6.14 Pipe Support

Over the majority of the site, we do not anticipate any difficulties with regard to the pipe support. Conventional methods for pipe support are considered feasible. However, fine grain non cohesive soils were encountered within the boreholes at the approximate pipe depth. As such these areas should be evaluated by M•L in the field at time of construction and remedial techniques developed in the field at that time. These techniques may consist of a geotextile soil separator between the bedding gravel and the native silt soils.

To prevent migration of fines, M•L recommends the installation of plugs consisting of compacted clay or lean-mix concrete at frequent intervals around the pipe and/or manholes. This will prevent the flow of water through the bedding gravel and in turn, reduce the potential for migration of fine grained soils into the bedding gravel. The frequency of the plugs should be determined by M•L prior to final design.

### 6.15 Backfill Materials and Compaction

Portions of existing materials on site may be suitable for use as general engineered fill subject to material evaluation and removal of deleterious materials. Imported fills should be approved for use as structural or general engineered fills.

Recommended compaction specifications and materials are as follows:

- Structural fill- 100 percent Standard Proctor Maximum Dry Density, maximum compacted lift thickness 250 mm, maximum grain size 200 mm. Structural fill materials should comprise clean well-graded inorganic granular soils.

- General engineered fill- 98 percent Standard Proctor Maximum Dry Density, 0 to +3 percent of optimum moisture content, maximum compacted lift thickness 250 mm. General engineered fill materials should comprise clean well-graded granular soils, or inorganic low plastic cohesive soils.

Where washing of fines is possible, fill material placed should be separated from coarser or finer material by a suitable geotextile.

Backfill comprising cohesive soils or silt should be considered frost susceptible and should not be used in areas where it may become frozen and where frost heaving would be unacceptable.

### 6.16 Concrete Type

Soluble sulphate concentration testing in samples recovered from the subsurface investigation has not yet been completed. Upon completion the results together with recommendations regarding concrete type will be forwarded.

If imported fills are to be placed in contact with concrete elements these fills must be tested for soluble sulphates.

## 7.0 REVIEW of DESIGN AND CONSTRUCTION

M•L should review details of design and specifications related to geotechnical aspects prior to construction. Adequate monitoring during construction will be required. All construction should be carried out by a qualified contractor experienced in foundation and earthworks construction. Adequate monitoring includes:

- Foundations: Written approval of all bearing surfaces prior to concrete or mud slab placement.
- Earthworks: Full-time monitoring and compaction testing.
- Temporary Shoring Walls: Adequate monitoring during construction.
- Underground Utility Installation - Full-time monitoring and compaction testing.

All monitoring should be carried out by qualified persons, independent of the contractor. M•L will provide these services if requested. Failure to provide an adequate level of foundation monitoring may be in contravention of building code requirements.

## 8.0 LIMITATIONS

Geotechnical recommendations presented herein are based on findings in fourteen (14) boreholes. If conditions other than those reported are noted, McIntosh•Lalani Engineering Ltd. should be given the opportunity to review current recommendations. The recommendations presented herein may not be valid if an adequate level of monitoring is not provided during construction, or if relevant building code requirements are not met. This report does not include any recommendations related to contaminants in soil or groundwater. Environmental issues are not included in this scope of work.

This report has been prepared for the exclusive use of MMM Group and its agents for specific application to the project noted within this report. McIntosh•Lalani Engineering Ltd. makes no representations to any party with whom McIntosh•Lalani Engineering Ltd. has not entered into a contract. This report has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty is made, either expressed or implied.

Respectfully submitted,

**McIntosh•Lalani Engineering Ltd.**

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## LIST of FIGURES


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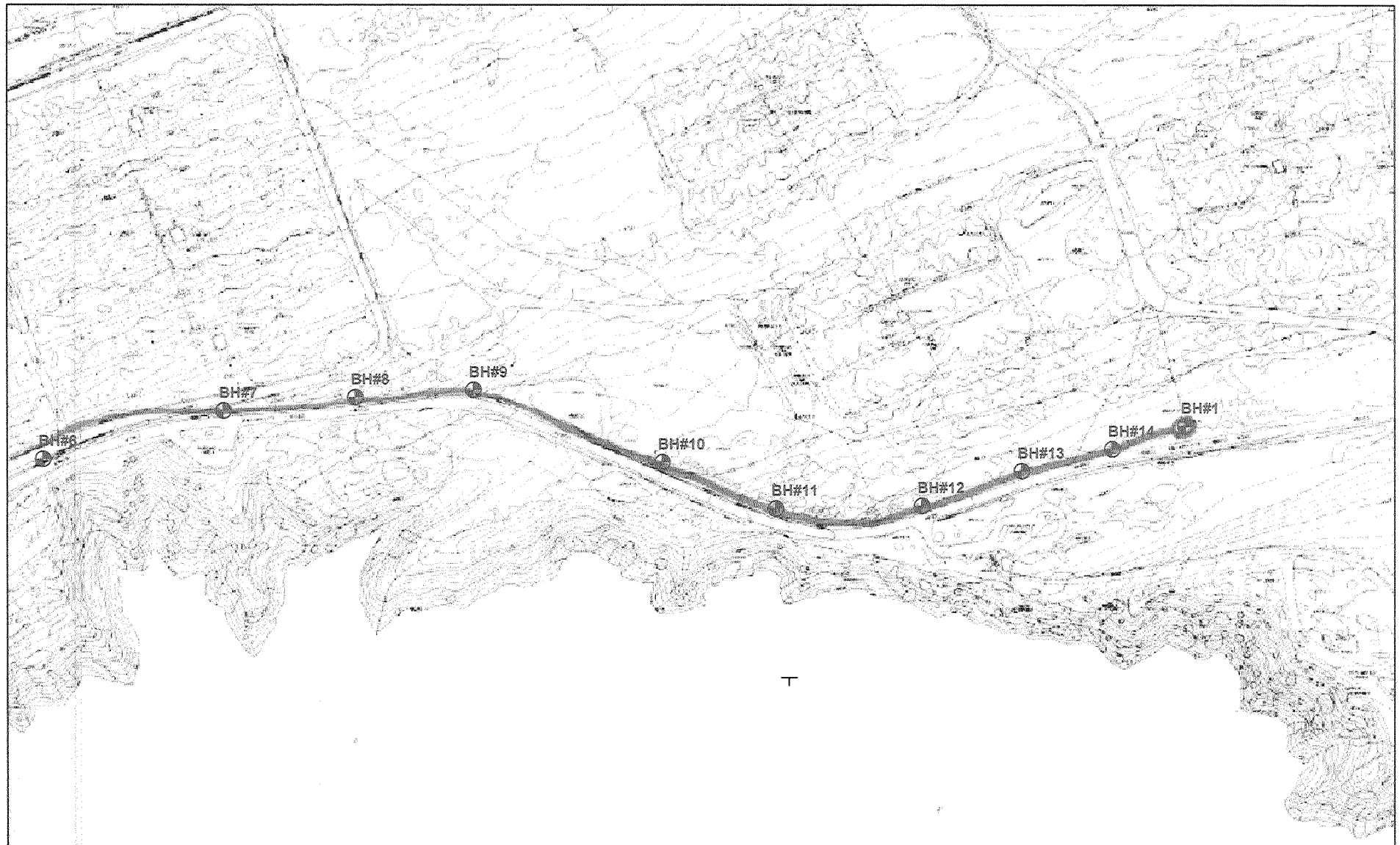
# TUNNEL MOUNTAIN WASTEWATER LIFT STATION AND FORCE MAIN

MMM GROUP

| JOB # | ML-4534 | DWG NO. | Figure 1 |
|---|---|---|---|
| SCALE | NTS | DATE | Dec. 17, 2009 | DRAWN BY | NRP |

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# TUNNEL MOUNTAIN WASTEWATER LIFT STATION AND FORCE MAIN

## MMM GROUP

| JOB # | ML-4534 | DWG NO. | Figure 2 |
|---|---|---|---|
| SCALE | NTS | DATE | Dec. 17, 2009 |
| DRAWN BY | NRP | | |

# TABLES

## TABLE NO. 1

## GROUNDWATER MEASUREMENTS

| Borehole No. | Depth Below Grade on December 14, 2009 |
|---|---|
| 1 | 13.15 m |
| 2 | Dry to 6.1 m |
| 3 | Dry to 6.1 m |
| 4 | Dry to 6.1 m |
| 5 | Dry to 6.1 m |
| 6 | Plugged at ground surface |
| 7 | 5.87 m |
| 8 | 5.27 m |
| 9 | Dry to 6.1 m |
| 10 | Dry to 6.1 m |
| 11 | Dry to 6.1 m |
| 12 | Dry to 6.1 m |
| 13 | Dry to 6.1 m |
| 14 | 4.83 m |
| 15 | 4.81 m |

# APPENDIX A

# BOREHOLE LOGS

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:1 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) Water Level | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | OTHER DATA |
|---|---|---|---|---|---|---|
| 0 | Topsoil - approx. 100mm thick. | | | TPSL | | |
| | Silt - compact, dry, trace sand, some gravel, medium brown. | | 1-1 | | | |
| 1 | | | | | | |
| 2 | - trace cobbles. | | 1-2 | | | |
| 3 | | | | | | |
| 4 | | | 1-3 | | | |
| 5 | - 0.6m of slough in hole.<br>- damp.<br>- moist, trace free water. | | -- | | 27-30-32 | |
| | | | 1-4 | | | |
| 6 | - damp. | | | ML | | |
| 7 | | | 1-5 | | | |
| 8 | - 1.8m of slough in hole. | | -- | | 27-28-35 | |
| | | | 1-6 | | | |
| 9 | | | | | | |
| 10 | | | 1-8 | | | |
| 11 | - 0.75m of slough in hole.<br>- moist, some clay, trace sand and gravel, trace oxides. | | -- | | 19-34-31 | |
| | | | 1-9 | | | |
| 12 | | | | | | |
| 13 ▼ | Silty Gravel - compact, wet, trace sand and cobbles, medium brown. | | 1-10 | | | |
| 14 | - damp. | | | GM | | |
| | | | 1-11 | | | |
| 15 | | | | | | |
| 16 | REFUSAL at a depth of 15.2m.<br>25mm PVC standpipe installed to a depth of 13.7m with 9.1m slotted.<br>1.5m of slough. Wet upon completion.<br><br>Water Levels:<br>December 14,2009- 13.15M. | | | | | |
| 17 | | | | | | |

PLASTIC — M.C. — LIQUID (10 20 30 40)

BLOW COUNT (10 20 30 40)

POCKETPEN (kPa) (80 160 240 320)

SLOTTED PIEZOMETER

Elevation (m)

ML STANDARD AUGER 4534 TUNNEL MOUNTAIN SEWAGE LIFT STATION.GPJ M-L STANDARD.GDT 12/17/09

McIntosh Lalani Engineering
Calgary, AB
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| Logged By: Scott Bryan | Completion Depth: 50 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/1/2009 |
| Groundwater Depth: 13.15 m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:2 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm |
|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 75mm thick. | | 2-1 | TPSL | |
| | | Silt (Fill) - compact, damp, trace sand, gravel and organics, medium brown. | | | FILL | |
| 1 | | Silt - compact, damp to moist, trace sand, gravel and clay, trace oxides, medium brown. | | 2-2 | | |
| | | - poor sample recovery, no clay. - spoon bouncing. | | 2-3 | | 20@4" |
| 2 | | | | 2-4 | | |
| 3 | | | | 2-5 | ML | 50@5" |
| | | | | 2-6 | | |
| 4 | | | | | | |
| 5 | | | | 2-7 | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | |
| 7 | | Water Levels: December 14,2009- Dry. | | | | |
| 8 | | | | | | |
| 9 | | | | | | |

PLASTIC — M.C. — LIQUID (10 20 30 40)

BLOW COUNT (10 20 30 40)

POCKETPEN (kPa) (80 160 240 320)

OTHER DATA

SLOTTED PIEZOMETER

Elevation (m)

ML STANDARD AUGER 4534 TUNNEL MOUNTAIN SEWAGE LIFT STATION.GPJ M-L STANDARD.GDT 12/17/09

McIntosh Lalani Engineering
Calgary, AB
(403) 291-2345

| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/1/2009 |
| Groundwater Depth: m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:3 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC / M.C. / LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 100mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | 3-1 | | | | | | | |
| 1 | | | | | | | | | | | |
| | | | | 3-2 | | 20-27-10@2.5" | | | | | |
| 2 | | | | 3-3 | | | | | | | |
| 3 | | | | | ML | | | | | | |
| | | | | 3-4 | | 17-24-20 | | | | | |
| | | | | 3-5 | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | 3-6 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| 7 | | Water Levels: December 14,2009- Dry. | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

McIntosh Lalani Engineering
Calgary, AB
(403) 291-2345

| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/1/2009 |
| Groundwater Depth: m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:4 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC M.C. LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 75mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | 4-1 | | | | | | | |
| 1 | | | | | | | | | | | |
| 2 | | | | 4-2 | | | | | | | |
| 3 | | | | | ML | | | | | | |
| | | | | 4-3 | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | 4-4 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| 7 | | Water Levels: December 14,2009- Dry. | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

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| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/4/2009 |
| Groundwater Depth: m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:5 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC / M.C. / LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 100mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | 5-1 | | | | | | | |
| 1 | | | | | | | | | | | |
| | | | | 5-2 | | 20-25-28 | | | | | |
| 2 | | | | 5-3 | | | | | | | |
| 3 | | | | | ML | | | | | | |
| | | | | 5-4 | | 13-21-19 | | | | | |
| | | | | 5-5 | | | | | | | |
| 4 | | | | | | | | | | | |
| | | | | 5-6 | | 16-34 | | | | | |
| 5 | | | | 5-7 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| | | Water Levels: December 14,2009- Dry. | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

ML STANDARD AUGER 4534 TUNNEL MOUNTAIN SEWAGE LIFT STATION.GPJ M-L STANDARD.GDT 12/17/09

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Calgary, AB
(403) 291-2345

| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/2/2009 |
| Groundwater Depth: m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:6 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC M.C. LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 100mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | 6-1 | | | | | | | |
| 1 | | | | | | | | | | | |
| 2 | | | | 6-2 | | | | | | | |
| 3 | | | | | ML | | | | | | |
| 4 | | | | 6-3 | | | | | | | |
| 5 | | | | 6-4 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| 7 | | Water Levels: December 14,2009- Plugged at ground level. | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

ML STANDARD AUGER 4534 TUNNEL MOUNTAIN SEWAGE LIFT STATION.GPJ M-L STANDARD.GDT 12/17/09

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(403) 291-2345

| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/2/2009 |
| Groundwater Depth: m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:7 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) Water Level | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC M.C. LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 100mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | 7-1 | | | | | | | |
| 1 | | | | | | | | | | | |
| | | | | 7-2 | | 37-33@2" | | | | | |
| 2 | | | | 7-3 | | | | | | | |
| 3 | | | | | ML | | | | | | |
| | | | | 7-4 | | 37-33@2" | | | | | |
| | | | | 7-5 | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | 7-6 | | | | | | | |
| | | -trace free water. | | | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| | | Water Levels: December 14,2009-5.87M. | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

ML STANDARD AUGER 4534 TUNNEL MOUNTAIN SEWAGE LIFT STATION.GPJ M-L STANDARD.GDT 12/17/09

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| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/2/2009 |
| Groundwater Depth: 5.87 m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:8 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) Water Level | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC M.C. LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 100mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some garvel, medium brown. | | 8-1 | | | | | | | |
| 1 | | | | | | | | | | | |
| 2 | | | | 8-2 | | | | | | | |
| 3 | | | | | ML | | | | | | |
| | | -moist. | | 8-3 | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | 8-4 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| 7 | | Water Levels: December 14,2009- 5.27M. | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

ML STANDARD AUGER 4534. TUNNEL MOUNTAIN SEWAGE LIFT STATION.GPJ M-L STANDARD.GDT 12/17/09

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| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/2/2009 |
| Groundwater Depth: 5.27 m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:9 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC M.C. LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 100mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | 9-1 | | | | | | | |
| 1 | | | | | | | | | | | |
| | | | | 9-2 | | 50@6" | | | | | |
| 2 | | | | 9-3 | | | | | | | |
| 3 | | | | | ML | | | | | | |
| | | | | 9-4 | | 50@6" | | | | | |
| | | | | 9-5 | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | 9-6 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| | | Water Levels: December 14,2009- Dry. | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

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| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/2/2009 |
| Groundwater Depth: m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:10 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC M.C. LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 75mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | 10-1 | ML | | | | | | |
| 1 | | | | | | | | | | | |
| 2 | | Sandy Gravel- dry, compact, medium brown. | | 10-2 | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | | | | 10-3 | GWS | | | | | | |
| 5 | | -some silt. | | 10-4 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| 7 | | Water Levels: December 14,2009- Dry. | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

ML STANDARD AUGER 4534_TUNNEL MOUNTAIN SEWAGE LIFT STATION.GPJ M-L STANDARD.GDT 12/17/09

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| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/2/2009 |
| Groundwater Depth: m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:11 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC / M.C. / LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 50mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | 11-1 | | | | | | | |
| 1 | | | | | | | | | | | |
| | | | | 11-2 | | 23-27 | | | | | |
| 2 | | | | 11-3 | | | | | | | |
| 3 | | | | | ML | | | | | | |
| | | | | 11-4 | | 17-33 | | | | | |
| | | | | 11-5 | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | 11-6 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| 7 | | Water Levels: December 14,2009- Dry. | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

ML STANDARD AUGER 4534. TUNNEL MOUNTAIN SEWAGE LIFT STATION.GPJ M-L STANDARD.GDT 12/17/09

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| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/3/2009 |
| Groundwater Depth: m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:12 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC M.C. LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 50mm thick. | | | TPSL | | | | | | |
| | | Sandy Gravel- trace silt, dry, compact, medium brown. | | 12-1 | GPS | | | | | | |
| 1 | | -some silt, moist. | | | | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | 12-2 | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | 12-3 | ML | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | 12-4 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| 7 | | Water Levels: December 14,2009- Dry. | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

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| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/3/2009 |
| Groundwater Depth: m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:13 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) Water Level | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC M.C. LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 100mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | | | | | | | | |
| 1 | | | | 13-1 | | | | | | | |
| 2 | | | | xx | | 19-31@2.5" | | | | | |
| | | | | 13-2 | | | | | | | |
| 3 | | | | | ML | | | | | | |
| 4 | | | | 13-3 | | | | | | | |
| 5 | | | | 13-4 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| 7 | | Water Levels: December 14,2009- 4.83M. | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

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| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/3/2009 |
| Groundwater Depth: 4.83 m | Page 1 of 1 |

| Project: Tunnel Mountain Sewage Lift Station | Drilling Information: | Borehole No.:14 |
|---|---|---|
| Client: MMM Group | Beck Drilling & Environmental Services | Project No.:4534 |
| | SB-61 SS-Auger | Elevation: |

SAMPLE TYPE: SHELBY TUBE | CORE SAMPLE | SPT SAMPLE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

| Depth (m) Water Level | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO | USCS | BLOWS /150 mm | PLASTIC M.C. LIQUID (10 20 30 40) | BLOW COUNT (10 20 30 40) / POCKETPEN (kPa) (80 160 240 320) | OTHER DATA | SLOTTED PIEZOMETER | Elevation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil - approx. 75mm thick. | | | TPSL | | | | | | |
| | | Silt - compact, damp, trace sand, some gravel, medium brown. | | | | | | | | | |
| 1 | | | | 14-1 | | | | | | | |
| 2 | | | | 14-2 | | | | | | | |
| 3 | | | | | ML | | | | | | |
| 4 | | | | 14-3 | | | | | | | |
| 5 | | | | 14-4 | | | | | | | |
| 6 | | END OF HOLE at a depth of 6.1m. 25mm PVC standpipe installed to a depth of 6.1m with 4.6m slotted. Dry upon completion. | | | | | | | | | |
| 7 | | Water Levels: December 14,2009- 4.81M. | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

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| Logged By: Scott Bryan | Completion Depth: 20 ft |
|---|---|
| Reviewed By: Nicholas Payne | Drilled on: 12/3/2009 |
| Groundwater Depth: 4.81 m | Page 1 of 1 |

# APPENDIX B

# DESIGN AND CONSTRUCTION GUIDELINES

## BACKFILL MATERIALS AND COMPACTION

Maximum density, as used in this section, means Standard Proctor Maximum Dry Density (ASTM Test D698) unless specified noted otherwise. Optimum moisture content is as defined in this text.

"General engineered fill" materials should comprise clean, well-graded granular soils or inorganic, low-plastic cohesive soils. Such material should be placed in compacted lifts not exceeding 200 mm and compacted to not less than 98 percent of maximum density, at a moisture content at or slightly above optimum.

"Structural fill" materials should comprise clean, well-graded inorganic granular soils. Such fill should be placed in compacted lifts not exceeding 150 mm and compacted to not less than 98 percent of maximum density, at a moisture content at or slightly (0 to 3 percent) above optimum.

"Landscape fill" material may comprise soils without regard to engineering quality. Such soils should be placed in compacted lifts not exceeding 300 mm and compacted to a density of not less than 90 percent of maximum density.

Backfill adjacent to and above footings, abutment walls, basement walls, grade beams and pile caps or below highway, street or parking lot pavement sections should comprise general engineered fill materials as defined above.

Backfill supporting structural loads should comprise structural fill materials as defined above.

Backfill adjacent to exterior footings, foundation walls, grade beams and pile caps and within 300 mm of final grade should comprise low-plastic cohesive general engineered fill as defined above. Such backfill should provide a relatively impervious surface layer to reduce seepage in the sub-soil.

Backfill should not be placed against a foundation structure until the structure has sufficient strength to withstand the earth pressures resulting from placement and compaction. During compaction, careful observation of the foundation wall for deflection should be carried out continuously. Where deflection is apparent, the compactive effort should be reduced accordingly. In order to reduce potential compaction induced stresses, only hand held compaction equipment should be used in the compaction of fill within 500 mm of retaining walls or basement walls.

Backfill materials should not be placed in a frozen state or placed on a frozen subgrade. All lumps of materials should be broken down during placement.

Where the maximum-sized particles in any backfill material exceed 50 percent of the lift thickness or minimum dimension of the cross-section to be backfilled, such particles should be removed and placed at other more suitable locations on site or screened-off to delivery to site.

Bonding should be provided between backfill lifts, if the previous life has become desiccated. For fine-grained materials, the previous lift should be scarified to 75 mm in depth followed by proper moisture conditioning and recompaction.

Recommendations for the specifications for various backfill types are presented below.

"Clean, well-graded inorganic granular soils" should conform to the following grading:

| SIEVE SIZES (SQUARE OPENINGS) | PERCENT PASSING BY WEIGHT |
|---|---|
| 200 mm | 100 of Total Sample |
| 150 mm | 96 - 100 of Total Sample |
| 75 mm | 60 - 80 of Total Sample |
| 25 mm | 70 - 100 of Material Passing 75 mm Sieve |
| 4.75 mm | 25 - 63 of Material Passing 75 mm Sieve |
| 1.18 mm | 14 - 41 of Material Passing 75 mm Sieve |
| 0.60 mm | 7 - 30 of Material Passing 75 mm Sieve |
| 0.15 mm | 3 - 18 of Material Passing 75 mm Sieve |
| 0.075 mm | 2 - 9 of Material Passing 75 mm Sieve |

Any grading variation from the above should be at the discretion of the Engineer; however, the percent of material passing the 0.075 mm sieve size should not exceed ⅔ of the material passing the 0.6 mm sieve. The pit-run gravel should be free of any form of coating and any gravel containing clay, loam or other deleterious materials should be rejected. No oversized material should be tolerated.

"Crushed gravel", should conform to the following grading:

PERCENT PASSING BY WEIGHT
NOMINAL GRAVEL SIZE

| SIEVE SIZES (SQUARE OPENINGS) | 100 mm | 50 mm | 25 mm |
|---|---|---|---|
| 100 mm | 100 | --- | --- |
| 75 mm | 90 - 100 | --- | --- |
| 50 mm | --- | 100 | --- |
| 40 mm | 60 - 80 | 90 - 100 | --- |
| 25 mm | --- | --- | 100 |
| 20 mm | 40 - 66 | 50 - 75 | 95 - 100 |
| 10 mm | 25 - 54 | 25 - 52 | 60 - 80 |
| 4.75 mm | 15 - 43 | 15 - 40 | 40 - 60 |
| 2.36 mm | 10 - 35 | 10 - 33 | 28 - 48 |
| 0.60 mm | 5 - 23 | 5 - 23 | 13 - 29 |
| 0.30 mm | --- | --- | 9 - 21 |
| 0.15 mm | 3 - 12 | 2 - 14 | 6 - 15 |
| 0.075 mm | 2 - 10 | 1 - 10 | 4 - 10 |

Gravel:

100 mm Crushed Gravel: At least 13 percent by weight of the material retained on the 4.75 mm sieve should have two more fractured faces.

50 mm Crushed Gravel: At least 13 percent by weight of the material retained on the 4.75 mm sieve should have two more fractured faces.

25 mm Crushed Gravel: At least 50 percent by weight of the material retained on the 4.75 mm sieve should have two more fractured faces.

Any gravel containing deleterious material should be rejected.

"Coarse gravel" for bedding and drainage should conform to the following grading:

| | PERCENT PASSING BY WEIGHT (NOMINAL GRAVEL SIZE) | |
|---|---|---|
| SIEVE SIZES (SQUARE OPENINGS) | 50 mm | 40 mm |
| 50 mm | 100 | --- |
| 40 mm | 90 - 100 | 100 |
| 25 mm | --- | 95 - 100 |
| 20 mm | 35 - 70 | --- |
| 15 mm | --- | 25 - 60 |
| 10 mm | 10 - 30 | --- |
| 4.75 mm | 0 - 5 | 0 - 10 |
| 2.36 mm | --- | 0 - 5 |

"Coarse sand" for bedding and drainage should conform to the following grading:

| SIEVE SIZES (SQUARE OPENINGS) | PERCENT PASSING BY WEIGHT |
|---|---|
| 10 mm | 100 |
| 4.75 mm | 95 - 100 |
| 2.36 mm | 80 - 100 |
| 1.18 mm | 50 - 85 |
| 0.60 mm | 25 - 60 |
| 0.30 mm | 10 - 30 |
| 0.15 mm | 2 - 10 |

"Lean-mix concrete" should be low strength concrete having a minimum 28 days compressive strength of 3.5 MPa.

## SHALLOW FOUNDATIONS

Design and construction of shallow foundations should comply with relevant Building Code requirements.

The term "shallow foundations" includes strip and spread footings, mat slab and raft foundations.

Minimum footing dimensions in plan should be 0.45 m and 0.9 m for strip and square footings, respectively.

No loose, disturbed or sloughed material should be allowed to remain in open foundation excavations. Hand cleaning should be undertaken to prepare an acceptable bearing surface. Recompaction of disturbed or loosened bearing surface may be required.

Foundation excavation and bearing surfaces should be protected from rain, snow, freezing temperatures, drying and the ingress of free water, during and after footing construction.

Footing excavations should be carried down into the designated bearing stratum.

After the bearing surface is approved, a mud slab should be poured to protect the soil and provide a working surface for construction, should immediate foundation construction not be intended.

All constructed foundations should be placed on unfrozen soils, which should be at all times protected from frost penetration.

All foundation excavations and bearing surface should be observed by a qualified geotechnical engineer to confirm that the recommendations contained in this report have been followed and that soil conditions are consistent with those assumed in the design.

Where over-excavation has been carried out through a weak or unsuitable stratum to reach into a suitable bearing stratum or where a foundation pad is to be placed above stripped natural ground surface, such over-excavation may be backfilled to subgrade elevation utilizing either structural fill or lean-mix concrete. These materials are defined under the separate heading "Backfill Materials and Compaction."

## CONSTRUCTION EXCAVATIONS

Construction should be in accordance with good practice and comply with the requirements of the responsible agencies.

All excavations greater than 1.5 m deep should be sloped or shored for work protection.

Shallow excavations up to 3 m depth may use temporary side slopes of 1H:1V. A flatter slope of 2H:1V should be used if groundwater is encountered. Localized sloughing can be expected from these slopes.

Deep excavations or trenches may require temporary support if space limitations or economic considerations preclude the use of sloped excavations.

For excavations greater than 3 m depth, temporary support should be designed by a qualified geotechnical engineer. The design and proposed installation and construction procedures should be submitted to McIntosh•Lalani Engineering Ltd. for review.

The construction of a temporary support system should be monitored. Detailed records should be taken of installation methods, materials, in situ conditions and the movement of the system. If anchors are used, they should be load tested. McIntosh•Lalani Engineering Ltd. can provide further information on monitoring and testing procedures, if required.

Attention should be paid to structures or buried service lines close to the excavation. For structures, a general guideline is that if a line projected down at $45^0$ from a horizontal, from the base of foundations of adjacent structures, intersects the extent of the proposed excavation, then these structures may require underpinning or special shoring techniques to avoid damaging earth movements. The need for any underpinning or special shoring techniques and the scope of monitoring required can be determined when details of the service ducts and vaults, foundation configuration of existing buildings and final design excavation levels are known.

No surface surcharges should be placed closer to the edge of the excavation than a distance equal to the depth of the excavation, unless the excavation support system has been designed to accommodate such surcharge.

## FLOOR SLABS-ON-GRADE

All soft, loose or organic material should be removed from beneath slab areas. If any local hard spots such as old basement walls are revealed beneath the slab area, these should be over-excavated and removed to not less than 0.9 m below underside of slab level. The exposed soil should be proof-rolled and the final grade restored by general engineered fill placement. If proof-rolling reveals any soft or loose spots, these should be excavated and the desired grade restored by general engineered fill placement. Proof-rolling should be carried out in accordance with the recommendations given elsewhere in this Appendix. The subgrade should be compacted to a depth of not less than 0.3 m to density of not less than 98 percent Standard Proctor Maximum Dry Density (ASTM Test Method D698).

If for economic reasons, it is considered desirable to leave low quality material in place beneath a slab-on-grade, special ground treatment procedures may be considered. McIntosh•Lalani Engineering Ltd. could provide additional advice on this aspect, if required.

A levelling course of structural fill at least 150 mm in compacted thickness is recommended directly beneath all slabs-on-grade. Alternatively, a minimum thickness of 150 mm of pit-run gravel overlain by a minimum thickness of 50 mm of crushed gravel may be used. Very coarse material (larger than 25 mm diameter) should be avoided directly beneath the slabs-on-grade to limit potential stress concentrations within the slab.

General engineered fill, structural fill, pit-run gravel and crushed gravel are defined under the heading "Backfill Materials and Compaction" elsewhere in this Appendix.

If the slab will receive a vapor sensitive floor covering, or the project will include a humidity controlled area, the use of a vapor retarder beneath the slab is recommended. Without a vapor retarder, moisture can build up beneath resilient floor covering over time resulting in delamination, even if the concrete has dried sufficiently prior to flooring application. Vapor retarders are generally plastic, in sheet or roll form, and should conform to ASTM E1745, 'Standard Specification for Water Vapour Retarders used in Contact with Soil or Granular Fill under Concrete Slabs'. They should be located either directly beneath the concrete or beneath a granular blotter layer, depending upon project specific schedule and requirements. AC1 302.2R, 'Guide for Concrete Slabs that Receive Moisture - Sensitive Flooring Materials', provides an extensive discussion on concrete moisture and guidance on the use of vapour retarders.

The slab should be structurally independent from walls and columns supported on foundations. This is to reduce any structural distress that may occur as a result of differential soil movements. If it is intended to place any internal non-load bearing partition walls directly on a slab-on-grade, such walls should be structurally independent from other elements of the building founded on a conventional foundation system so that some relative vertical movement of the walls can occur freely.

The excavated subgrade beneath slabs-on-grade should be protected at all times from rain, snow, freezing temperatures, excessive drying and the ingress of free water. This applies during and after the construction period.

A minimum slab concrete thickness of 100 mm is recommended. Control joints should be provided in all slabs. Typically for a 125 mm slab thickness, control joints should be placed on a 3 m square grid, should be sawn to a depth of one-quarter the slab thickness and have a width of approximately 3 mm.

Wire mesh reinforcement, 150 mm square grid, should be provided to reduce the possibility of uncontrolled slab cracking. The mesh should be adequately supported and should be located at or above mid-height of the slab with adequate cover.