

*Providing Innovative Solutions to
Subsurface Problems Since 1985*



REPORT OF
GEOTECHNICAL EXPLORATION

NARBERTH COMMUNITY BUILDING TERRACE ADDITION
80 WINDSOR AVENUE
NARBERTH BOROUGH, MONTGOMERY COUNTY, PA

PREPARED FOR

BOROUGH OF NARBERTH
c/o CIRILLI ASSOCIATES
1489 BALTIMORE PIKE
SUITE 228
SPRINGFIELD, PA 19064

PROJECT 4545G1R1
April 7, 2015

DAVID BLACKMORE AND ASSOCIATES, INC.
3335 WEST RIDGE PIKE
POTTSTOWN, PENNSYLVANIA 19464
(610) 495-6255

Mr. Brian D. McCree, PE
Vice President

Matthew T. Uhrig, EIT
Geotechnical Engineer

TABLE OF CONTENTS

	<u>PAGE</u>
EXECUTIVE SUMMARY	4
1. INTRODUCTION	6
2. PROPOSED CONSTRUCTION	6
3. GEOTECHNICAL EXPLORATION	7
4. GEOTECHNICAL BACKGROUND	7
4.1 SITE DESCRIPTION	7
4.2 GEOLOGY	8
4.3 SOILS	8
5. LABORATORY TESTING	9
6. SUBSURFACE CONDITIONS	9
7. GEOTECHNICAL ANALYSIS AND RECOMMENDATIONS	10
7.1 SITE PREPARATION	12
7.2 SOIL REPLACEMENT	13
7.2.1 SEISMIC SITE COEFFICIENT	14
7.3 SLAB ON-GRADE	15
7.4 BACKFILL OF FOUNDATION AND UTILITY TRENCHES	16
7.5 PAVEMENTS AND WALKWAYS	16
7.6 FILL AND COMPACTION CRITERIA	16
7.7 LATERAL EARTH PRESSURES - RETAINING WALLS	17
8. QUALITY CONTROL	18
9. LIMITATIONS	19

FIGURES AND TABLES

FIGURE I: *SITE LOCATION*

FIGURE II: *GEOLOGY*

FIGURE III: *SOILS*

TABLE I: *LABORATORY TEST RESULTS*

TABLE IIA: *APPROXIMATE ROCK and FILL ELEVATIONS*

TABLE IIB: *APPROXIMATE GROUNDWATER ELEVATIONS*

TABLE III: *COMPACTION CRITERIA*

APPENDIX

SOIL PARTICLE SIZE ANALYSIS RESULTS
SOIL PLASTIC AND LIQUID LIMIT TEST RESULTS
TEST BORING LOGS
BORING LOCATION PLAN

EXECUTIVE SUMMARY

Purpose

This exploration was completed to evaluate the subsurface conditions and their effect upon the proposed site development. This exploration focused on the proposed terrace addition to the existing Narberth Community Building located at 80 Windsor Avenue in Narberth Borough, Montgomery County, PA.

Scope

A total of five (5) borings were completed at the subject site. The proposed borings were drilled within the proposed terrace addition area to a maximum depth of 20 feet or auger refusal on schist bedrock. The test borings were located in the field by DBA personnel using the Terrace Plan prepared by Brawer & Hauptman Architects numbered A1 dated 02/28/2013. Site design was underway during the implementation of our exploration. Therefore, final site design may vary from the preliminary design used to complete this exploration. A copy of the site plan used for our exploration which has been annotated with our test boring locations is included in the appendix of this report.

Findings

Preliminary findings include the following:

- Existing fill soils
- Compressible organic silt
- Shallow depths to groundwater

The results of our exploration indicate the presence of existing fill material (Stratum IF) across the addition footprints to depths ranging from 4.3 feet to 8.8 feet below existing grade. This existing fill material is considered to vary from loose to moderately dense and consists of brown and orange brown fine sand and silt with quartz and schist fragments and occasional roots. A 0.58 to 2.92 feet thick layer of brown and gray organic silt (Stratum I) was encountered below this fill material. Laboratory analysis of this material indicates an organic content (by weight) ranging from 1.93% to 5.20%. Dense weathered rock (DWR), as determined by SPR data and auger difficulty was encountered predominately at the north and west portions of the site at depths ranging from 11 feet to 19 feet below existing grade in borings B1 through B3. Bedrock, as determined by auger refusal, was encountered in borings B1 and B2 at depths of 13.8 feet and 16.3 feet below existing grade, respectively. See Table IIA – Approximate Rock and Fill Elevations for information regarding the depths and relative elevations at which rock was encountered in each test boring completed.

Groundwater was encountered in each test boring completed at depths ranging from 6.6 feet to 9.2 feet below existing grade. In general, the groundwater surface elevation is shallowest at the southwest end of the site and becomes deeper in a northern direction. See Table IIB – Approximate Groundwater Elevations for depths and elevations at which groundwater was encountered in each test boring.

Recommendations:

Comparing the existing topography with the proposed elevation of the proposed terrace, an embankment of up to 4.2 feet of *structural fill* will be required to achieve the proposed terrace elevation. Due to this fill placement and the variability in both the content and strength of the existing fill material of Stratum IF, there is a risk of settlement of the terrace slab. The complete removal and replacement of the existing fill material of Stratum IF would resolve this problem. However this approach is considered to be economically infeasible for a project of this size. Therefore, as an alternative, DBA recommends the removal of 2 feet of the existing fill material. After this material is removed, the exposed subgrade shall be densified in-place and evaluated through a proofroll via a heavy (minimum 15-ton) smooth drum roller to detect the presence of any soft conditions. Any soft conditions encountered shall be repaired to the satisfaction of the Geotechnical Engineer. In order to minimize the potential for differential settlement within the terrace footprint, a geosynthetic reinforced rigid stone layer shall be installed on the exposed subgrade prior to fill placement to construct the terrace embankment.

Our settlement analysis indicates that the total settlement of the terrace addition is estimated to be on the order of 1 inch. Settlements of this magnitude are typically considered to be within normal construction tolerances, the differential settlement between the terrace and the existing Community Building may create a tripping hazard. The partial soil exchange procedure will mitigate this condition to some extent. In an effort to further reduce the total settlement of the proposed terrace, the use of a lightweight fill alternative for the construction of the terrace embankment can be considered. The use of this material in lieu of traditional fill material would reduce the stress imposed on the loose underlying soils and consequently reduce the magnitude of settlement. For additional information regarding these alternatives, see Section 7.2 – Soil Replacement.

1. INTRODUCTION

David Blackmore and Associates, Inc. (DBA) has completed the geotechnical exploration of the subject site in accordance with our Proposal 4545G1P1, dated May 14, 2014. This Exploration was completed to evaluate the existing subsurface conditions and their effect upon the proposed site development. Specifically, DBA has provided recommendations regarding the following:

- Foundation support of the structure and slabs, including soil bearing pressures, bearing elevations, foundation design recommendations and anticipated settlement for shallow foundations,
- Depth to material requiring rock excavation methods for removal, if encountered,
- Depth to and management of groundwater for design of structures and pavements, if encountered
- Relative elevations of surface and subsurface features,
- Fill and compaction criteria,
- Pavements and floor slabs,
- Lateral earth pressures for retaining walls, and
- General geotechnical related construction procedures.

The following section (2. PROPOSED CONSTRUCTION) summarizes the information available to DBA regarding the proposed site development. This report has been prepared based on the proposed construction. Changes to the proposed construction may require alterations to this report or additional investigative work. DBA should be notified of significant changes to the proposed construction.

2. PROPOSED CONSTRUCTION

The proposed construction consists of a terrace to the existing Narberth Community Building, including steps, railings, lighting, receptacles, and underground rainwater piping. The terrace is to cover a footprint area of +/- 2,000 square feet, spanning the west side of the existing structure and wrapping around the southwest corner. The terrace will consist of slab on grade construction with a finished elevation that will match the Community Building finished floor elevation.

3. GEOTECHNICAL EXPLORATION

A total of five (5) borings were completed at the subject site. The proposed borings were drilled within the proposed terrace addition area to a maximum depth of 20 feet or auger refusal on schist bedrock.

The test borings were located in the field by DBA personnel using the Terrace Plan prepared by Brawer & Hauptman Architects numbered A1 dated 02/28/2013. The test borings were drilled by our subcontractor, **The Corcoran Drilling Company**, under the direction of DBA personnel.

All test boring logs and a test boring location plan are included in the appendix of this report.

4. GEOTECHNICAL BACKGROUND

4.1 SITE DESCRIPTION

The subject site is located at the west and south portions of the property of the Narberth Community Building located at 80 Windsor Avenue in Narberth Borough, Montgomery County, PA. These portions of the site consist of landscaped lawn area with medium to large sized trees scattered throughout the area. The southeast corner of the proposed terrace addition is located within an existing paved parking/driveway area. At the time of preparing this report, there was no topographic survey data available; therefore an elevation of 100 feet was arbitrarily assigned to the finished floor of the existing Community Building in order to provide more specific recommendations for the proposed construction. The terrace elevation will match this finished floor elevation to provide access to the terrace from the Community Building. Using the surface elevations of the borings determined in the field, the low point of the site is 95.8 feet (relative to the assigned finished floor elevation of 100 feet) at the southwest corner of the site, at boring B3. The grade then gently slopes to the north and east to an elevation of 96.5 feet at both boring B1 and B5.

A photocopy of the USGS Topographical Map, Norristown Quadrangle, indicating the site is included as Figure I.

4.2 GEOLOGY

Available geological sources indicate the site is underlain by **Wissahickon Formation – Oligoclase-mica Schist (Xw)**. This rock consists primarily of quartz, feldspar, muscovite, and chlorite, and is excessively micaceous. Bedding of this formation is fissile to thin and steeply dipping in most places. Fracturing is highly abundant, very closely spaced, open and steeply dipping. Joints are primarily poorly formed, widely spaced, dipping and open. This formation is moderately resistant to weathering and is often weathered to a moderate depth. Weathering results in uneven, hackly, small sized, plate-like rubble at the base of exposure.

A photocopy of the USGS Geological Map of the Norristown Quadrangle, indicating the site is included as Figure II.

4.3 SOILS

Soil records indicate the site soils to be of the following series:

Urban land - Glenelg complex, 0 to 8 percent slopes (UrmB): This soil type consists of soils of the Glenelg series as well as Urban land soils. **Urban land** soils are variable due to earthmoving which has destroyed or covered the soil's natural profile. The parent material of this soil consists of pavement, buildings and other artificially covered areas. **Glenelg series** soils are primarily composed of loamy residuum weathered from schist and phyllite. It is typically well drained with a moderately high to high capacity to transmit water in the most limiting layer. A typical profile of this soil type can be described as: 0 to 10 inches – loam; 10 to 30 inches – clay loam; 30 to 54 inches – loam; 54 to 80 inches – very channery sandy loam.

A photocopy of site mapping prepared at the USDA Natural Resources Conservation Service website indicating the site is included as Figure III.

5. LABORATORY TESTING

Representative soil samples taken during the field exploration were tested in DBA's laboratory for basic engineering properties. The laboratory testing consisted of classification of soil samples for engineering purposes. The laboratory testing included Particle Size Analysis (ASTM D442), Plastic and Liquid Limits (ASTM D4318), and Natural Moisture Content (ASTM D2216). The Unified Soil Classification System (USCS) was used to assign group symbols and group names to the soils tested.

A summary of the test results is provided on Table I. A photocopy of the particle size analysis results and the plastic and liquid limit analysis results are included in the appendix of this report.

6. SUBSURFACE CONDITIONS

The results of the drilling program revealed a fairly consistent subsurface profile. The following strata, beneath 4" to 6" of topsoil in landscaped lawn or 3" of asphalt and 11" of modified stone in paved areas, can describe a typical soil profile.

Stratum IF: 3.16' to 5.33' thick; FILL consisting of orange brown and brown micaceous fine sand and silt with some quartz fragments, occasional roots and schist fragments. This stratum is considered to be variable in density with SPR¹ values ranging from 3 blows per foot (B/F) to 10 B/F. This stratum was encountered in each of the test borings completed.

Stratum I: 0.58' to 2.92' thick; Brown and gray organic silt with roots. This stratum is considered to be relatively loose to loose with SPR¹ values ranging from 1 blow per foot (B/F) to 7 B/F. The average SPR value for this stratum is 5 B/F. Laboratory testing of representative soil samples retrieved from this stratum indicates organic contents (by weight) ranging from 1.93% to 5.20%. This stratum was encountered in each of the test borings completed.

Stratum II: 3.0' to 5.17' thick; Orange brown and gray mottled fine sand with some silt, occasional rock fragments. This stratum is considered to be loose to moderately dense with SPR values ranging from 6 B/F to 17 B/F. The average SPR value is

¹ SPR = is the Standard Penetration Resistance or number of blows required of a 140 pound hammer dropping 30", to drive a 2" OD split spoon sampler one foot.

11.4 B/F. This stratum was encountered in each of the test borings completed.

Stratum III: 4.75' to 9.25' thick; Gray, brown and orange brown weathered schist. This stratum is considered to be moderately dense to very dense with SPR values ranging from 14 B/F to 50 blows per 2 inches of penetration. The average SPR value for this stratum is 49 B/F. Low SPR values ranging from 2 to 5 B/F were measured within the upper portion of this stratum. The low blows counts can be attributed to the release of hydrostatic pressure during the drilling procedure and is not considered to be indicative of that actual density of this stratum. These values were not used for calculation of the average SPR value for this stratum. This stratum was encountered in each of the test borings completed.

Bedrock: Bedrock was encountered in borings B1 and B2 at depths ranging of 13.8 feet and 16.3 feet below existing grade, respectively. In general, the bedrock surface slopes downward in a southern direction. See Table IIA – Approximate Rock and Fill Elevations for information regarding the depths and relative elevations at which rock was encountered in each test boring completed.

Groundwater²: Groundwater was encountered in each test boring completed at depths ranging from 6.6 feet to 9.2 feet below existing grade. In general, the groundwater surface elevation is shallowest at the southwest end of the site and becomes deeper in a northern direction. See Table IIB – Approximate Groundwater Elevations for depths and elevations at which groundwater was encountered in each test boring.

7. GEOTECHNICAL ANALYSIS AND RECOMMENDATIONS

The results of our exploration indicate the presence of existing fill material (Stratum IF) across the addition footprints to depths ranging from 4.3 feet to 8.8 feet below existing grade. This existing fill material is considered to vary from loose to moderately dense and consists of brown and orange brown fine sand and silt with quartz and schist fragments and occasional roots. A 0.58 to 2.92 feet thick layer of brown and gray organic silt (Stratum I) was encountered below this fill material. Laboratory analysis of this material indicates an organic content (by weight) ranging from 1.93% to 5.20%. Beneath the organic silt, a 3.0 to 5.17 foot thick layer of orange

² The groundwater information provided is based on conditions encountered during the drilling program. Seasonal fluctuations in the groundwater table are to be expected.

brown and gray mottled fine sand and silt with occasional schist fragments (Stratum II) was encountered which transitions into gray, brown, and orange brown weathered schist (Stratum III). Dense weathered rock (DWR), as determined by SPR data and auger difficulty was encountered predominately at the north and west portions of the site at depths ranging from 11 feet to 19 feet below existing grade in borings B1 through B3. Bedrock, as determined by auger refusal, was encountered in borings B1 and B2 at depths of 13.8 feet and 16.3 feet below existing grade, respectively. See Table IIA – Approximate Rock and Fill Elevations for information regarding the depths and relative elevations at which rock was encountered in each test boring completed.

Groundwater was encountered in each test boring completed at depths ranging from 6.6 feet to 9.2 feet below existing grade. In general, the groundwater surface elevation is shallowest at the southwest end of the site and becomes deeper in a northern direction. See Table IIB – Approximate Groundwater Elevations for depths and elevations at which groundwater was encountered in each test boring.

Comparing the existing topography with the proposed elevation of the proposed terrace, an embankment of up to 4.2 feet of *structural fill* will be required to achieve the proposed terrace elevation. Due to this fill placement and the variability in both the content and strength of the existing fill material of Stratum IF, there is a risk of differential settlement of the terrace slab. In order eliminate this risk, the complete removal and replacement of the existing fill material of Stratum IF and underlying organic silt of Stratum I from beneath the proposed terrace addition and replacement with *structural fill* would be required. However, the removal and replacement alternative is considered to be economically infeasible for a project of this size.

As an alternative to the complete removal of the existing fill within the proposed terrace footprint, DBA recommends the removal of 2 feet of the existing fill material.

After this material is removed, the exposed subgrade shall be densified in-place and evaluated through a proofroll via a heavy (minimum 15-ton) smooth drum roller to detect the presence of any soft conditions. Due to the loose nature of the existing fill material of Stratum IF, localized subgrade repair consisting of removal of unsuitable material and replacement with *structural fill* shall be anticipated. In order to minimize the potential differential settlement within the terrace footprint, a geosynthetic reinforced rigid stone layer shall be installed on the exposed subgrade prior to fill placement to construct the terrace embankment. The subgrade evaluation and stabilization is to be completed under the direction of the Geotechnical Engineer.

Our settlement analysis indicates that the total settlement of the terrace addition is estimated to be on the order of 1 inch. Settlements of this magnitude are typically considered to be within normal construction tolerances, the differential settlement between the terrace and the existing Community Building may create a tripping hazard. The partial soil exchange procedure will mitigate this condition to some extent. In an effort to further reduce the total settlement of the proposed terrace, the use of a lightweight fill alternative for the construction of the terrace embankment can be considered. The use of this material in lieu of traditional fill material would reduce the stress imposed on the loose underlying soils and consequently reduce the magnitude of settlement. For additional information regarding these alternatives, see Section 7.2 – Soil Replacement.

7.1 SITE PREPARATION

All deleterious materials including topsoil, root mass, trees and vegetation, asphalt and other materials determined in the field by the Geotechnical Engineer to be unsuitable shall be removed from all structural areas (buildings, pavements and walkways) prior to placement of *structural fill*. Recycling of the asphalt and underlying stone can be accomplished on site if the asphalt is milled

to a maximum 1 inch particle size and the material is used in the upper fill zones of pavement areas only. This fill is not suitable for other structural areas.

7.2 SOIL REPLACEMENT

Comparing the existing topography with the proposed elevation of the proposed terrace, it is anticipated that an embankment of up to 4.2 feet of *structural fill* will be required to achieve the proposed terrace elevation. Due to this fill placement and the variability in both the content and strength of the existing fill material of Stratum IF, there is a risk of settlement of the terrace slab. In order to eliminate this risk, the complete removal and replacement of the existing fill material of Stratum IF and underlying organic silt of Stratum I from beneath the proposed terrace addition and replacement with *structural fill* would be required. In addition this removal shall extend beyond the building footprint for a minimum lateral distance equal to the removal depth to ensure adequate lateral stability. However, the removal and replacement alternative is considered to be economically infeasible for a project of this size.

As an alternative to the complete removal of the existing fill within the proposed terrace footprint, DBA recommends the removal of 2 feet of the existing fill material. After this material is removed, the exposed subgrade shall be densified in-place and evaluated through a proofroll via a heavy (minimum 15-ton) smooth drum roller to detect the presence of any soft conditions. Due to the loose nature of the existing fill material of Stratum IF, localized subgrade repair consisting of removal of unsuitable material and replacement with *structural fill* shall be anticipated. In order to minimize the potential differential settlement within the terrace footprint, geosynthetic reinforcement via a layer of Tensar BX Type 1 (or approved equal) geogrid shall be placed on the exposed subgrade prior to placing fill to build the terrace embankment. The geosynthetic reinforcement shall be covered with a 12" to 18" of dense graded aggregate meeting the

gradation requirements of PADOT 2A stone. The subgrade evaluation and stabilization is to be completed under the direction of the Geotechnical Engineer.

DBA performed a settlement analysis of the embankment under the proposed loading assuming a partial replacement of the existing fill material. This analysis considered normally consolidated conditions and an embankment material weight of 140 lb/ft³. Based on these assumptions, an estimated settlement of **1.0 inch** was calculated. While settlements of this magnitude are typically considered within normal construction tolerances, the differential settlement between the Community Building and the proposed terrace may cause a tripping hazard. The partial soil exchange procedure will mitigate this condition to some extent. If this condition is considered to be unacceptable, In an effort to further reduce the total settlement of the proposed terrace, the use of a lightweight fill alternative for the construction of the terrace embankment can be considered. Options for lightweight fill options include expanded aggregate material and Geofoam. The use of this material in lieu of traditional fill material would greatly reduce the stress imposed on the loose underlying soils and consequently reduce the magnitude of settlement. In the event the use of a lightweight fill alternative is determined to be necessary, DBA can provide further direction and calculate anticipated settlement reduction.

7.2.1 SEISMIC SITE COEFFICIENT

A review of Section 1613.5.5 of the International Building Code (IBC 2006 edition) and the existing soil profile indicates that a site class C should be used in the design of the proposed structure for seismic load resistance.

7.3 SLAB ON-GRADE

The proposed terrace elevation will reportedly match the existing community building's finish floor elevation of 100.0, which was assigned arbitrarily for discussion purposes of this report. This elevation compared to the existing topography indicates that the placement of up to 4.2 feet of *structural fill* of existing fill with *structural fill* will be required. Prior to the placement of this fill, the soil replacement procedure set forth in Section 7.2 shall be completed.

Upon completion of the soil replacement and prior to the placement of fill to achieve the proposed terrace grades, the exposed slab subgrade areas shall be proofrolled with a heavy smooth drum roller (minimum 15 ton static weight) to detect the presence of loose or soft zones. This proofrolling operation shall be performed in the proposed fill areas under the supervision of the Geotechnical Engineer. Proofrolling of the subgrade shall also be performed in the cut areas when the required grades have been achieved and immediately prior to pouring the floor slab. Loose or soft zones detected during the proofrolling operation shall be repaired to the satisfaction of the Geotechnical Engineer.

Based on the soil type encountered, standard penetration testing of the existing slab subgrade and provided that all structural fill will be placed in accordance with the fill and compaction criteria set forth in Section 7.7 an estimated modulus of subgrade reaction of 150 psi/inch may be used for the design of slab sections. Should an increased modulus of subgrade reaction be required for the proposed design it is recommended that field or laboratory testing be completed to establish specific modulus values.

All slab subgrade areas shall be evaluated by the Geotechnical Engineer prior to pouring the slab so that repair can be completed. It is recommended that the slab be poured under roof during periods of harsh weather.

A smooth drum roller shall be made available to seal the subgrade in the event of predicted precipitation.

7.4 BACKFILL OF FOUNDATION AND UTILITY TRENCHES

All foundation and utility trenches shall be backfilled with *structural fill*, under the supervision of a Geotechnical Engineer (Refer to Section 7.7, Fill and Compaction Criteria).

7.5 PAVEMENTS AND WALKWAYS

Pavement and sidewalk areas shall be prepared in a manner similar to the slab on-grade areas. A minimum of 8 inches of crushed aggregate base shall be used beneath exterior pavements due to the frost heave potential of the subgrade soils. The pavement subgrade shall be graded to drain water from beneath the pavement system to prevent ponding and subsequent pumping of silty subgrade soils.

For pavement design a preliminary estimated California Bearing Ratio (CBR) Value of 5.0 may be used for stabilized subgrade areas consisting of stabilized portions of on-site existing fill consisting of silty sand (Stratum IF) or *structural fill* selected and placed in accordance with the Section 7.7 of this report. Should anticipated heavy duty pavement requirements or other project conditions require final site specific CBR values DBA can complete field and/or laboratory CBR testing of proposed subgrade soils at the client's request.

7.6 FILL AND COMPACTION CRITERIA

Fill supporting slabs, pavements, and foundations is considered herein to be *structural fill*. *Structural fill* shall be placed on an approved, proofrolled, nonyielding, level subgrade, in lifts not exceeding 8 inches (loose thickness), unless otherwise directed by the Geotechnical Engineer. *Structural fill* shall be maintained nominally at *Optimum Moisture Content* (ASTM D-698) and

uniformly compacted to the percentages of *Maximum Dry Density* (ASTM D-698) provided in Table III - Compaction Criteria.

Suitable *structural fill* shall consist of clean soils without deleterious inclusions. On-site soils identified as *Stratum II*, and *Stratum III*, are acceptable for use as *structural fill* if given the opportunity to dry and the soils are maintained nominally at *Optimum Moisture Content*. It is anticipated that the existing fill material of Stratum IF will be suitable for reuse as structural fill provided any deleterious/organic content is removed. The organic silt of Stratum I is NOT considered suitable for re-use as structural fill. Samples retrieved from the upper 5 feet of the subgrade indicated moisture contents ranging from 18.7 to 20.1 percent. The optimum moisture content for compaction of these soils is estimated to range between 14 and 18 percent. Therefore, some of these soils may require aeration and drying prior to re-use as structural fill, which is best accomplished in the summer months. Specific moisture content test results and associated depths are indicated on the test boring logs in the appendix of this report.

Borrow fill shall be clean well-graded soils with good strength characteristics with a maximum particle size of 3 inches and containing not more than 20% silt/clay (by weight). Samples of on-site or borrow sources of fill shall be submitted to the Geotechnical Engineer for testing at least 1 week before use on site. A minimum of 65 lbs. or two (2) five-gallon buckets is required for testing.

7.7 LATERAL EARTH PRESSURES - RETAINING WALLS

The retaining/loading dock walls of the structure, if proposed, should be designed for an at rest condition (K_0). The foundations and walls must be fully drained to relieve potential hydrostatic pressure. A foundation/wall drainage system is recommended. Soil backfill around the basement walls shall be well compacted and should consist of granular soils to prevent the trapping of water.

Retaining walls outside the structure which are free to rotate should be similarly designed except with an active earth pressure as opposed to K_0 condition. Soil parameters used to establish the effective fluid pressures (excluding hydrostatic loads) and some additional parameters which may be used in the design of a retaining wall system are summarized in the following table:

SOIL PROPERTIES FOR DETERMINATION OF LATERAL LOADS

Parameter	Stratum II	Stratum III
Angle of Internal Friction, ϕ	28 degrees	30 degrees
Moist unit weight, γ_m	125 pcf	120 pcf
Active Earth Pressure Coefficient, K_a	0.36	0.33
Passive Earth Pressure Coefficient, K_p	2.77	3.03
At Rest Earth Pressure Coefficient, K_0	0.53	0.50
Soil/Mass concrete interface friction Angle, δ	22 degrees	24 degrees

8. QUALITY CONTROL

This report was prepared to provide design criteria for the design team. DBA assumes that Geotechnical and Construction Quality Control Services will be provided in order to implement the recommendations provided herein and to identify unanticipated or changed conditions. The Geotechnical Engineer's representative should review the consistency and texture of the exposed soils with the conditions encountered by this exploration as described herein. Since localized loose and yielding subgrade conditions may be encountered between test locations, provisions for the undercutting and subsequent replacement of these materials should be anticipated in the construction documents. The environmental quality of the subgrade soils was not reviewed as part of this evaluation. All materials generated

by grading and excavation shall be managed in accordance with regulatory requirements.

DBA can provide a contract for Geotechnical and Construction Quality Control Services (Special Inspections), as required. A pre-work meeting with the design professionals, contractors, and the Geotechnical Engineer is strongly recommended.

9. LIMITATIONS

Services performed by DBA, including the Geotechnical Exploration, report, and any subsequent construction monitoring have been or will be conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other warranty or guarantee is indicated or intended in this report or any opinion, document or otherwise stated.

The recommendations included herein are based on the conditions encountered by the test borings performed at the subject site. It is noted that, although soil quality has been inferred from the interpolation of the site sampling data, subsurface conditions beyond the test borings are in fact, unknown. As a result, these recommendations may require modifications based on the conditions encountered and exposed during construction excavation. Should any conditions encountered during construction differ from those described in the report, this office should be notified immediately in order to review and possibly modify the recommendations included in this report.

**TABLE I
LABORATORY TEST RESULTS**

BORING #	B1	B4	B4 B5
SAMPLE #	S-2 S-3	S-7 S-8	S-6 S-5
DEPTH	4'-6' 6'-8'	14'-16' 16'-18'	12'-14' 13'-15'
STRATUM	II	III	III
NMC* (%)	18.7 21.4	51.3 44.7	50.8 54.4

* NMC = Natural Moisture Content

SOIL PARTICLE SIZE DISTRIBUTION

SIEVE # PERCENT PASSING BY WEIGHT

3/4"	100.0	100.0	100.0
3/8"	96.1	100.0	100.0
4	93.9	100.0	100.0
10	90.3	99.2	99.8
40	75.6	94.3	97.5
100	53.0	71.9	67.4
200	37.0	57.6	37.5

ATTERBERG LIMIT ANALYSIS

LL*	N/A	N/A	N/A
PL*	N/A	N/A	N/A
PI*	N/A	N/A	N/A

* LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index

USCS CLASSIFICATION

Eng. Class.	SM	ML	SM
Descr.	Orange brown and gray silty sand	Brown sandy silt (weathered schist)	Brown silty sand (weathered schist)

TABLE I (CONT'D)
LABORATORY TEST RESULTS

BORING #	B3	B4	B5
SAMPLE #	S-2	S-3	S-3
DEPTH	4'-6'	6'-8'	6'-8'
STRATUM	I	I	I
NMC* (%)	38.92	26.52	20.11
ORG** (%)	5.20	2.76	1.93

* NMC = Natural Moisture Content

** ORG = Organic Silt Content

**TABLE IIA
APPROXIMATE ROCK ELEVATIONS**

Boring Number	Surface Elevation	Depth to Stratum II	Stratum II Surface Elevation	Depth to Dense Weathered Rock ¹	Dense Weathered Rock Elevation	Depth to Bedrock ²	Bedrock Elevation
B1	96.5 feet	4.3 feet	92.2 feet	11 feet	85.5 feet	13.8 feet	82.7 feet
B2	96.5 feet	6.3 feet	90.2 feet	13.8 feet	82.7 feet	16.3 feet	80.2 feet
B3	95.8 feet	6.8 feet	89.0 feet	19.0 feet	76.8 feet	>20.3 feet	<75.5 feet
B4	96.1 feet	7.0 feet	89.1 feet	>20.0 feet	<76.1 feet	>20.0 feet	<76.1 feet
B5	96.5 feet	8.8 feet	87.7 feet	>21.0 feet	<75.5 feet	>21.0 feet	<75.5 feet

NOTES:

Surface elevations at each boring location were determined using an arbitrary finished floor elevation of 100.0 for the existing Narberth Community Building.

¹ As determined by drilling difficulty and Standard Penetration Resistance data.

² As determined by auger refusal.

**TABLE IIB
APPROXIMATE GROUNDWATER ELEVATIONS**

Boring Number	Surface Elevation	Depth to Groundwater	Groundwater Elevation³
B1	96.5 feet	9.2 feet	87.3 feet
B2	96.5 feet	8.5 feet	88.0 feet
B3	95.8 feet	6.7 feet	89.1 feet
B4	96.1 feet	6.6 feet	89.5 feet
B5	96.5 feet	6.8 feet	89.7 feet

NOTES:

Surface elevations at each boring location were determined using an arbitrary finished floor elevation of 100.0 for the existing Narberth Community Building.

³ Groundwater information is based on conditions encountered during the field exploration. Seasonal fluctuation in groundwater elevation shall be expected.

**TABLE III
COMPACTION CRITERIA**

LOCATION	PERCENT COMPACTION (ASTM-D698)
Foundations	98%
Floor Slabs	98%
Pavements	95%
Berms(non structural)	93%

FIGURES AND TABLES

APPENDIX

SOIL PARTICLE SIZE ANALYSIS RESULTS

SOIL PLASTIC AND LIQUID LIMIT TEST RESULTS

TEST BORING LOGS

TEST BORING LOCATION PLAN