

Preliminary Geotechnical Investigation

SEH No.

July 1, 2008

July 1, 2008

RE:
Preliminary Geotechnical Investigation
SEH No.

Dear:

We have completed the preliminary geotechnical investigation for the proposed {Project Name}. The purpose of the investigation was to evaluate the suitability of the site for the proposed {Proposed Facility}. This letter summarizes the findings of the investigation and provides geotechnical recommendations for design and construction of the facility and associated utilities. Please refer to the report for more detailed information about the investigation.

Summary of Results

Soils around the site vary with location and topography. In general, higher portions of the site consist primarily of layers of clayey and silty sand tills intermixed with layers of cleaner poorly graded sand alluvium. Lower portions of the site, areas delineated as wetland, contain areas of swamp deposits and soft clayey alluvium and till. Fill soils were encountered in the area of the existing parking area and structure. Although the borings show a relatively thin layer of fill, less than 4 feet thick, visual observation of the fill along the eastern edge of the existing {Proposed Facility} indicates that fill thickness likely increase to the east of the borings and approaches a thickness of 15 feet. Given the slope of the face on the existing fill it is unlikely the fill was placed with the level of compactive effort that would be required to support a foundation. Corrective efforts will be needed to remove fill from under the footprint of the proposed structure.

Groundwater was encountered at most locations where borings were performed. The depth to groundwater ranged from nearly 20 feet in higher portions of the site to at or near the ground surface in the wetland areas. Given the soil conditions at the site, areas of perched water that may not have been detected during drilling should be anticipated around the site.

Recommendations and Conclusions

Construction of the {Project Features} at proposed locations will require soil correction to remove soft clayey alluvium and till along with swamp deposits. Extensive filling will be required if the proposed structure is to be constructed at the grade of the existing parking area. Suitable foundation fill may be obtained from the proposed borrow area west of {Proposed Facility} or the proposed borrow area on the eastern edge of the property.

Due to the extensive thickness of fill that will be required under the {Proposed Facility}, we recommend extending footings and column pads into the fill so that no more than 10 feet of fill is present under the foundation. Since the {Proposed Facility} and {Proposed Facility} are unlikely to be supported on a structural foundation, we recommend looking at alternative locations on the site for those features. Even with careful compaction control, placing the {Proposed Facility} and {Proposed Facility} on a large thickness of compacted fill will likely result in cracking of the {Proposed Facility} and {Proposed Facility} surface due to settlement.

This report concludes our scope of services for the preliminary geotechnical investigation phase of the {Project Name}. Please contact me at 651.490.2139 if you would like to discuss the results of the investigation or the recommendations.

July 1, 2008
Page 2

Sincerely,

, PE
Principal Geotechnical Engineer

Attachment: Geotechnical Report

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Preliminary Geotechnical Investigation

SEH No.

July 1, 2008

I hereby certify that this report was prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Date: July 1, 2008 Lic. No.: _____

Reviewed by: _____ July 1, 2008
Date

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Table of Contents

Letter of Transmittal
Certification Page
Table of Contents

	Page
1.0 Introduction.....	1
1.1 Background.....	1
1.2 Proposed Facility Details	1
1.3 Project Goals	1
1.4 Scope of Work	1
1.5 Site History and Reconnaissance	2
1.5.1 Aerial Photographs.....	2
1.5.2 Site Reconnaissance	2
1.6 Geotechnical Borings.....	3
1.7 Laboratory Analyses	3
1.8 Boring Elevations	3
2.0 Results.....	3
2.1 Soil Borings Logs	3
2.2 Materials Summary and site Stratigraphy	4
2.2.1 Bituminous Pavement	4
2.2.2 Topsoil.....	4
2.2.3 Swamp Deposits	4
2.2.4 Fill.....	5
2.2.5 Coarse Alluvium	5
2.2.6 Till.....	5
2.2.7 Fine Alluvium.....	5
2.2.8 Bedrock	5
2.3 Groundwater Conditions	6
2.4 Laboratory Results.....	7
3.0 Preliminary Geotechnical Conclusion and Recommendation	7
3.1 {Proposed Facility}.....	7
3.1.1 Structure and Site Description.....	7
3.1.2 Foundation Recommendations and Alternatives.....	8
3.1.2.1 Proposed Layout.....	8
3.1.2.2 Alternative Foundation Elevation	8
3.1.2.3 Structure Relocation	9
3.2 Exterior and	9
3.2.1 Structure and Site Description.....	9
3.2.2 Foundation Recommendations	9
3.3 Parking Lot and Access Roads.....	10
3.3.1 Site Description	10

Table of Contents (Continued)

3.3.2	Pavement Recommendations	11
3.4	Groundwater	11
3.4.1	11
3.4.2	{Proposed Facility}	12
3.4.3	Pavement Areas.....	12
3.5	Borrow Sources and Reuse of On-site Soils.....	12
3.5.1	Western Borrow Area	13
3.5.2	Eastern Borrow Area	13
3.5.3	Reuse of Excavated Soils for Fill.....	14
3.6	Backfill for Structures	14
3.7	Utility Trenching and Backfilling	14
3.7.1	Trenching	14
3.7.2	Bedding	15
3.7.3	Groundwater Control	15
3.7.4	Utility Trench Backfill Above the Pipe Zone	15
3.7.4.1	Beneath Structures	15
3.7.4.2	Beneath Paved Areas	15
3.7.4.3	All Other Areas.....	15
3.8	Exterior Slabs and Utility Pads.....	16
3.8.1	Sidewalks	16
3.8.2	Entrance Stoops.....	16
3.8.3	Utility Pads	16
4.0	Construction Considerations	16
4.1	Inclement Weather	16
4.1.1	Soil Compaction	16
4.1.2	Dewatering	16
4.2	Winter Construction	17
4.3	Excavation Safety	17
4.4	Field Observation and Testing	17
4.4.1	Excavation Observation	17
4.4.2	Compaction Testing	17
5.0	Basis of Recommendations.....	18

List of Tables

Table 1	Depth to Bedrock	6
Table 2	Groundwater Observed During Drilling	6
Table 3	Piezometer Data	7

Table of Contents (Continued)

List of Figures

Figure 1 – Soil Boring Locations

List of Appendices

Appendix A Report of Subsurface Borings {Name of Drilling Firm}

Preliminary Geotechnical Investigation

Prepared for the

1.0 Introduction

1.1 Background

This report summarizes the results of a geotechnical investigation for the {Owner Name}. The work was authorized as part of the {Project Name}.

A proposed site layout provided to SEH by {Owner Name} (included in Appendix A) indicates the facility will consist of {Project Features}.

1.2 Proposed Facility Details

1.3 Project Goals

The goals of the geotechnical investigation included:

- Defining soil types likely to be encountered during construction,
- Observing groundwater conditions during drilling, and from three (3) piezometers installed at boring locations selected by SEH,
- The development of parameters for foundation design including allowable bearing capacity, subgrade modulus, and equivalent fluid density for earth pressure against structures.
- Develop recommendations for construction including the suitability of site soils for use as fills, requirements for imported fills, and construction QA/QC testing.

Recommendations regarding moisture proofing or vapor barriers are not included in this report. Please refer to the discussion of the soil and groundwater conditions to determine if these features are necessary for the facility.

1.4 Scope of Work

The scope of services for the geotechnical investigation included:

- {Number of Borings} soil borings at the locations of structures, utilities and access roads.

-
- {Number} piezometers to monitor groundwater elevations,
 - Geotechnical laboratory testing to classify site soils and aid in the development of design parameters,
 - A geotechnical engineering report presenting results of the borings, laboratory testing, and geotechnical recommendations.

1.5 Site History and Reconnaissance

1.5.1 Aerial Photographs

The proposed site for the facility has had a variety of previous uses. Based on aerial photographs of the site dating to 1949 the site appears to have been used for agricultural purposes prior to 1970. The aerial photographs indicate the original topography of the site likely included a hill sloped downward from the western edge of the site to low areas currently delineated as wetland. The site then rose again to the east, away from the low lying wetland area. A 1991 photograph taken after the construction of {Street Name}, and the existing road embankment along the western side of {Street Name}, indicates that the western portion of the site was cut to establish the grade of the road. Some of this cut material may have been pushed eastward to provide portions of the now roughly level area east of {Street Name}. A 2000 aerial photograph shows the presence of a [redacted] facility consisting of [redacted] and a [redacted] along the western portion of the site. The eastern portion of the site looks relatively unchanged compared to the 1949 photograph of the site. The [redacted] facility has since been closed. However the [redacted] and [redacted] remain intact.

1.5.2 Site Reconnaissance

Reconnaissance of the existing site was performed by a geotechnical engineer from SEH while staking boring locations. The site appears to have changed little since 2000. Existing structures include the [redacted] building for the now closed [redacted] facility and a [redacted] facility constructed by the {Current Occupant} at the northwest corner of the site. The [redacted] remain intact along with some support equipment used to operate the [redacted] that previously covered the [redacted].

The {Owner Name} is currently using the site to store construction materials, and as a stockpile site for [redacted] and [redacted]. Uncontrolled poor quality fill has been primarily placed at the northwest corner of the site.

Based on observations of the existing steep bank running along the eastern edge of the [redacted], fill was placed up to the edge of the existing wetland area to level the site for construction of the [redacted]. At the eastern edge of the [redacted], fill thickness appears to be on the order of 10 to 15 feet and the existing slope face is likely at or near the angle of repose for the fill. Fill thickness likely decreases to the west, as the original grade sloped upward in that direction. An examination of the surface of the [redacted] did not indicate that the fill has experience excessive settlements or slope failures. Some minor cracking of the asphalt surface of the [redacted] was observed, and standing water roughly 1 inch deep was noted in some locations.

The remainder of the site consists of two south to north running wetland areas, separated by a roughly 5-foot rise in grade. The eastern edge of the

site slopes uphill to the property line. A series of gravel surface roads are present along the eastern half of the property, and some construction debris, consisting of abandoned culverts was observed in the southeast corner of the property.

1.6 Geotechnical Borings

Geotechnical borings at the locations of the proposed structures, parking areas, and potential borrow sources were drilled by {Name of Drilling Firm} of {Drilling Firm Location}, on {Date Drilling Performed}. {Number of Borings} soil borings, numbered 1 through _____, were drilled. _____ of the borings (numbers _____ through _____) were drilled to evaluate the suitability of areas of the site as potential borrow sources. The remainder of the borings were drilled at locations of proposed structures and pavements. Borings were drilled using a hollow stem auger and standard penetration test (SPT) sampling in general accordance with ASTM D 1586. A site map showing boring locations and elevations is included in Appendix A.

Samples were collected at _____-foot intervals to a depth of _____ feet below the ground surface. Samples were collected at _____-foot intervals from a depth of _____ feet to the bottom of the borings.

Undisturbed samples were obtained in Borings _____, _____, and _____ at the depths shown on the boring logs.

1.7 Laboratory Analyses

Laboratory analyses were performed on SPT samples to classify site soils and aid in developing foundation design parameters. Testing included Atterberg limits (ASTM D 4318), water content (ASTM D 2216), and particle size analysis (ASTM D 421). Results of the laboratory testing are included in Appendix A. Results of the Atterberg limits and particle size distribution testing are also summarized in Section 2.

Neither shear strength nor consolidation tests were conducted on the undisturbed samples obtained during this investigation. Completing these types of tests may be recommended in future phases of the geotechnical investigation depending on the final locations(s) and elevations of the proposed facilities.

1.8 Boring Elevations

Boring elevations were estimated from a map of the site with a 2-foot contour interval. Estimates of the elevations shown on the boring logs should only be considered accurate within ± 2 feet.

2.0 Results

2.1 Soil Borings Logs

Soils boring logs showing approximate stratigraphy and water conditions observed during drilling were prepared by {Name of Drilling Firm}. Copies of the soil boring logs are included in Appendix A along with a site map showing the boring locations.

2.2 Materials Summary and site Stratigraphy

Soils at the site consist primarily of sandy coarse alluvium and clayey sand or silty sand till. Swamp deposits were encountered in borings located in the wetland portions of the site, and fill soils were encountered in areas of the site that were developed for the existing recreation center. Silty fine alluvium layers are intermixed with the till and coarse alluvium deposits.

Site stratigraphy varies considerably with location. The site consists of a mixture of glacial deposits that results in non-continuous layers of clayey or silty till intermixed with layers of sandy coarse alluvium and silty fine alluvium. No single stratigraphy can be defined for the site. The heterogeneous nature of the soils results in variable ground water conditions and the presence of isolated layers of softer till and fine alluvium. Swamp deposit soils are isolated in areas delineated as wetland along the center portion of the site. Some areas currently defined as wetland may have been constructed to provide drainage for the former [REDACTED] facility.

The majority of the soils at the site are considered to be Type [REDACTED], in accordance with OSHA regulations 29 CFR Parts 1926.650 through 1926.652, due to either their consistency or saturation. In the event groundwater conditions cause seepage into excavations, excavation side slopes will be susceptible to sloughing.

Materials encountered in the borings are described in the following sections.

2.2.1 Bituminous Pavement

Four (4) inches of bituminous pavement was observed at Boring 6. Bituminous pavement in the area of Boring 6 is the former [REDACTED]. Bituminous pavement also exists in the parking area for the former [REDACTED]. No borings were performed through this pavement section, therefore the bituminous thickness is unknown.

2.2.2 Topsoil

Topsoil across the site varies in consistency from silty sand with organics, to organic silts and clays. Siltier topsoil was generally observed at the higher elevations of the site, with the more organic topsoil occurring in lower lying areas of the site near the wetlands. Topsoil thickness ranges from less than 0.5 feet to roughly 2 feet.

2.2.3 Swamp Deposits

Swamp deposits were encountered in six of the borings drilled in the delineated wetland area. Boring logs indicate that some of the organic soil in the wetland area may be fill. These possible fill soils have been included with this discussion of swamp deposits because they will likely have engineering properties similar to that of swamp deposits.

Swamp deposits consist of very soft to soft sapric peat, organic clay and organic silt. Swamp deposit thickness ranges from 0.5 feet to 8.5 feet, with the thickest deposits existing near Borings 10 and 11. All swamp deposit soils are considered highly compressible.

2.2.4 Fill

Fill soils were encountered at various boring locations. Some fill soils appear to have been placed as a topsoil layer in areas of the site. Fill soils described here are related to structural fill placed to build the existing [REDACTED] and other site structures. Fill in the area of the existing structures and [REDACTED] (Borings [REDACTED]) consists of a mixture of clayey sand, sand with silt and silty sand. Sandy fills have SPT blow counts that indicate they are in a loose condition. Fill thickness at the three boring locations ranges from 1.5 to 4 feet. Based on visual observations, thicker deposits of fill soil likely exist along the eastern edge of the existing [REDACTED]. Fill thickness approaches 15 feet at some locations, and based on the angle of the existing embankment at the edge of the [REDACTED] fill was likely placed by end dumping and graded with minimal compaction.

2.2.5 Coarse Alluvium

Coarse alluvium was encountered in eleven of the nineteen borings drilled at the site. Coarse alluvium across the site consists of a range of granular soils including fine to medium grained poorly graded sand, sand with silt, silty sand, and gravel with sand. The majority of coarse alluvium soils are comprised of poorly graded sand and silty sand. Coarse alluvium soils are generally medium dense, with occasional layers of looser and denser soil. Layers of coarse alluvium range in thickness from 1.5 to 15 feet, with most layers being less than 4 feet in thickness.

2.2.6 Till

Till soils were encountered in all of the borings. Till at the site consists of layers of clayey sand, sandy lean clay, and silty sand, with silty sand being the most prevalent till soil. The majority of silty sand tills range in density from medium dense to dense, with isolated layers of looser silty sand. Clayey till soils (sandy lean clay and clayey sand) range in stiffness from very soft to very stiff. Softer clay tills are located near the ground surface, with deeper deposits generally being stiff. Till layer thicknesses range from 1.5 feet to over 15 feet, and it is common to find alternating layers of clayey till and silty till in the same boring.

2.2.7 Fine Alluvium

Fine alluvium soils were encountered in eight of the nineteen borings. Fine alluvium layers consist of a range of silty soils, including silt, silt with sand, sandy silt, lean clay, lean clay with sand, and fat clay. The majority of the fine alluvium soils are silty, with lean clay alluvium being encountered at two boring locations, and fat clay being encountered at two locations. Fine alluvium layers are generally less than 3 feet thick. Silty alluvium layers are generally very loose to loose, with the lean clay alluvium ranging from very soft to stiff, and the fat clay alluvium layers are stiff.

2.2.8 Bedrock

Bedrock was encountered in the bottom of five borings. Bedrock consists of highly weathered Shakopee Formation Dolostone. A summary of the depth to bedrock, and the estimated bedrock elevation is provided in Table 1.

**Table 1
Depth to Bedrock**

Location	Depth to Rock (ft)	Estimated Elevation (ft)
Boring 1		
Boring 10		
Boring 12		
Boring 13		
Boring 16		

2.3 Groundwater Conditions

Groundwater was observed in eighteen of the nineteen borings at the site. A summary of the observed water condition during drilling is provided in Table 2.

**Table 2
Groundwater Observed During Drilling**

Location	Depth to Water (ft)	Estimated Elevation (ft)
Boring 1		
Boring 2		
Boring 3		
Boring 4		
Boring 5		
Boring 6		
Boring 7		
Boring 8		
Boring 9		
Boring 10		
Boring 11		
Boring 12		
Boring 13		
Boring 14		
Boring 15		
Boring 16		
Boring 17		
Boring 18		
Boring 19		

NA – Water not observed during drilling.

Piezometers were installed at Borings [redacted] after the completion of drilling. A summary data collected from the piezometers is included in Table 3.

**Table 3
Piezometer Data**

Date	PZ-1		PZ-7		PZ-16	
	Depth to Water (ft) ¹	Elevation (ft) ²	Depth to Water (ft) ¹	Elevation (ft) ²	Depth to Water (ft) ¹	Elevation (ft) ²

¹ Measured from ground surface

² Based on estimated ground surface elevation

Groundwater conditions across the site appear highly variable based on the results of the borings, the piezometer readings, and visual inspection of the site and soil samples collected from the borings. Clayey and silty till layers likely result in perched water conditions at various elevations across the site. During visual inspection of the soil samples, layers above the water level recorded on the soil boring logs were observed to be wet at some locations.

In general it is anticipated that the groundwater table in the low portion of the site is at or near the ground surface. In other areas of the site, perched water conditions can be expected when clayey and silty till layers are encountered.

2.4 Laboratory Results

The results of laboratory classification tests are included in Appendix A.

3.0 Preliminary Geotechnical Conclusion and Recommendation

3.1 {Proposed Facility}

3.1.1 Structure and Site Description

The {Proposed Facility} is expected to be constructed using a series of pad supported columns, strip footings and floating slabs. Based on the layout provided by {Owner}, column service loads are expected to range from [redacted] to [redacted] kips around the exterior of the building, and [redacted] to [redacted] kips around the interior of the structure. The perimeter strip load is anticipated to be [redacted] kips per foot. The structure is expected to have a floating concrete slab floor. It is anticipated that the structural design of the building will tolerate total settlement of [redacted]-inch and differential settlements of up to [redacted]-inch.

The proposed grade of the building has not been finalized. However, it is anticipated that floor elevation will be similar to the existing parking area and [redacted], near an elevation of 986 feet. The proposed layout of the building and anticipated grade will require placing fill on the order of 15 or more feet thick for the majority of the structure.

The proposed location of the structure places the majority of the structure over areas identified as wetlands. The southwest corner of the structure will overlie the existing [redacted] in an area of fill. Relevant borings for this structure include Boring 8 and 9, which are located in the wetland area, and Boring 6 which is located west of the structure on the [redacted]. The borings indicate that soil conditions at the proposed location will vary. At the southwest corner of the structure, approximately 15 feet of fill is likely to

exist. It is unclear if all unsuitable soil was removed under the fill prior to placement as the existing fill face abuts the wetland area. Under the center of the structure, layers of swamp deposit and soft till soils will be encountered. At Boring 8, unsuitable soft soils extend to a depth of approximately 6.5 feet (estimated elevation 967.5 feet). At Boring 9, unsuitable soils extend to a depth of 9 feet (estimated elevation 963 feet). Unsuitable soils appear to increase in thickness with distance to the north.

3.1.2 Foundation Recommendations and Alternatives

3.1.2.1 Proposed Layout

Constructing the structure at the proposed location and anticipated elevation will require the removal of unsuitable soft soils and existing fill soils. Removal of fill soils will need to occur at the southwest corner of the structure, with the remaining footprint of the structure required removal of unsuitable soft soils.

We recommend that the area under the footprint of the building be subcut to an elevation of 963 feet to remove fill soils and unsuitable soft soils. The excavation should be extended beyond the footprint of the structure foundation a distance of 1 foot horizontal for every foot of vertical distance from the bottom of the structure foundation to the bottom of the subcut. Excavation side slopes below the water table can be expected to slump due to groundwater seepage. Replacement fill should meet the requirements of [REDACTED]. Place replacement fill in loose lifts no thicker than [REDACTED] foot and compact to [REDACTED] of modified Proctor Density (ASTM D 1557). The thickness of the initial lift of fill may need to be increased to [REDACTED] feet in areas where water is present at the base of the excavation to provide a stable platform for the remaining fill placement.

To limit settlement we recommend that strip footings and column pads be constructed on no more than [REDACTED] feet of compacted fill. Since fill thickness will likely be on the order of [REDACTED] feet, column pads and strip footing will need to extend into the fill a greater distance than would normally be required for simple frost protection. For a subcut elevation of [REDACTED] feet we recommend that strip footings and column pads extent to an elevation of [REDACTED] feet.

Footings, pads and slabs placed on the compacted granular fill, as recommended above, may be designed with a net allowable bearing capacity of [REDACTED] psf, and a modulus of subgrade reaction of [REDACTED] psi.

Footings for heated structures should have a minimum of [REDACTED] inches of cover. Footings for non-heated structures should have a minimum of [REDACTED] inches of cover.

3.1.2.2 Alternative Foundation Elevation

An alternative to reduce the amount of fill required would be to add a lower level to the structure. Adding a lower level adds air space to reduce the amount of fill. Lowering the base elevation of the structure will also reduce the required embedment depth for strip footings and column pads. Specific foundation recommendations for constructing a lower level would need to be made after a proposed structural design is developed.

3.1.2.3 Structure Relocation

An alternative, to reduce the required subcut and fill placement, is to relocate the structure to another portion of the site. Based on the available borings, the southern portion of the site contains less fill and fewer layers of soft compressible soil. Based on the results of Borings 15 and 19, the anticipated subcut on the southern end of the site would be on the order of 5 feet. The shallower subcut combined with the higher existing grade will result in less required filling. We recommend that additional investigation be completed if the proposed structure is relocated on the site.

3.2 **Exterior [REDACTED] and [REDACTED]**

3.2.1 **Structure and Site Description**

The proposed site layout includes an [REDACTED], [REDACTED] and [REDACTED] area north of the [REDACTED] structure. Design details of the [REDACTED] and [REDACTED] are not available at this time. It is anticipated that the elevation of the [REDACTED] and [REDACTED] area will be roughly that of the main floor of the [REDACTED] and parking area.

Soils under the proposed [REDACTED] and [REDACTED] will vary with location. The majority of the area will be constructed over an existing wetland, with the southeast portion of the area being constructed over a less swampy gassy area with a slightly higher elevation. Borings relevant to the [REDACTED] and [REDACTED] include Borings 10, 11, 12 and 14. Based on the results of Borings 10, 11 and 12 the majority of the [REDACTED], [REDACTED], and [REDACTED] area will be constructed over an area containing swamp deposits and soft clayey soils. Deeper deposits consist of stiffer clayey tills and medium dense silty sand tills.

Swamp deposit soils were encountered in Boring 10 to a depth of 8.5 feet (estimated elevation 961.5 feet), and in Boring 11 to a depth of 7 feet (estimated elevation 964 feet). Soft clayey soils were encountered in Boring 12 to a depth of 6.5 feet (estimated elevation 957.5 feet).

3.2.2 **Foundation Recommendations**

Construction of the [REDACTED] and [REDACTED] at a grade near the elevation of the main floor of the [REDACTED] and parking area will require removal of swamp deposits and soft clayey soils under the proposed footprint. Removal of these soils will require excavation to elevations between 957.5 and 964 feet. Replacement fill thicknesses of over 20 feet will be required, and subcuts will need to be made below the water table.

Given the required excavation and replacement fill thickness, we do not recommend constructing the [REDACTED] structure or [REDACTED] at the proposed location on replacement fill. Granular soils, even when carefully compacted, will experience a degree of self weight settlement. For a 20 foot fill thickness this settlement is likely to exceed the allowable settlement for the [REDACTED] structure. Assuming the [REDACTED] is constructed of concrete, settlement and cracking can be expected if the [REDACTED] is constructed at the proposed location in over 20 feet of compacted replacement fill. Differential settlement would likely be noticeable in the playing surface of the [REDACTED] and surrounding [REDACTED] area.

We recommend the location of the [REDACTED] be reconsidered and moved to a portion of the site that will require less unsuitable soil removal, have less fill placement, and will not require excavation below the water table. The proposed grade of the [REDACTED] should also be carefully considered. If possible it would be preferable to place the [REDACTED] directly on native silty sand till, which would require adjusting the [REDACTED] elevation to conform with the surface topography of the existing site.

If the [REDACTED] cannot be relocated we recommend looking at options for deeper soil improvement to limit the potential for settlement. One such option would be the installation of [REDACTED] through the replacement fill into the denser native deposits. [REDACTED] are a proprietary design build foundation system consisting of densely compacted aggregate columns.

3.3 Parking Lot and Access Roads

3.3.1 Site Description

The majority of the proposed parking area will be constructed west of the [REDACTED], [REDACTED] and [REDACTED] over what is now and existing [REDACTED] and [REDACTED]. Additional parking will be provided along the southern edge of the [REDACTED], and an access road will wrap around the eastern side of the structure. It is assumed that the paved areas will be constructed at a relatively uniform grade consistent with the existing parking lot (estimated elevation 986 feet).

Soils under the proposed parking area vary greatly as does the topography. Existing fill soils can be expected under the majority of the parking area. Swamp deposit soils will exist at the northeast corner of the parking area, and along the southern edge of the parking area where the proposed access road wraps around the fitness center. Borings relevant to the parking area and access road include Borings 4, 5, 6, 7, 11, and 14.

Fill thickness at Borings 4, 5, and 6 ranges from 1.4 to 4 feet and varies in quality from most sand to clayey sand with some organic material. Visual inspection of the area indicates that uncontrolled fill appearing to consist of ditch cleanings or street sweepings has been deposited between Borings 4 and 5.

Near the northeast corner of the parking area, the existing grade drops significantly into a wetland area where peat deposits of 7 feet and 2 feet were encountered. Based on the existing grade, approximately 15 feet of fill will be required at this location. Based on visual observations, a stockpile of waste soil containing organics has been placed between Borings 4 and 11.

Along the southern edge of the parking area approximately 10 feet of fill will be required over a wetland area. No boring was drilled directly in the wetland at this location. Boring 7 was drilled on the edge of the wetland and did not contain significant layers of compressible soils.

The access road along the eastern edge of the [REDACTED] will follow a ridge of higher ground that splits two wetland areas. Boring 14, drilled along the northern end of the access road, contained no substantial soft deposits.

3.3.2 Pavement Recommendations

Construction of the parking area and access road will require placement of varying thicknesses of new fill, and removal of swamp deposit soils and uncontrolled fill within the proposed footprint.

All uncontrolled fill placed between Borings 4, 5, and 11 should be fully removed from the footprint of the paved area. Based on the visual quality of this material we recommend that it be spoiled in an area of the site away from structures and pavements, or removed from the site. Swamp deposits and soft alluvial clay near Boring 11 should be removed to its full extent (estimated elevation of 962 feet). Topsoil should be fully stripped near Borings 7 and 14, and the area west of Boring 7 should be inspected for the presence of swamp deposit soils during excavation.

In general, replacement fill and fill to establish grade should meet the requirements of [REDACTED]. However, fill placed below the groundwater table should meet the requirements of [REDACTED]. Place replacement fill in loose lifts with a maximum thickness of [REDACTED] foot and compact to [REDACTED] of the maximum dry unit weight at standard Proctor effort. The thickness of the initial lift of fill may need to be increased to [REDACTED] feet in areas where water is at the base of the excavation (Borings 11 and west of Boring 7) to provide a stable platform. We recommend that the top [REDACTED] feet of fill under the pavement section consist of [REDACTED].

Pavements constructed on [REDACTED] feet of [REDACTED] may be designed with a subgrade R-value of [REDACTED].

3.4 Groundwater

3.4.1 [REDACTED]

Groundwater encountered in the area of the [REDACTED] during drilling ranged in elevation between 949.8 feet (Boring 9) and 972.2 feet (Boring 8). Groundwater encountered in Boring 9 at an elevation of 949.8 feet is not representative of the actual groundwater condition at this location. Inspection of soil samples collected from the boring indicate that the water table is more likely near an elevation of 969 feet, which is in line with Borings 8 and 10 which are located in the same wetland area. Water near Boring 6, which was performed in the existing tennis court area, is consistent with the water elevation observed in the lower wetland borings.

Based on the results of the borings and visual observations of surface water in the wetland we anticipate that the water table in the area the [REDACTED] will be at or near the ground surface of the wetland at an estimated average elevation of 970 feet.

The high water table will complicate the removal of soft soils under the footprint of the proposed structure. It is estimated that excavation depths of up to 10 feet below the groundwater table will be required to replace existing soft swamp deposits, alluvial clays and clayey tills.

Based on the particle size distribution of soils from the borings in the area of the [REDACTED], and the presence of numerous clayey till layers, it does not appear that well points or a series of deep wells will be effective in dewatering the

excavation. It will likely be necessary to direct groundwater to sumps using ditches and trench drains as the excavation(s) are extended to depth. We anticipate a layer of [redacted] inch crushed rock wrapped in a Mn/DOT Type [redacted] geotextile will need to be placed in the bottom of the excavation so that groundwater may be removed by sumping.

3.4.2 **{Proposed Facility}**

Groundwater in the area of the [redacted] and [redacted] during drilling ranged between estimated elevations of 962.7 feet (Boring 11) and 966.6 feet (Boring 14). At some locations water was observed at the ground surface. Given that much the area within the footprint of the proposed [redacted] and [redacted] is wetland, it should be expected that groundwater will be at or near the ground surface, especially during periods of precipitation.

The high water table will complicate the removal of soft soils under the footprint of the [redacted] and [redacted]. It is estimated that excavation depths of up to 10 feet below the groundwater table will be required to replace existing soft swamp deposits, alluvial clays and clayey tills.

Based on the particle size distribution of soils from the borings in the area of the [redacted], and the presence of numerous clayey till layers it does not appear that well points or a series of deep wells will be effective in dewatering the excavation. It will likely be necessary to direct groundwater to sumps using ditches and trench drains as the excavation(s) are extended to depth. We anticipate a layer of [redacted]-inch crushed rock wrapped in a Mn/DOT Type [redacted] geotextile will need to be placed in the bottom of the excavation so that groundwater may be removed by sumping.

3.4.3 **Pavement Areas**

Estimated groundwater elevations observed under areas of proposed pavement ranged from 964.7 feet (Boring 7) to 975 feet (Boring 4). Based on the stratigraphy of Boring [redacted] and other groundwater elevations, it appears that the water observed at Boring 4 is perched on layer of clayey sand till. Additional areas with perched water are likely to exist under the footprint of the proposed parking area.

We recommend that groundwater be maintained a minimum of [redacted] feet below any pavement section. If clay till soils are encountered in areas where only a [redacted] foot subcut is required, we recommend installing a drain tile at the base of the subcut.

We do not anticipate that widespread dewatering will be required to construct paved areas and access roads. Any required dewatering will likely be localized around the wetland area west of Boring 7.

3.5 **Borrow Sources and Reuse of On-site Soils**

Two areas, one west of [redacted] (termed the Western Borrow Area) and the other on the eastern edge of the property (termed the Eastern Borrow Area), were evaluated for their potential use as borrow sources.

3.5.1 Western Borrow Area

Three borings (Borings 1, 2 and 3) were drilled in the proposed Western Borrow Area.

Soils at Boring 1 include roughly 6.5 feet of topsoil and clayey sand which would be unsuitable for foundation fill. Below the clayey soils, 12.5 feet of silty sand was encountered. The silty sand layer would generally be considered acceptable for foundation fill. Water was encountered at 20.2 feet during drilling, and 19.0 feet in the piezometer constructed at Boring 1.

Boring 2 indicates the presence of mostly granular soils consisting of silty sand till and poorly graded sand alluvium to a depth of approximately 28 feet. Both soils would be considered acceptable for foundation fill. Water was encountered at a depth of 20.8 feet during drilling. It will not be practical to excavate soils from below the water table for use as borrow.

At Boring 3, suitable granular soils consisting of silty sand with gravel were encountered at depths below 6.5 feet to the bottom of the borings at a depth of 21 feet. Groundwater was observed at a depth of 19.1 feet during drilling.

3.5.2 Eastern Borrow Area

Three borings (Borings 16, 17, and 18) were drilled in the Eastern Borrow Area.

At Boring 16, layers of granular silty sand and silty fine alluvium were encountered to the bottom of the boring. However, groundwater was encountered at a depth of 8.1 feet during drilling and at 3.0 feet in a piezometer constructed at Boring 16. Given the high groundwater elevation at this location we do not recommend excavation at this location for borrow material.

At Boring 17, layers of clayey and silty fine alluvium and till extend to a depth of 11.5 feet. This material is considered unsuitable for foundation fill. The clayey soils may be useable as general site fill. The clayey and silty layers in the upper 11.5 were observed to be wet to very wet, and moisture conditioning will likely be required if these soils are to be used as general fill. Below 11.5 feet, silty sand till was encountered to the bottom of the boring at a depth of 21 feet. Groundwater was not observed in the boring during drilling. However, given the wet condition of the clayey and silty soils in the upper 11.5 feet areas of perched water should be anticipated when excavating the lower silty sand deposits.

At Boring 18, silty sand till with varying gravel content suitable for foundation construction extends from a depth of 4 feet below the existing ground surface to a depth of 48 feet. Groundwater was encountered at a depth of 25 feet during drilling. Excavation of borrow material below the water table will not be practical.

Based on the results of the 3 borings performed in the Eastern Borrow Area we recommend that borrow material be excavated from the area of Boring 18. Soils in the area of Boring 18 are suitable for foundation fill and will require less overburden removal than at Boring 17. We do not recommend

excavating near Boring 16 for borrow material because of the high groundwater table at that location.

3.5.3 Reuse of Excavated Soils for Fill

Based on the results of the borings and the anticipated construction grades, it does not appear that a significant volume of suitable backfill material will be generated from construction excavations.

The majority of excavation work that will be required is to remove unsuitable soft swamp deposit and clayey till and alluvium soils from under the footprint of the proposed project features. Swamp deposits should not be used as backfill under or near any structure, pavement, or utility trench. Soft clayey soils will require significant drying prior to being used as fill. We do not recommend that excavated clayey soils be used as backfill under or adjacent to structures. If dried to permit proper compaction, it may be possible to use excavated clayey soils as fill under areas to be paved, but we do not recommend that it be placed in the upper [REDACTED] feet of fills under paved areas.

3.6 Backfill for Structures

We recommend that backfill for the interior of structures consist of granular soil meeting the requirements of [REDACTED]. Site soils classified as poorly graded sand (sp) and sand with silt (sp-sm) from the borrow areas may meet the requirements of [REDACTED]. If an insufficient amount of soil meeting the criteria of [REDACTED] is generated during excavation, imported borrow should be used for interior backfill.

Exterior backfill should consist of granular soil consisting of poorly graded sand or silty sand from the borrow areas. The top [REDACTED] feet of exterior backfill may consist of site clayey soils only in areas where turf is to be established.

Place exterior granular backfill in loose lifts no thicker than [REDACTED] inches and compact to [REDACTED]% of the maximum dry unit weight at standard Proctor effort on the exterior of structures. In areas where pavement or walkways will extend over the exterior backfill, compact the top [REDACTED] feet of backfill to [REDACTED]% of the maximum dry unit weight at standard Proctor effort. Compact all interior backfill to [REDACTED]% of the maximum dry unit weight at standard Proctor effort. Bring backfill up evenly on each side of strip footings, and walls.

Except where noted otherwise, design walls using an equivalent fluid density of [REDACTED] pcf above the water table and [REDACTED] pcf below the water table.

General site fill beneath structures should be placed in accordance with Section 3.1.2 of this report.

3.7 Utility Trenching and Backfilling

3.7.1 Trenching

It is recommended that the width of utility trenches at any point below the top of the pipe be limited to the outside diameter of the pipe plus [REDACTED] inches. Soils within anticipated utility trenches are generally classified as

Type [REDACTED] soils in accordance with OSHA regulations, 29 CFR Parts 1926.650 through 1926.652. In the event groundwater conditions cause seepage into excavations, side slopes of the trenches will be susceptible to sloughing.

3.7.2 Bedding

All utility piping should be bedded on a minimum of [REDACTED] inches of granular bedding meeting the requirements of [REDACTED]. Compact the bedding to [REDACTED] % of the maximum dry unit weight at standard Proctor effort and form the excavation to the shape of the pipe. Backfill to the top of the pipe with granular bedding in loose lifts no thicker than [REDACTED] inches and compact to [REDACTED] % of the maximum dry unit weight at standard Proctor effort. Backfill above the pipe should be placed in accordance with Section 3.7.4.

3.7.3 Groundwater Control

Excavation for utility installation at elevations below 970 feet will likely require dewatering. If needed, dewatering of trenches will most likely be accomplished using sumps constructed at various locations within the trench. When crushed rock is required to aid in trench dewatering it is recommended to wrap the crushed rock in Geotextile Type [REDACTED], conforming to [REDACTED]. If [REDACTED] is used for dewatering a geotextile will not be needed.

3.7.4 Utility Trench Backfill Above the Pipe Zone

Once bedding has been placed and compacted to the top of the utility pipe conform to the following requirements to backfill the remainder of the utility trench:

3.7.4.1 Beneath Structures

It is recommended that utility trenches be backfilled with excavated poorly graded sand from the borrow area or granular borrow meeting the requirements of [REDACTED]. Compact the backfill in [REDACTED]-inch loose lifts, or less, to [REDACTED] % of standard Proctor maximum dry unit weight.

3.7.4.2 Beneath Paved Areas

Backfill trenches with granular soils. When properly moisture conditioned, it may be possible to use clayey till soils from the site to fill under paved areas. We do not recommend placing clayey soils in the upper [REDACTED] feet of trenches under paved areas. Compact the soil in [REDACTED]-inch loose lifts, or less, to at least [REDACTED] % of standard Proctor maximum dry unit weight to within [REDACTED] feet of the subgrade. Within three feet of subgrade compact trench backfill to at least [REDACTED] % of standard Proctor maximum dry unit weight.

3.7.4.3 All Other Areas

Backfill with native site soils excluding swamp deposits to at least [REDACTED] % of standard Proctor maximum dry unit weight. Compact the soils in [REDACTED]-inch loose lifts, or less. In areas where turf is to be re-established maintain the upper [REDACTED] inches in a relatively loose condition, approximately compacted to [REDACTED] % of standard Proctor maximum dry unit weight.

3.8 Exterior Slabs and Utility Pads

Surficial soils consist of a range of soils from lean clay tills to silty sands. Clayey till soils are likely to be susceptible to softening during periods of frost melt and are poorly drained. Silty sands are unlikely to soften during periods of frost melt, but may be poorly drained.

3.8.1 Sidewalks

We recommend sidewalks be constructed on a minimum of [REDACTED] inches of compacted [REDACTED]. Compact the material beneath sidewalks to [REDACTED]% of standard Proctor maximum dry unit weight in maximum [REDACTED]-inch thick loose lifts.

3.8.2 Entrance Stoops

It is recommended that entrance stoops be founded on shallow strip footings a minimum of [REDACTED] inches wide, consistent with the footing depth of adjacent foundations. Perform soil correction for the stoops in accordance with the foundations recommendations. We recommend the fill for interior strip footings consist of granular material meeting the requirements of [REDACTED]. Compact the fill and foundation soil to [REDACTED]% of standard Proctor maximum dry unit weight in maximum [REDACTED]-inch loose lifts.

3.8.3 Utility Pads

We recommend the utility pads be constructed on a minimum of [REDACTED] inches of compacted [REDACTED]. Compact the material beneath the utility pad to [REDACTED]% of standard Proctor maximum dry unit weight in maximum [REDACTED]-inch loose lifts.

4.0 Construction Considerations

4.1 Inclement Weather

4.1.1 Soil Compaction

Depending on precipitation conditions, and the time of year, it may not be possible to provide adequate drying to clayey soils to ensure proper compaction. In general, precipitation, low temperatures and shorter days result in early spring and late fall being poor times for attempting to dry clayey soils. If construction is expected to proceed during this time period we recommend that the plan set and specifications require the use of granular soils as fill and backfill in all locations except in grassy areas.

4.1.2 Dewatering

Dewatering requirements for construction will vary with seasonal changes in precipitation. Because of the presence of numerous layers of clayey till in the native soils, perched water conditions should be expected when performing excavations. The amount of perched water encountered will likely be the highest after snow melts in the spring, or after periods of high precipitation. The use of stand-alone wells and well pointes will not likely be effective at controlling seepage from layers of perched water. Perched water will likely need to be sumped from the bottom of trenches or exactions, and excavation slopes will need to be adjusted to remain stable under seepage conditions. Slumping of excavation slopes below the groundwater table should be expected.

At the time of drilling, groundwater was at or near the surface of the majority of the area delineated as wetland. In the spring and during periods of high precipitation it should be expected that standing water will be encountered in the wetland areas.

4.2 Winter Construction

The following recommendations are provided in the event that construction occurs during winter conditions. Do not place concrete on frozen ground. All ice and snow should be removed from areas to receive fill. No fill should be placed on frozen ground or ground that contains snow or ice. Only unfrozen backfill should be used. No frozen materials or materials containing snow or ice should be used as fill. Utilization of material which requires on-site moisture modification(s) will be impractical and difficult to control compaction levels.

4.3 Excavation Safety

All excavations must comply with OSHA 29 CFR, Part 1926, Subpart P, "Excavations and Trenches".

4.4 Field Observation and Testing

4.4.1 Excavation Observation

We recommend that a geotechnical engineer or technician observe the excavations to evaluate if the subgrade soils are consistent with the results of the soil borings. These observations should be conducted prior to placement of the backfill in excavations or construction of structure foundations.

In areas where we have recommended the removal of soft clayey alluvium and till soils and swamp deposits we recommend that a geotechnical engineer or geotechnical technician observe the excavation to revise the excavation limits as need to ensure full removal of unsuitable soils.

4.4.2 Compaction Testing

It is recommended that density testing of the native soils and imported granular borrow be conducted prior to placement of backfill. It will be necessary to sample the material and perform standard Proctor compaction tests (ASTM D 698) a minimum of three days prior to field density testing.

Dry unit weight and moisture content testing to confirm compaction of granular fill beneath structures should take place at the following rates:

- Granular fill placed under [redacted] foundations. Minimum [redacted] tests per lift.
- Granular fill placed under the [redacted] and [redacted] area. Minimum [redacted] tests per lift.
- Backfill around structure walls: Minimum [redacted] tests per lift, both interior and exterior.
- Fill placed under access roads and paved areas. Minimum [redacted] test per [redacted] cubic yards of fill.

Test compaction of backfill in utility trenches at a rate of one test per [redacted] cubic yards of backfill.

We also recommend that gradation tests (ASTM D422) be conducted on representative samples of imported granular borrow materials and material from on-site borrow pots. Imported borrow should be tested at the beginning of construction. On-site borrow should be tested at the beginning of construction and when material characteristics change within the pit areas.

5.0 Basis of Recommendations

The analysis, conclusions and recommendations contained in this report are based on the data obtained from the soil borings, the locations of which are indicated in this report, and our interpretation of that data with respect to the proposed structures. No guarantees, certifications or warranties are processed or implied.

Groundwater conditions are extremely susceptible to fluctuation. The period of observation in any one borehole was relatively short and changes can be expected to occur during flooding, due to rainfall or irrigation, spring thaw, drainage and other seasonal and periodic cycles not evident when the observations were made. Designs and related construction dewatering planning should recognize the potential for groundwater level changes before, during and after construction.

This report is intended for use in preparing the plans and specifications for the facility at the location indicated in this report. Use for any other structure or purpose is not recommended without review by a competent professional familiar with the soils at the site and implications with regard to the proposed facilities.

List of Figures

Figure 1 – Soil Boring Locations

Appendix A

Report of Subsurface Borings
{Name of Drilling Firm}