GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 East 50th Street North
Sioux Falls, South Dakota 57104
Phone 605-335-5512 Fax 605-335-0773

January 15, 2018

City of Baltic
130 St. Olaf Avenue
Baltic, South Dakota 57003

Attn: Mike Wendland, Mayor

Subj: Geotechnical Exploration
Proposed Street Improvements
Oak Avenue, Douglas Drive & Douglas Boulevard
Baltic, South Dakota
GeoTek #17-F56

This correspondence presents our written report of the geotechnical exploration program for the referenced project. Our work was performed in accordance with your authorization. We are transmitting an electronic copy of our report for your use. An additional copy is also being sent as noted below.

We thank you for the opportunity of providing our services on this project and look forward to continued participation during the design and construction phases. If you have any questions regarding this report, please contact our office at (605) 335-5512.

Respectfully Submitted,
GeoTek Engineering & Testing Services, Inc.

Jared Haskins

Jared Haskins, PE
Geotechnical Manager

Cc: Banner Associates, Inc., Attn: Rich Uckert, PE

TABLE OF CONTENTS

INTRODUCTION **4**
PROJECT INFORMATION 4
SCOPE OF SERVICES 4
SITE & SUBSURFACE CONDITIONS **5**
SITE LOCATIONS & DESCRIPTIONS 5
GROUND SURFACE ELEVATIONS & TEST BORING LOCATIONS 5
EXISTING PAVEMENT CONDITIONS 5
SUBSURFACE CONDITIONS 5
WATER LEVELS 6
ENGINEERING REVIEW & RECOMMENDATIONS **6**
OVERALL PROJECT DESIGN DATA 6
WATER VALUES 7
Dewatering 7
OSHA Requirements 7
Backfill 7
STREET IMPROVEMENTS 8
Subgrade Soils 8
Stripping & Removals 9
Scarify & Compact 9
Filling 9
Unstable Subgrade in Normal Subgrade Preparation Areas 10
Asphalt Pavement Section Thicknesses 10
Aggregate Base Course Materials 11
Granular Subbase Material 11
Existing Gravel Base 11
Corrosive Potential 11
CONSTRUCTION CONSIDERATIONS **12**
GROUNDWATER & SURFACE WATER 12
DISTURBANCE OF SOILS 12
COLD WEATHER PRECAUTIONS 12
EXCAVATION SIDESLOPES 12
OBSERVATIONS & TESTING 13
Excavation 13
Testing 13
SUBSURFACE EXPLORATION PROCEDURES **14**
TEST BORINGS 14
SOIL CLASSIFICATION 14
WATER LEVEL MEASUREMENTS 15
LABORATORY TESTS 15

LIMITATIONS **15**

STANDARD OF CARE **16**

APPENDIX A FIGURE 1 – TEST BORING LOCATION MAP
BORING LOGS
SOIL CLASSIFICATION SHEET
SYMBOLS & DESCRIPTIVE TERMINOLOGY

GEOTECHNICAL EXPLORATION
PROPOSED STREET IMPROVEMENTS
OAK AVENUE, DOUGLAS DRIVE & DOUGLAS BOULEVARD
BALTIC, SOUTH DAKOTA
GEOTEK #17-F56

INTRODUCTION

Project Information

This report presents the results of the recent geotechnical exploration program for the proposed street improvements on Oak Avenue, Douglas Drive and Douglas Boulevard in Baltic, South Dakota.

Scope of Services

Our work was performed in accordance with the authorization of Mike Wendland with the City of Baltic. The scope of work as presented in this report is limited to the following:

1. To perform five (5) standard penetration test (SPT) borings to gather data on the subsurface conditions at the project areas.

2. To perform laboratory tests that include moisture content and dry density.

3. To prepare an engineering report that includes the results of the field and laboratory tests as well as our geotechnical engineering opinions and recommendations regarding the following:

    - Existing pavement section;
    - excavation and backfilling for water valves;
    - Subgrade strength and potential corrective measures;
    - Pavement section thicknesses;
    - Corrosive potential;
    - Special geotechnical conditions that may impact the constructability and final performance of the project;
    - Quality control observation and testing.

The scope of our work was intended for geotechnical purposes only. This scope of work did not include determining the presence or extent of environmental contamination at the project areas or to characterize the project areas relative to wetlands status.

SITE & SUBSURFACE CONDITIONS

Site Locations & Descriptions

The project areas are located on Oak Avenue, Douglas Drive and Douglas Boulevard in Baltic, South Dakota. The existing streets have asphalt surfacing. All of the streets have curb and gutter.

Ground Surface Elevations & Test Boring Locations

We did not determine the ground surface elevations at the test boring locations. A test boring location map is attached showing the relative location of the test borings.

Existing Pavement Conditions

Table 1 summarizes the thickness of the existing asphalt pavement and gravel base encountered at the respective test boring locations.

Table 1. Thickness of the Existing Asphalt Pavement & Gravel Base

Test Boring	Street	Asphalt Thickness, in	Gravel Base Thickness, in
1	Oak Avenue	2 ½	5
2	Douglas Drive	4 ½	5
3	Douglas Drive	4	3
4	Douglas Boulevard	3	2
5	Douglas Drive	3	4

Subsurface Conditions

Five (5) test borings were performed on December 14, 2017. Of the five (5) test borings, one (1) test boring (test boring 1) was performed on Oak Avenue, three (3) test borings (test borings 2, 3 and 5) were performed on Douglas Drive and one (1) test boring (test boring 4) was performed on Douglas Boulevard. The subsurface conditions encountered at the test boring locations are illustrated by means of the boring logs included in Appendix A.

At the test boring locations, existing fill materials, topsoil materials, fine alluvium soils, mixed alluvium soils and coarse alluvium soils were encountered beneath the existing pavement section. The topsoil materials were only encountered at test boring 4.

The existing fill materials consisted of lean clay with sand soils and sandy lean clay soils. The topsoil materials consisted of lean clay soils. The fine alluvium soils consisted of lean clay soils, silt soils and lean clay with sand soils. The mixed alluvium soils consisted of silty sand soils and clayey sand soils. The coarse alluvium soils consisted of sand with silt soils.

The consistency or relative density of the soils is indicated by the standard penetration resistance ("N") values as shown on the boring logs. A description of the soil consistency or relative density based on the "N" values can be found on the attached Soil Boring Symbols and Descriptive Terminology data sheet.

We wish to point out that the subsurface conditions at other times and locations at the project areas may differ from those found at our test boring locations. If different conditions are encountered during construction, then it is important that you contact us so that our recommendations can be reviewed.

Water Levels

Measurements to record the groundwater levels were made at the test boring locations. The time and level of the groundwater readings are recorded on the boring logs. Groundwater did not enter the boreholes at the test boring locations at the time of our measurements.

ENGINEERING REVIEW & RECOMMENDATIONS

Overall Project Design Data

We understand that the project will consist of street improvements on Oak Avenue, Douglas Drive and Douglas Boulevard in Baltic, South Dakota. The new pavement surfacing will be asphalt. A few new water valves will also be installed.

The information/assumptions detailed in the project design data sections of this report are important factors in our review and recommendations. If there are any corrections or additions to the information detailed in these sections, then it is important that you contact us so that we can review our recommendations with regards to the revised plans.

Water Values

Dewatering

Water may enter the excavations as a result of subsurface water, precipitation or surface run off. Dewatering procedures may be required in order to control and remove water entering the excavations. Where clay soils are encountered, it may be possible to remove and control water entering the excavations using normal sump pumping techniques. However, if waterbearing sand soils are encountered, then extensive dewatering techniques will likely be required due to the potentially large volumes of water. The contractor should provide appropriate dewatering methods and equipment. Any water that accumulates at the bottom of the excavations should be immediately removed and surface drainage away from the excavations should be provided during construction.

OSHA Requirements

All excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, “Excavations and Trenches”. This document states that the excavation safety is the responsibility of the contractor. Reference to this OSHA requirement should be included in the project specifications.

Backfill

It is our opinion that the majority of the on-site existing fill materials, fine alluvium soils, mixed alluvium soils and coarse alluvium soils can likely be reused as backfill. We recommend that the backfill soils be placed and compacted in uniform thin lifts (6-inch maximum lifts). The backfill should be compacted to a minimum of 95 percent of standard Proctor density (ASTM:D698). Generally, it will be easier to achieve the compaction specification if the moisture content of the backfill soils is adjusted to a moisture level that is within plus or minus 2 percent of the optimum

moisture content as determined by standard Proctor (ASTM:D698). We anticipate that some moisture adjustment (wetting or drying) will be needed with some of the on-site existing fill materials, fine alluvium soils, mixed alluvium soils and coarse alluvium soils in order to adjust the moisture content of the soils to a level that is within the recommended range.

A portion of the on-site soils encountered in the excavations may not be suitable for use as backfill. These unsuitable soils would consist of organic soils as well as soils having high moisture content levels such that the specified compaction level cannot be reasonably achieved. The topsoil materials at test boring 4 are considered organic soils. The organic materials should be replaced with suitable material available at the project areas or with suitable off-site borrow soils. The wet soils will require significant drying in order to adjust the moisture content of the soils to a level that will facilitate the specified compaction requirement. Alternatively, the wet soils could be replaced with suitable material available at the project areas or with suitable off-site borrow soils.

Street Improvements

Subgrade Soils

The upper portions (upper 4 ½ feet) of the subgrade soils encountered at the test boring locations consisted of topsoil materials, existing fill materials, fine alluvium soils and coarse alluvium soils. These subgrade soils have Unified Soils Classification System symbols of CL and SP-SM and AASHTO classifications of A-2, A-6 and A-7.

The test borings and laboratory tests indicate varying subgrade conditions for the project. At test borings 1 and 4, we estimate California Bearing Ratio (CBR) values of 1.5 to 2.0 for the upper portions of the subgrade soils. CBR values of 1.5 to 2.0 are considered low CBR values. In our opinion, subgrade reinforcement will be needed at and around test borings 1 and 4. The subgrade reinforcement should consist of a geogrid or coarse granular subbase overlying a geotextile fabric. At test borings 2, 3 and 5, we estimate CBR values of 3.0 to 3.5 for the upper portions of the subgrade soils. In our opinion, normal subgrade preparation (scarification and compaction) could be used at and around test borings 2, 3 and 5.

Stripping & Removals

We recommend removing the existing pavement section in order to achieve the design elevations. Low-ground-pressure construction equipment or excavators with smooth-edged buckets should be used for the stripping and removals in areas where soft/wet soils are present. We expect the low-ground-pressure equipment will be needed at and around test borings 1 and 4.

At and around test borings 1 and 4, we recommend observing the condition of the subgrade prior to the placement of the geogrid or geotextile fabric. Depending on the condition of the existing subgrade, the thickness of the aggregate base course (over the geogrid) or granular subbase (over the geotextile fabric), shown in Table 2, may need to be increased or could be decreased.

Scarify & Compact

After the stripping and removals have been completed, we recommend that the exposed subgrade be scarified to a minimum depth of 8 inches and adjusted to a moisture level that is 1 percent to 4 percent below the optimum moisture content as determined by standard Proctor (ASTM:D698). The scarification should be performed by a disc harrow and not a road grader with teeth. The moisture-conditioned soils should then be compacted. If shallow utilities are present and the scarification cannot be performed, then at a minimum, we recommend that the exposed subgrade be compacted.

If it is determined during construction that the scarification and compaction will not improve a poor subgrade condition, then the scarification and compaction can be eliminated. This situation may occur at and around test borings 1 and 4.

Filling

If filling is required to achieve the design subgrade elevations, then the fill materials should consist of non-organic lean clay or sandy lean clay soils having a liquid limit less than 45 and a plasticity index between 15 and 35. The moisture content of the fill soils should be 1 percent to 4 percent below the optimum moisture content. The fill soils should be placed in compacted lifts having a maximum thickness of 6 inches. We recommend a minimum compaction specification of 95 percent of standard Proctor (ASTM:D698) for the fill soils.

Unstable Subgrade in Normal Subgrade Preparation Areas

Areas of unstable subgrade may be encountered in areas where normal subgrade preparation is recommended. The soils within the unstable area should be removed, and either moisture-conditioned and recompacted, or replaced with suitable subgrade fill. If the unstable area will not stabilize using this method, then alternative stabilization methods may be used such as a modified cross-section involving a geogrid or granular subbase overlying a geotextile fabric. The alternative stabilization method should be determined after observing the condition of the subgrade. This section pertains to areas of the project where normal subgrade preparation is recommended (at and around test borings 2, 3 and 5), as we expect that unstable subgrade will be encountered at and around test borings 1 and 4 and subgrade reinforcement is recommended.

Asphalt Pavement Section Thicknesses

We were not provided a traffic volume for the streets. We assume that the traffic will consist of mostly automobiles with occasional trucks. Table 2 summarizes the recommended asphalt pavement section thicknesses based on the subsurface conditions and assumed traffic loads.

Table 2. Recommended Asphalt Pavement Section Thicknesses

Test Borings	Asphalt Pavement Thickness, in	Aggregate Base Course Thickness, in	Granular Subbase Thickness, in	Subgrade Reinforcement
1 & 4	4	10*	-	Tensar TX7
1 & 4	4	6	10*	Geotextile Fabric
2, 3 & 5**	4	8	-	-

*May need to be increased depending on the subgrade conditions encountered during construction.
**Subgrade reinforcement may be needed at and around these areas if unstable subgrade is encountered.

The asphalt pavement should meet the requirements of sections 320 and 321 for Class G. We recommend that routine maintenance such as crack filling, localized patching and seal coating be performed. The design section could be reduced if the owner is willing to assume additional maintenance costs or potentially shorter pavement life. For the geotextile fabric, we recommend using Mirafi HP 370, Propex Geotex 3x3 HF, Huesker Comtrac P 45/45 or a product that has similar strength properties as the products listed above.

Aggregate Base Course Materials

We recommend that the aggregate base course materials meet the requirements of Sections 260 and 882 of the SDDOT Standard Specifications. The aggregate base course materials should be compacted to a minimum of 97 percent of standard Proctor (ASTM:D698).

Granular Subbase Material

The granular subbase should consist of crushed quartzite, recycled concrete or a crushed pit-run material meeting the gradation specifications shown in Table 3. The granular subbase should be compacted to a minimum of 97 percent of standard Proctor density (ASTM:D698). It should be noted that compaction testing may not be practical for the granular subbase due to the large aggregate.

Table 3. Granular Subbase Gradation Specifications

Sieve Size	Percent Passing
4-inch	100
1-inch	40 – 80
#4	10 – 50
#40	5 – 20
#200	0 – 5

Existing Gravel Base

Due to the limited thickness of the existing gravel base encountered at the test boring locations, it is our opinion that it will likely be difficult to reclaim the existing gravel base for use as aggregate base course.

Corrosive Potential

In our opinion, the on-site clay soils are considered extremely corrosive to corrosive, while the on-site granular soils are considered corrosive to mildly corrosive. Our opinions are based on previous resistivity tests performed on similar soil types.

CONSTRUCTION CONSIDERATIONS

Groundwater & Surface Water

Water may enter the excavations due to subsurface water, precipitation or surface run off. Any water that accumulates in the bottom of the excavations should be immediately removed and surface drainage away from the excavations should be provided during construction.

Disturbance of Soils

The soils encountered at the test boring locations are susceptible to disturbance and can experience strength loss caused by construction traffic and/or additional moisture. Precautions will be required during earthwork activities in order to reduce the risk of soil disturbance. Where soft/wet soils are encountered, the excavations should be performed with low-ground-pressure construction equipment or an excavator (backhoe) having a smooth cutting edge on the bucket.

Cold Weather Precautions

If site preparation and construction is anticipated during cold weather, then we recommend that all subgrades, slabs and other improvements that may be affected by frost movements be insulated from frost penetration during freezing temperatures. If filling is performed during freezing temperatures, then all frozen soils, snow and ice should be removed from the areas to be filled prior to placing the new fill. The new fill should not be allowed to freeze during transit, placement and compaction. Concrete and asphalt should not be placed on frozen subgrades. If subgrades freeze, then we recommend that the frozen soils be removed and replaced, or completely thawed. The subgrade soils will likely require reworking and recompacting due to the loss of density caused by the freeze/thaw process.

Excavation Sideslopes

All excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, “Excavations and Trenches”. This document states that the excavation safety is the responsibility of the contractor. Reference to this OSHA requirement should be included in the project specifications.

Observations & Testing

This report was prepared using a limited amount of information for the project and a number of assumptions were necessary to help us develop our conclusions and recommendations. It is recommended that our firm be retained to review the geotechnical aspects of the final design plans and specifications to check that our recommendations have been properly incorporated into the design documents.

The recommendations submitted in this report have been made based on the subsurface conditions encountered at the test boring locations. It is possible that there are subsurface conditions at the site that are different from those represented by the test borings. As a result, on-site observation during construction is considered integral to the successful implementation of the recommendations. We believe that qualified field personnel need to be on-site at the following times to observe the site conditions and effectiveness of the construction.

Excavation

We recommend that a geotechnical engineer or geotechnical engineering technician working under the direct supervision of a geotechnical engineer observe all excavations for utilities, slabs and pavements. These observations are recommended to determine if the exposed soils are similar to those encountered at the test boring locations, if unsuitable soils have been adequately removed and if the exposed soils are suitable for support of the proposed construction.

Testing

After the subgrade is observed by a geotechnical engineer/technician and approved, we recommend a representative number of compaction tests be taken during the placement of the backfill placed below slabs and pavements. The tests should be performed to determine if the required compaction has been achieved. As a general guideline, we recommend at least one (1) test be taken for every 10,000 square feet of embankment fill placed, at least one (1) test for every 500 feet in trench fill, and for every 2-foot thickness of fill or backfill placed. The actual number of tests should be left to the discretion of the geotechnical engineer. Samples of proposed

fill and backfill materials should be submitted to our laboratory for testing to determine their compliance with our recommendations and project specifications.

SUBSURFACE EXPLORATION PROCEDURES

Test Borings

We drilled five (5) SPT borings on December 14, 2017 with a truck rig equipped with hollow-stem auger. Soil sampling was performed in accordance with the procedures described in ASTM:D1586. Using this procedure, a 2-inch O.D. split barrel sampler is driven into the soil by a 140-pound weight falling 30 inches. After an initial set of 6 inches, the number of blows required to drive the sampler an additional 12 inches is known as the penetration resistance, or "N" value. The "N" value is an index of the relative density of cohesionless soils and the consistency of cohesive soils. In addition, thin walled tube samples were obtained according to ASTM:D1587, where indicated by the appropriate symbol on the boring logs.

The test borings were backfilled with on-site materials and some settlement of these materials can be expected to occur. Final closure of the holes is the responsibility of the client or property owner.

The soil samples collected from the test boring locations will be retained in our office for a period of one (1) month after the date of this report and will then be discarded unless we are notified otherwise.

Soil Classification

As the samples were obtained in the field, they were visually and manually classified by the crew chief according to ASTM:D2488. Representative portions of all samples were then sealed and returned to the laboratory for further examination and for verification of the field classification. In addition, select samples were then submitted to a program of laboratory tests. Where laboratory classification tests (sieve analysis and Atterberg limits) have been performed, classifications according to ASTM:D2487 are possible. Logs of the test borings indicating the depth and identification of the various strata, the "N" value, the laboratory test data, water level

information and pertinent information regarding the method of maintaining and advancing the drill holes are also attached in Appendix A. Charts illustrating the soil classification procedures, the descriptive terminology and the symbols used on the boring logs are also attached in Appendix A.

Water Level Measurements

The water levels indicated on the boring logs may or may not be an accurate indication of the depth or lack of subsurface groundwater. The limited length of observation restricts the accuracy of the measurements. Long term groundwater monitoring was not included in our scope of work.

Laboratory Tests

We performed laboratory tests on select samples to aid in determining the index properties of the soils. The tests consisted of moisture content and dry density. The laboratory tests were performed in accordance with the appropriate ASTM procedures. The results of the laboratory tests are shown on the boring logs opposite the samples upon which the tests were performed or on the attached data sheets.

LIMITATIONS

The recommendations and professional opinions submitted in this report were based upon the data obtained through the sampling and testing program at the test boring locations. We wish to point out that because no exploration program can totally reveal the exact subsurface conditions for the entire site, conditions between test borings and between samples and at other times may differ from those described in our report. Our exploration program identified subsurface conditions only at those points where samples were retrieved or where water was observed. It is not standard engineering practice to continuously retrieve samples for the full depth of the test borings. Therefore, strata boundaries and thicknesses must be inferred to some extent. Additionally, some soils layers present in the ground may not be observed between sampling intervals. If the subsurface conditions encountered at the time of construction differ from those represented by our test borings, it is necessary to contact us so that our recommendations can be

reviewed. The variations may result in altering our conclusions or recommendations regarding site preparation or construction procedures, thus, potentially affecting construction costs.

This report is for the exclusive use of the addressee and its representatives for use in design of the proposed project described herein and preparation of construction documents. Without written approval, we assume no responsibility to other parties regarding this report. Our conclusions, opinions and recommendations may not be appropriate for other parties or projects.

STANDARD OF CARE

The recommendations submitted in this report represent our professional opinions. Our services for your project were performed in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering profession currently practicing at this time and area.

This report was prepared by:
GeoTek Engineering & Testing Services, Inc.

Jared Haskins, PE
Geotechnical Manager

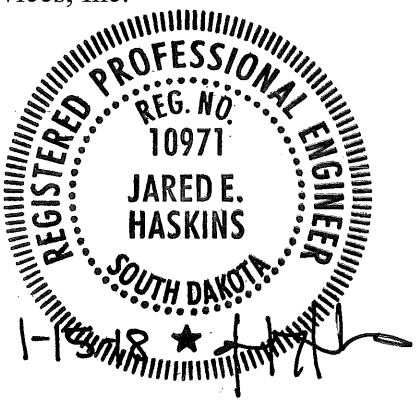

FIGURE 1
TEST BORING LOCATION MAP
PROPOSED STREET IMPROVEMENTS
OAK AVE, DOUGLAS DR & DOUGLAS BLVD
BALTIC, SD

ACAD\GEOTEK\JARED\17-F56

PROJECT#: 17-F56

DRAWN BY: CDW CHECKED BY:

GEOTEK ENGINEERING & TESTING SERVICES, INC.

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 E. 50th St. N.
Sioux Falls SD 57104
605-335-5512 Fax 605-335-0773
www.geotekeng.com

GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-F56** BORING NO. **1 (1 of 1)**

PROJECT **Proposed Street Improvements, Oak Avenue, Douglas Drive & Douglas Boulevard, Baltic, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS WC	D	LL	PL	QU
0.2	**ASPHALT**: 2.5" thick					HSA					
0.6	**FILL, MOSTLY CLAYEY SAND**: with gravel, brown, dry, 5" thick	EXISTING GRAVEL BASE									
	FILL, MOSTLY SANDY LEAN CLAY: a trace of gravel, brown and dark brown, moist	FILL	6		1	SPT	23	96			
2	**LEAN CLAY**: brown, moist, soft, (CL)	FINE ALLUVIUM	4		2	SPT	19	101			
4½	**SILTY SAND**: fine grained, brown, dry, very loose to loose, (SM)	MIXED ALLUVIUM	4		3	SPT					
			5		4	SPT					
8½	Bottom of borehole at 8½ feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
12-14-17	11:30 am	8.5	--	7	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 12-14-17 COMPLETE 12-14-17 11:30 am

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 E. 50th St. N.
Sioux Falls SD 57104
605-335-5512 Fax 605-335-0773
www.geotekeng.com

GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-F56** BORING NO. **2 (1 of 1)**

PROJECT **Proposed Street Improvements, Oak Avenue, Douglas Drive & Douglas Boulevard, Baltic, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
0.4	**ASPHALT**: 4.5" thick					HSA					
0.8	**FILL, MOSTLY CLAYEY SAND**: with gravel, brown, dry, 5" thick	EXISTING GRAVEL BASE									
	FILL, MOSTLY LEAN CLAY WITH SAND: a trace of gravel, dark brown and black, moist	FILL	5		1	SPT	19	107			
2	**LEAN CLAY WITH SAND**: dark brown, moist, soft, (CL)	FINE ALLUVIUM	4		2	SPT	21	100			
					3	BAG					
4½	**LEAN CLAY**: brown, moist, soft, (CL)	FINE ALLUVIUM	3		4	SPT	25				
7	**LEAN CLAY**: grayish brown, moist, firm, a few lenses of sand above 8' (CL)	FINE ALLUVIUM	5		5	SPT					
8½	Bottom of borehole at 8½ feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
12-14-17	10:25 am	8.5	--	7	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 12-14-17 COMPLETE 12-14-17 10:25 am

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 E. 50th St. N.
Sioux Falls SD 57104
605-335-5512 Fax 605-335-0773
www.geotekeng.com

GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-F56** BORING NO. **3 (1 of 1)**

PROJECT **Proposed Street Improvements, Oak Avenue, Douglas Drive & Douglas Boulevard, Baltic, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS WC	D	LL	PL	QU
0.3	**ASPHALT**: 4" thick					HSA					
0.6	**FILL, MOSTLY CLAYEY SAND**: with gravel, brown, dry, 3" thick	EXISTING GRAVEL BASE									
	FILL, MOSTLY SANDY LEAN CLAY: a trace of gravel, brown and dark brown, moist	FILL	20		1	SPT	9	127			
2	**SAND WITH SILT**: fine grained, brown, dry, loose, with a few lenses of clay (SP-SM)	COARSE ALLUVIUM	5		2	SPT					
4½	**SILT**: brown, dry, soft to firm, (ML)	FINE ALLUVIUM	4		3	SPT	17				
					4	BAG					
			5		5	SPT					
8½	Bottom of borehole at 8½ feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
12-14-17	9:45 am	8.5	--	7	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 12-14-17 COMPLETE 12-14-17 9:45 am

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 E. 50th St. N.
Sioux Falls SD 57104
605-335-5512 Fax 605-335-0773
www.geotekeng.com

GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-F56** BORING NO. **4 (1 of 1)**

PROJECT **Proposed Street Improvements, Oak Avenue, Douglas Drive & Douglas Boulevard, Baltic, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
0.3	**ASPHALT**: 3" thick					HSA					
0.4	**FILL, MOSTLY CLAYEY SAND**: with gravel, brown, dry, 2" thick	EXISTING GRAVEL BASE									
	LEAN CLAY: a trace of gravel, black, moist to wet, firm, (CL)	TOPSOIL	6		1	SPT	31	87			
2	**LEAN CLAY**: dark brown, moist, soft, (CL)	FINE ALLUVIUM	4		2	SPT	22	100			
4½	**CLAYEY SAND**: fine grained, brown, dry, very loose, (SC)	MIXED ALLUVIUM	4		3	SPT					
6	**LEAN CLAY**: mottled brown and gray, moist, firm, (CL)	FINE ALLUVIUM	5		4	SPT					
8½	Bottom of borehole at 8½ feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
12-14-17	11:00 am	8.5	--	7	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 12-14-17 COMPLETE 12-14-17 11:00 am

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 E. 50th St. N.
Sioux Falls SD 57104
605-335-5512 Fax 605-335-0773
www.geotekeng.com

GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-F56** BORING NO. **5 (1 of 1)**

PROJECT **Proposed Street Improvements, Oak Avenue, Douglas Drive & Douglas Boulevard, Baltic, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS WC	D	LL	PL	QU
0.3	**ASPHALT**: 3" thick					HSA					
0.6	**FILL, MOSTLY CLAYEY SAND**: with gravel, brown, dry, 4" thick	EXISTING GRAVEL BASE									
	LEAN CLAY WITH SAND: brown, moist, firm, (CL)	FINE ALLUVIUM	7		1	SPT	15	112			
2	**SAND WITH SILT**: fine grained, brown, dry, loose, with a few lenses of clay (SP-SM)	COARSE ALLUVIUM	5		2	SPT	5				
			6		3	SPT					
7	**SILT**: brown, dry, firm, (ML)	FINE ALLUVIUM	6		4	SPT					
8½	Bottom of borehole at 8½ feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
12-14-17	9:00 am	8.5	--	7	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 12-14-17 COMPLETE 12-14-17 9:00 am

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

BORING LOG SYMBOLS AND DESCRIPTIVE TERMINOLOGY

SYMBOLS FOR DRILLING AND SAMPLING

Symbol	Definition
Bag	Bag sample
CS	Continuous split-spoon sampling
DM	Drilling mud
FA	Flight auger; number indicates outside diameter in inches
HA	Hand auger; number indicates outside diameter in inches
HSA	Hollow stem auger; number indicates inside diameter in inches
LS	Liner sample; number indicates outside diameter of liner sample
N	Standard penetration resistance (N-value) in blows per foot
NMR	No water level measurement recorded, primarily due to presence of drilling fluid
NSR	No sample retrieved; classification is based on action of drilling equipment and/or material noted in drilling fluid or on sampling bit
SH	Shelby tube sample; 3-inch outside diameter
SPT	Standard penetration test (N-value) using standard split-spoon sampler
SS	Split-spoon sample; 2-inch outside diameter unless otherwise noted
WL	Water level directly measured in boring
▼	Water level symbol

SYMBOLS FOR LABORATORY TESTS

Symbol	Definition
WC	Water content, percent of dry weight; ASTM:D2216
D	Dry density, pounds per cubic foot
LL	Liquid limit; ASTM:D4318
PL	Plastic limit; ASTM:D4318
QU	Unconfined compressive strength, pounds per square foot; ASTM:D2166

DENSITY/CONSISTENCY TERMINOLOGY

Density Term	N-Value	Consistency Term
Very Loose	0-4	Soft
Loose	5-8	Firm
Medium Dense	9-15	Stiff
Dense	16-30	Very Stiff
Very Dense	Over 30	Hard

DESCRIPTIVE TERMINOLOGY

Term	Definition
Dry	Absence of moisture, powdery
Frozen	Frozen soil
Moist	Damp, below saturation
Waterbearing	Pervious soil below water
Wet	Saturated, above liquid limit
Lamination	Up to ½” thick stratum
Layer	½” to 6” thick stratum
Lens	½” to 6” discontinuous stratum

PARTICLE SIZES

Term	Particle Size
Boulder	Over 12”
Cobble	3” – 12”
Gravel	#4 – 3”
Coarse Sand	#10 – #4
Medium Sand	#40 – #10
Fine Sand	#200 – #40
Silt and Clay	passes #200 sieve

GRAVEL PERCENTAGES

Term	Range
A trace of gravel	2-4%
A little gravel	5-15%
With gravel	16-50%