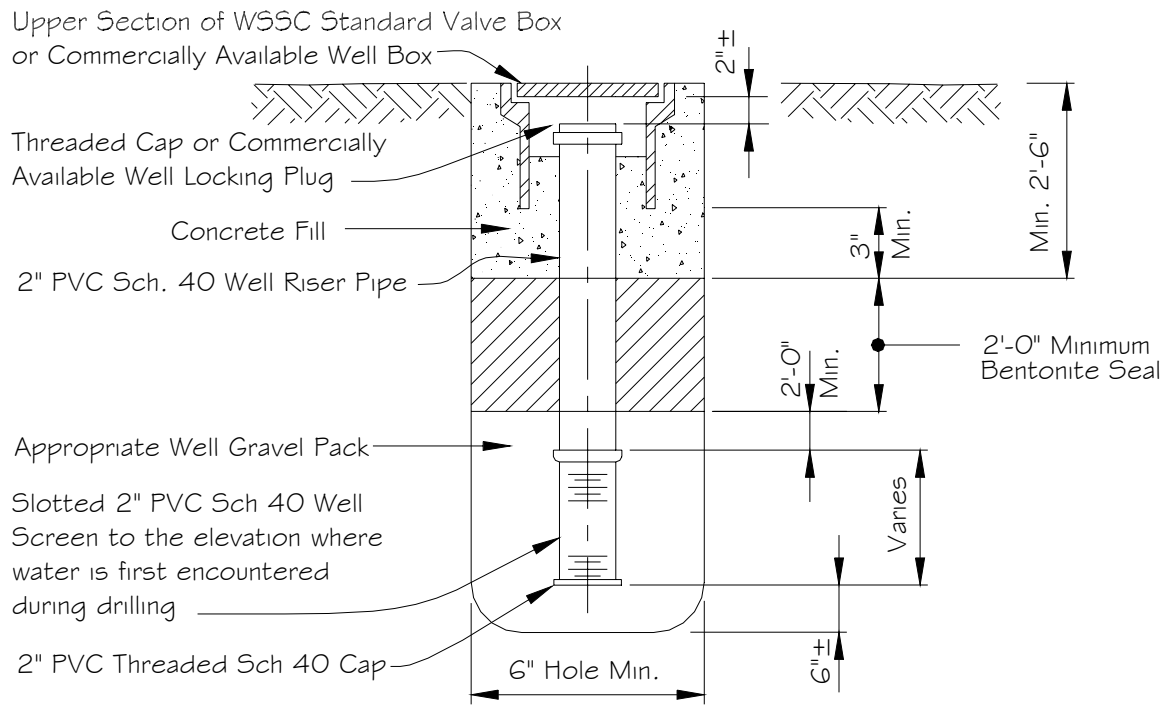


APPENDIX F**SOIL INVESTIGATION FOR SOFT GROUND TUNNEL PROJECTS****a. Soil Borings.**

- 1) Number and location of borings. When the tunnel is less than sixty (60) feet long, provide a minimum of two (2) borings, one (1) at each end of the tunnel. When the tunnel is equal to or longer than sixty (60) feet but shorter than six hundred (600) feet, provide three (3) borings, one (1) at each end of the tunnel and one (1) near the center. If the tunnel length is equal to or greater than six hundred (600) feet, provide a minimum of four (4) borings, located one (1) at each end of the tunnel and at locations between at a spacing of not more than three hundred (300) feet.
- 2) Boring depth and sampling requirements.
 - a) Extend the depth of the borings a minimum of one tunnel diameter (D) or five (5) feet, whichever is deeper, below the invert of the tunnel. Except in the borings for railway tunnels, Standard Penetration Tests (SPT) are to be performed at two and one half (2- 1/2) feet below the surface, at each five (5) feet thereafter and at any change of material, to a depth of one tunnel diameter above the tunnel. From one tunnel diameter above to one tunnel diameter below the tunnel, take continuous standard split spoon samples (ASTM D 1586). For soil borings for railway tunnels, SPT tests are to be performed and samples are to be taken continuously from the ground surface to the bottom of the boring. If soft to medium clays or cemented soils are encountered, obtain at least one undisturbed sample (ASTM D 1587) for each stratum.
 - b) Describe each sample as outlined in ASTM D 2488. Retain a representative sample of each type of material encountered in the split spoon sample for possible examination by WSSC personnel until contract is awarded.
 - c) If auger refusal is encountered in a drilled hole before the depth specified above is reached, do not terminate the drilling. Advance the drilling continuously using a double tube core barrel, with a diamond bit, capable of retrieving rock samples at least 1-5/8-inch diameter (ASTM D 2113). Determine the percent of core recovery and Rock Quality Designation (RQD).
- 3) Groundwater and observation well requirements.
 - a) If ground water is encountered in the boring, record the water table in each boring upon completion and at twenty four (24) hours after the completion of the boring except for the two end borings.
 - b) Install an observation well as shown on Sketch "HH" at the boring at each end of the tunnel for continuous ground water monitoring. Record at least one additional water level reading prior to the submission of the tunnel design to WSSC.
- 4) Grouting of boring hole(s). Fill all soil boring holes with lean grout at the completion of the drilling or at the end of ground water monitoring period as specified above, following the removal of any observation wells.





SKETCH "HH"
Observation Well

b. Laboratory Testing.

- 1) Perform laboratory tests on the samples obtained. Select samples to be tested after review of the soil samples and field logs. The following are the minimum tests to be performed on the soil samples:
 - a) Classification of all samples in accordance with the Unified Soil Classification System (ASTM D 2487).
 - b) Moisture content tests (ASTM D 2216) and sieve analysis (ASTM D 422), made on representative cohesionless soil samples.
 - c) Moisture content, density and atterberg limit (ASTM D 4318) tests, performed on representative samples that exhibit a plastic nature.
 - d) Unconfined compression tests (ASTM D 2166), made on undisturbed clay and cemented soil samples.
 - e) Laboratory unconfined compression tests (ASTM D 2938), performed on selected rock samples.



c. Submittals.

- 1) The following results are to be submitted as part of the Preliminary Tunnel Submittal review materials to: (For a description of the Preliminary Tunnel Submittal review materials, see Part Three, Section 26 (Tunnel Design Criteria)).

WSSC (Project Manager and Office)
14501 Sweitzer Lane
Laurel, Maryland 20707

- a) Map of boring locations. A copy of the construction plans with boring locations marked will be adequate.
- b) Boring logs (in triplicate).
- (1) The log for each boring (WSSC boring log form) must be completed in full. Due to the increased use of computer generated boring logs, gradation curves, etc., the lab shall have the option of using computer generated forms provided the format of the forms has been pre-approved by WSSC. The forms must be typed and must contain the following information:
- (a) Penetration resistance of each split spoon sample per 6-inch of spoon penetration. Core recovery and RQD for rock cores if rock is encountered.
- (b) Boring surface elevation.
- (c) Elevation and depth from surface to each soil and rock (if encountered) stratum.
- (d) Depth and elevation of bottom of boring.
- (e) Soil description including color, moisture condition, consistency/relative density and ASTM classification designation (ASTM D 2488).
- (f) Extent and character of weathering, type, color and hardness of rock if it is encountered.
- (g) Orientation of bedding or foliation relative to axis of boring if rock is encountered.
- (h) Ground water information.
- (i) Information on any bag samples, special observations or other pertinent remarks such as presence of sand stringers, slickenside clay layers, etc.
- (j) WSSC grid coordinates for the boring (example, S-33513 & E-16283)
- c) WSSC gradation curves (in triplicate).
- d) Tabulate field moisture contents, density values, atterberg limits and unconfined compressive strengths according to boring and sample numbers (in triplicate).
- e) Unconfined compression test stress-strain curve if the test is performed (in triplicate).
- 2) All data submitted must be signed/sealed by a Professional Engineer registered in the State of Md.

