SPECIFICATIONS FOR SUBSURFACE INVESTIGATIONS & DESIGN

1. General

The Consultant shall be responsible for all subsurface investigation and analysis including the reconnaissance and planning, test borings and sampling, testing of samples, the report of findings and recommendations pertaining to the design, construction methods or construction control necessitated by subsurface conditions.

Prior to performing any subsurface investigations in the field, the Consultant shall submit a plan showing the location of all proposed test borings. This plan will be reviewed by the Iowa DOT, Soils Design Section, and is to be approved before field operations are initiated.

The subsurface findings and recommendations shall be utilized for and incorporated into the final design and plans submitted by the Consultant. This shall be considered an Engineering service to be performed in accordance with the Engineering Agreement.

The Highway Soil Survey is to be conducted in accordance with the following:

**Specifications for Highway Soils Survey**

**Purpose.** The purpose of the soil survey is to provide sufficient information for design and analysis of the following subjects:

(a) The final location of road, both vertical and horizontal
(b) The suitability of materials obtained from cuts, borrow, or channel changes for use in embankments.
(c) The design of the roadway section, including foreslopes and backslopes.
(d) The need for subgrade treatment, the type of treatment required, the location of select soils and quantities available, and need for intercepting drains.
(e) The foundation conditions for embankments or structures (other than bridges) with their strength and consolidation characteristics.

**Scope.** The work specified under this heading consists of furnishing all labor, material, equipment, machinery, transportation, services, facilities, and performing all operations incidental to making a soil survey and soil report in strict accordance with instructions as specified hereinafter. This soil survey shall include the entire length of the project under consideration. The soil survey shall determine if subsoil conditions are present which may adversely affect the stability of cuts and embankments.

Clearing. The Consultant shall carry out all clearing and grubbing necessary to provide access and working space at the location of each boring.

Right-of-Way and Damage to Property. The Consultant shall obtain all permits and licenses from all applicable authorities having jurisdiction, and shall also obtain permission for work to be done on private property. The Consultant shall comply with all local laws and ordinances of the area in which the work is being done. All boring holes shall be adequately filled, and tamped to avoid settlement.

The Consultant shall take every precaution against injury to any public or private property and shall promptly repair or pay for any such damage to the satisfaction of the Iowa DOT, Highway Division, and private property owners.

Equipment for Soils Survey. The equipment used shall be power drilling and/or driving equipment or such other tools or equipment as are suitable for determining the limits of the various soil layers, and obtaining representative samples for examination and laboratory test from each cut, borrow, or fill area. The equipment shall meet the approval of the Iowa DOT, Soils Design Section.

Location of Borings.

Cuts. In cut areas, borings shall be made on the centerline of each proposed pavement. When the proposed cut is designed to accommodate only one pavement, the boring interval shall be 200 ft. for cuts less than 5 ft. in depth and 100 ft. for cuts greater than 5 ft. in depth. Spacing of all borings shall be adjusted to no more than 100 ft. intervals to identify the locations of rock, select soils and unsuitable soils. When the proposed cut accommodates more than one pavement, the boring interval may be increased to 400 ft. on each pavement for cuts less than 5 ft. and 200 ft. on each pavement for cuts exceeding 5 ft. in depth. Boring intervals for all cut depths shall be adjusted to identify major materials as noted for single lane pavements. For multi lane pavements the borings shall be staggered so that there will be a boring either right or left of centerline at not more than 200 ft. intervals. All borings shall extend to a depth of not less than six feet below subgrade elevation, except as otherwise noted.

Where more than one major layer is encountered on centerline profile, borings on the backslope on both sides of centerline shall be made at 200 ft. intervals near the toe of the proposed cuts and parallel to centerline to a depth not less than 6 ft. below subgrade.

Borings shall also be made as described above for intersecting roads and frontage roads included in this project.
Any areas of weak soils encountered, or potential sliding planes, shall be investigated thoroughly by the Consultant. Any areas of select granular or glacial till soils shall also be investigated by the Consultant to determine if additional borings shall be made for borrow sources.

Where material is encountered which would classify as rock excavation, the boring shall be carried to a depth sufficient to determine the presence of solid rock. Sufficient borings shall be made on centerline and backslopes to definitively outline the surface of the classified material. Where rock exists at 8 ft. or higher above profile grade, one boring in each cut will be cored to ditch grade. The rock core and borings shall be sufficient to determine if presplitting is feasible.

**Location Other Than Cuts.** Borings shall be made on the centerline of each proposed pavement. Where there is only one proposed pavement, and the proposed fill is less than 10 ft. in height, the boring interval shall be 400 ft. For fills greater than 10 ft. the boring interval shall be 200 ft. Where there is more than one pavement the boring interval shall be staggered so that there will be a boring either right or left of each 200 ft. station on the centerline of the proposed improvement. The depth of the borings shall be such that it extends at least 10 ft. into firm noncompressible soil, 10 ft. into sands, or to rock.

Where an area of weak subsoil is encountered, borings shall be made near the toes of the proposed foreslopes in the weakest area at 100 ft. intervals. The Engineer shall be notified immediately of the presence of weak subsoil which may affect the stability of embankment.

Borings shall also be made as described above for intersecting roads and frontage roads included in this project.

**Peat Deposits.** Peat deposits, or muck deposits of equally soft consistency, shall be investigated by borings at 100 ft. intervals on a grid extending along centerline and to at least 50 ft. beyond the proposed embankment. Borings shall extend to a depth penetrating the deposit and 10 ft. into sand or other firm material.

**Channel Change.** When channel change material is proposed for use in embankment, borings need to extend at least 3 ft. below the grade of the proposed new channel. Such materials do not ordinarily exhibit normal profiles; therefore, sufficient samples must be obtained for laboratory test to insure their suitability for such use.

**Environmental Concerns.** If items are discovered which are potentially of environmental concern, the Consultant shall immediately notify the Engineer.

**Borrow Sources.** Borrow areas needed as sources of material for embankment construction shall be investigated by borings at no greater than 400 ft. intervals. They shall be spaced to accurately define the major soils layers to be encountered in the borrow area. These borings shall extend to a depth of 10 ft. below the proposed bottom of cut.
**Field Record.** The soils encountered in each boring shall be carefully examined at the time of boring and a written record or "boring log" prepared, which will include a complete description (classification, color, texture, moisture, apparent strength, consistency, etc.) of the soils in each layer or horizon, and the thickness and position of the layers in the profile. The log of each boring shall be plotted to form a continuous soil profile as the boring progresses.

The elevation of the ground (referred to plan datum) must be recorded or be available at each boring location. The thickness and location of the various soil layers may then be recorded in feet below ground surface or by elevation. The elevation of the top of free water is to be logged. In general, holes will remain open and where it is practical to do so, the water table should be reported as the elevation of the water in the holes approximately 24 hours after the holes were bored. Where this is done, it should be noted at what hour after boring the water level is determined, if present or not. After this information is obtained, the holes shall be backfilled.

**Sampling and Laboratory Testing.** Boring samples shall be obtained from the soils horizons for laboratory testing as the work progresses. The following samples shall be obtained in each cut area:

1. A loose sample of sufficient size shall be obtained from each different soil encountered and shall be tested for mechanical analysis, determination of Atterberg limits, and Munsell color comparisons. At least two samples shall be tested for standard maximum density and optimum moisture (AASHTO-T-99-57) for each major soil layer encountered in each cut area representing 600 ft. or less.

2. At least two undisturbed cores not less than 2 in. in diameter nor less than 4 in. in length from each major soil layer and each select soil layer shall be tested for each cut area representing 600 ft. or less for determination of in-situ dry density and moisture content.

3. All samples shall be properly preserved by the Consultant until the final report is accepted.

The following samples shall be obtained from each area or location other than cuts:

1. A loose sample of sufficient size shall be obtained from each different soil encountered and shall be tested for mechanical analysis and determination of Atterberg limits.

2. Undisturbed "Shelby" type samples of each compressible soil layer greater than 5 ft. thick for consolidation testing and for triaxial compression strength testing. In addition, the dry density and moisture content of each core shall be determined.
All these samples shall be sufficient in number to confirm field classifications and serve as a definite guide in the preparation of the final soils profile. The results of laboratory tests and all other pertinent data shall be developed to show the grain size classifications (soil type) and the AASHTO M-145-91 classification for all significant soil types in the profile. The results of all analyses shall be included in the soils report.

The grain size classification shall be based on the entire sample, in which gravel size will be considered as larger than 2 mm in diameter, sand grains will be considered as larger than 0.074 mm in diameter and smaller than 2 mm, silt as having diameters smaller than 0.074 mm and larger than 0.002 mm, and clay as having diameters smaller than 0.002 mm.

A prefix, gravelly, shall precede the grain size classification if more than 10% is gravel.

**Soils Report.** The end objective of the Soils Survey is a final Soils Report summarizing the findings of the survey and making appropriate recommendations for the handling of the soils encountered. This report shall include:

1. The location of the project beginning and ending by station, township and range, or by streets and name of city in urban areas, and county or counties.

2. A general description of the proposed improvement - including surface type and width, number of traffic lanes, median, intersections, or grade separations, etc., and any other information which may be of value in the proper interpretation of the survey data.

3. A detailed description of the investigation consisting of:
   - Date (month and year) when the field soils survey and investigation was made.
   - Climatic conditions during investigation and for at least three months previous to the start of the investigation.
   - General description of terrain with special emphasis on springs and drainage and erosion patterns. Any conditions of high water, flooding, etc., which may have been noted and which might be of value in the design of bridges or culverts.

4. Boring logs providing "Unified" field descriptions, the elevation of all samples obtained, in-place moisture conditions, measured water table elevations and drilling data.

5. Definite recommendations for incorporation into the plans relative to the design and construction of embankments, subgrade treatment...
requirements, availability and use of select soils, placement or disposal of unsuitable soils, placement or disposal of unsuitable soils, drainage installations, subgrade removal and replacement, the use of channel change materials, the special handling of unusual soil types or conditions or other pertinent factors affecting the design or construction of the section.

6. Settlement estimated for all design structures including concrete pipes 36 in. diameter and larger. Also, time vs. settlement curves shall be plotted for all areas where settlements are estimated to be one foot or greater.

7. A map showing the location of each boring.

8. The results of all laboratory tests on samples obtained during the survey recorded on approved forms. These tests consist of the color comparisons, mechanical analysis, standard maximum density and optimum moisture, the determination of the Atterberg limits, moisture content, in-situ moisture and density, consolidation characteristics, and strength analysis.

The Soils Report and all recommendations will be reviewed and must meet the approval of the Iowa DOT Soils Design Section prior to final plan incorporation.

Three copies of the final approved report shall be furnished to the Iowa DOT, Soils Design Section.

**Plan Incorporation.** Soils profiles and boring location layouts will be prepared at design plan scale for incorporation into the final design plans. All borings made shall be shown in the plans either on soil profiles, cross sections, borrow layouts or other required special details. All recommendations, including placement requirements, special cutting, stability requirement, special shaping, top-soiling requirements, shrinkage estimates, boulder estimates, all subsurface drainage requirements and pavement under drainage requirement shall be incorporated into the final design plans.
USDA TEXTURAL CLASSIFICATION

CHART FOR 2-MICRON CLAY
January 2006 Discussion
ASSHTO Classification and Unsuitable Soils

Projects will be designed and built using the Standard Specifications Book – Series 2001 (red cover). Page 147, of that book, states that the Group Index of soils is based on AASHTO M-145-91, and that unsuitable soils are those with a Group Index of (30) or more. Note that this is a change from the Specifications Book – Series 1992 which used M-145-49 and a Group Index of (19) or (20) for unsuitables.

Defining unsuitable soils as those with GI = 30 or more as per AASHTO M-145-91 and the Specifications Book has not been found to be universally appropriate. Revision or modification of the “GI = 30 or more” criteria for unsuitable soils has been found to be necessary with some soils in certain parts of Iowa (especially with the loess and claypan soils in southeast Iowa), with revisions or modifications either above (30) and below (30) being necessary and being implemented on certain projects.

The Soils Consultant is instructed to evaluate the applicability of the “GI = 30 or more” criteria for unsuitable soils on each project based on an over-view of the project as a whole, on any relationships to geologic types of soil (claypan, loess, gumbo, topsoil, etc), on their experience with differing soils, on the geographical location of the project in Iowa, and on any other identifiable criteria. The Soils Consultant shall then make a recommendation to the Iowa Department of Transportation Soils Design Section on what Group Index criteria is to be used to define unsuitable soils on each project. No final determination of the unsuitable soil criteria shall be made or incorporated into soils design plans prior to an evaluation of this recommendation by the Iowa Department of Transportation Soils Design Section.
Guidelines for Soil Use in Roadways  
(AASHTO-Test Procedures, M-145-91)  
(Classification 0.002 mm clay)

I. Select Treatment Materials

1. Cohesive Soils
   1. 45% or less silt
   2. 110 pcf or greater T-99-Proctor Density
   (must meet all):
   3. P.I. greater than 10
   4. A-4, A-6 or A-7-6 Soils of Glacial Origin

2. Granular Soils
   1. 110 pcf or greater T-99-Proctor Density
   2. 15% or less silt & clay
   (must meet all):
   3. P.I. = 3 or less
   4. A-1, A-2 or A-3(0)

3. Special Backfill
   1. Article 4132 IA DOT specifications

II. Situations may arise where it is necessary to utilize marginal select soils. The following variances to the select criteria may be considered as limiting.

1. Individual tests may be discarded if the majority of tests within the depositional horizon meet all requirements.

2. Providing all other criteria are met, the silt limit may be raised to 47%.

3. Providing all other criteria are met, the Proctor Density limit may be lowered to 108 pcf.

4. Providing all other criteria are met the Plastic Index limit may be lowered to 8. This variance should not be used for deposits containing interbedded sand or silt.

Designated Select Treatment sources should contain significant amounts of material to assure uniformity of treatments. The material may be hauled as necessary but an attempt should be made to limit this distance to two miles. Borrow sources are desirable because they may be worked independently of any staging required for roadway grading.
III. Unsuitable Soil

### Use (RL-1B Standard)

<table>
<thead>
<tr>
<th>Use</th>
<th>Definition</th>
</tr>
</thead>
</table>
| Slope Dressing Only: | 1. Peat or Muck  
2. Soils with P.L. 35 or greater  
3. A-7-5 or A-5 having less than 85 pcf T-99-Proctor Density |
| Type C Disposal-3 ft. below subgrade in fills: | 1. All soils other than A-7-5 or A-5 having a T-99-Proctor Density of 95 pcf or less.  
2. All soils other than A-7-5 or A-5 containing 3% or more carbon. |
| Type B Disposal-5 ft. below subgrade in fills: | 1. A-7-6 (GI \geq 30)  
2. Residual clays (overlaying bedrock) regardless of classification |
| Type A Disposal in fills | 1. Shale  
2. A-7-5 or A-5 soils having a T-99-Proctor Density greater than 85 pcf but less than 95 pcf. |

A. It is desirable to dispose of all unsuitable soils within a reasonable haul distance ± 1 mile and to utilize all materials found on the project. If disposal of excessive "unsuitable" soils becomes a problem, it may be necessary to make minor grade adjustments to minimize the unsuitable soil cut and require that suitable material be obtained from borrow.

B. Excess Type B soils may be disposed of following the Type C criteria if the Type B disposal requirements cause the material to be wasted.

IV. Cut area subgrade situations requiring treatment.

1. When unsuitable soils are located within 2 ft. of finished subgrade, a minimum treatment of 2 ft. select soil or 1 ft. Special Backfill (Section 4132) is required.

2. Nonuniform soils within 3 ft. of subgrade top, particularly contact zones of major soil horizons and these soils containing pockets or interbedded layers of sand or silt, indicate potential frost heave areas. Treatments and/or drainage must assure that protection from ice lensing extends a minimum of 3 ft. below subgrade.
3. A-4 soils with a Group Index of (7) or less have a high frost heave potential but are easily drainable. Treat as per #1 and assure that the 3 ft. of subgrade is well drained.

4. Bedrock cuts shall be subcut and treated a minimum of 1 ft. Shale cuts should be treated full width with select cohesive soil. All rock cuts requiring blasting shall be treated with Special Backfill.

5. Drainage (subdrains or ditching) should assure that the ground water level is maintained at least 3 ft. below finished subgrade. In areas where conditions are severe or where positive drainage cannot be assured, a minimum 1 ft. Special Backfill treatment should be used. In most cases, continuous longitudinal subdrainage should be used.

6. In all urban designs, areas mentioned above shall be subcut and treated with 1 ft. of Special Backfill (4132). Those areas not requiring treatments shall have the upper 1 ft. placed as per Article 2109.06 - Special Compaction of Subgrade.

V. Other Surface Treatments

1. If available project materials are limited, it may be desirable to treat only areas meeting the above requirements. Moisture Control (Article 2107.09) may be used in areas not requiring "treatment" as follows: In cuts the upper 2 ft. of the subgrade shall be subcut and replaced with Moisture Control. All fill areas shall have the upper 3 ft. placed with Moisture Control.

2. Treatments composed of materials meeting the criteria for granular soils shall have the upper 1 ft. placed with Moisture Control (Article 2107.09).
SPECIFICATIONS FOR BRIDGE BORINGS

Purpose. It is the intent of these specifications to secure complete and accurate information relative to subsurface conditions at bridge locations as specified hereinafter, for use in designing required foundations.

The soil explorations and foundation investigations conducted under these specifications shall furnish reliable detailed information on subsurface conditions. In addition to the normal investigations to be conducted under these specifications, all special subsurface conditions shall be noted and explored to the fullest extent.

Scope. The work specified under this heading consists of furnishing all labor, materials, equipment, transportation, services, facilities, and performing all operations incidental to making soil borings on land or on water in strict accordance with applicable drawings, directions, instructions, and as specified hereinafter.

General. Paragraphs, as outlined for "Subsurface Investigations and Design (Rev. 1/06)" covering "Traffic Control", "Clearing", and "Right-of-Way and Damage to Property", and "Environmental Concerns" will apply.

Location of Borings. The Consultant, in general, shall make at least one boring at each pier and abutment where piling foundations are used. At least two borings shall be made at each pier and abutment where rock is encountered within 20 ft. of the surface or 10 ft. below proposed footing elevation.

Description of Equipment and Methods. Borings with split spoon sampling in substantial compliance with ASTM D-1586 shall be made at locations of each proposed footing. Sampling spoons shall be of a standard design having an outside diameter of approximately 2 in. exclusive of head; a length of 18 in. and shoe, and an inside diameter of not less than 1.4 in. or more than 1.5 in. The spoon shall be advanced by driving, using a drop hammer weighing 140 lbs. and having a free fall of 2.5 ft. Automatic hammers may be used with the permission of the Engineer. The Engineer may require testing to correlate Standard Penetration Testing to IDOT results.

The following equipment or methods will not be permitted in taking split spoon samples: Walking beam, crank, or spudding arm type machinery for raising the 140 lbs. weight, a wire hoisting cable, a reversible hoisting winch, more than two wraps of the hoisting line over the cat head, or split spoon samplers equipped with battered drive shoes in which the diameter of the opening has been reduced by more than 0.06 in from the opening diameter as manufactured.

Where the hole fails to stand open, the Consultant shall use a casing or hollow stem auger with an inside diameter no less than 0.5 in. greater than the outside diameter of the sampler.
The casing (auger) shall in no case be advanced ahead of the horizon to be sampled. In general, the casing (auger) shall be stopped approximately 6 in. above the horizon to be sampled. After the casing (auger) has been advanced, the inside and bottom of the hole shall be cleaned of all loose material before the sample is taken. The boring log must show where water has been used.

**Boring Requirements.** Standard Penetration Test Values (N Values) are required at intervals of 5 ft. These values are obtained by counting the number of blows required to drive the split spoon sampler a distance of 12 in. using a drop hammer weighing 140 lbs. falling freely through a distance of 2.5 ft. The spoon shall be driven 6 in. below the bottom of the hole, which has been cleaned out by means of a water jet and/or auger, before the penetration test is started. All values shall be recorded in increments of penetration.

At least one soil classification and gradation test as described in "Subsurface Investigations and Design (Rev 1/06)" is required for each major soil layer of all compressible soil encountered in each hole.

The borings shall be drilled from ground line to a depth below the proposed footing elevation affording a minimum of 55 tons bearing for 10 in. "H" piling as described in the IDOT "Foundation Soils Information Chart for Pile Foundations, January 1989 (Revised Charts 9/94)" or other bearings as specified by the Engineer.

The Consultant must assume the risk of encountering boulders or other obstacles and must either carry the drilling through or past such obstacles.

For all rock encountered above 20 ft. in depth, the material shall be tested by Standard Penetration means as described above until the Standard Penetration Test values exceed 200 N. For rock materials with values above 200 N the material shall be cored to a depth of 10 ft. on one boring for each structure or every fourth boring, whichever is the most frequent. Seventy percent (70%) recovery shall be attained for the last 5 ft. of core or additional core depth shall be taken until this condition is met, unless otherwise authorized.

Sampling with undisturbed “Shelby” samples of each compressible soil layer shall be performed as described in "Subsurface Investigations and Design (Rev. 1/06)". These samples shall be tested as necessary by consolidation and/or triaxial testing in order to evaluate, report, and design all aspects of the bridge and site for settlement, slope stability, and related factors.

**Information Required.** A field record shall be required for the full depth of each boring. This record shall contain the date when the boring was made, the location of each boring with reference to station number and distance right or left of survey line, and the elevation of ground surface with respect to a permanent bench mark. It shall include the elevations at which the water table and upper boundary of each of the successive soil strata were encountered, the soil color, field Unified description and geological type.

The information obtained from these field notes shall be assembled in the form of boring logs which provide boundaries between strata, water table information, all Standard Penetration Test values, soils classifications, gradations and the elevation at which these tests were made.
If rock is cored, it shall be described geologically and classified according to "R.Q.D." (Rock Quality Designation) values. A sheet suitable for incorporation into the plan, which shows all of the above data, shall be prepared as described for "Subsurface Investigations and Design (Rev. 1/06)".