

Appendix: Geotechnical Exploration Guidelines

The following general guidelines are provided to help determine drilling needs. Engineering and geological judgment should be used when assessing project-specific requirements.

Test borings should be located as close as possible to areas of concern. Exact boring locations in the field depend on several factors, including but not limited to subsurface variability, foundation types, utilities, existing structures, equipment access, permit and environmental restrictions, private property limitations, and traffic impacts.

Test boring locations and depths will vary according to the proposed structure, soil variability, and underlying rock conditions. Boring plans should generally follow AASHTO Bridge Specifications Table 10.4.2-1 (Minimum Number of Exploration Points and Depth of Exploration). The depth of drilling is a function of project requirements and local geology. In areas with uniform geology, less drilling may be required, whereas areas with erratic geology may need more drilling. The maximum spacing between borings is typically determined by site conditions and project complexity.

Efforts shall be made to strategically place borings. At times, minor adjustments to initial boring locations can allow for a single boring to cover multiple aspects of the project (e.g., structural borings can double as roadway borings). If borings are covering multiple aspects, minimum frequencies and depths shall still be followed.

The following values represent minimum expectations for a project and serve as a guide. The exact project requirements and details will dictate the final number and frequency of borings.

1 - Reference/Definitions

- **AASHTO LRFD Bridge Design Specifications, 10th Edition Table 10.4.2-1**
- **Competent Rock:** A single rock core run (not an average) with a minimum recovery ratio of 85% and RQD of 85% or higher.
- **Continuous Rock:** A rock core run with a recovery ratio of 85 percent or higher.

2 - Roadway Alignment Borings

2.1 Minimal Cuts and Fills (less than 5 feet)

- **Spacing:** As needed, typically 500 to 1,500 feet based on plans.
- **Depth:** 5 feet below the ditch line; rock coring may be required if refusal material is encountered above the proposed grade.

2.2 Soil Cuts

- **Cut Depth < 40 feet, Cut Length < 600 feet:**
 - **Spacing:** 2 test borings.

- **Depth:** Located in the deepest portion of the cut, at least 10 feet below the ditch line or auger refusal. Core one test boring if auger refusal is encountered to a minimum of 10 feet or proposed depth, whichever is reached first.
- **Cut Depth < 40 feet, Cut Length > 600 feet:**
 - **Spacing:** Test borings typically spaced 400 to 600 feet apart, minimum of 3 borings.
 - **Depth:** At least 10 feet below the ditch line or auger refusal. Core a minimum of 20% of the borings if refusal material is encountered to a minimum of 10 feet or proposed depth, whichever is reached first.
- **Cut Depth > 40 feet, Cut Length < 600 feet:**
 - **Spacing:** 2 test borings.
 - **Depth:** Located in the deepest portion of the cut, at least 10 feet below the ditch line or auger refusal. Core one boring if auger refusal is encountered to a minimum of 10 feet or proposed depth, whichever is reached first.
- **Cut Depth > 40 feet, Cut Length > 600 feet:**
 - **Spacing:** Test borings typically spaced 300 to 500 feet apart, minimum of 3 borings.
 - **Depth:** Located in the deepest portion of the cut, at least 10 feet below the ditch line or auger refusal. Core a minimum of 20 percent of the borings if refusal material is encountered to a minimum of 10 feet or proposed depth, whichever is reached first.

2.3 Fills

- **Fill Height < 30 feet, Fill Length < 600 feet:**
 - **Spacing:** 2 test borings.
 - **Depth:** 2 times the embankment depth. Core one boring 5 feet if auger refusal is encountered within the first 10 feet.
- **Fill Height < 30 feet, Fill Length > 600 feet:**
 - **Spacing:** Test borings typically spaced 400 to 600 feet apart, minimum of 3 borings.
 - **Depth:** 2 times the embankment depth. Core 5 feet in at least 20 percent of borings if refusal is encountered within the first 10 feet.
- **Fill Height > 30 feet, Fill Length < 600 feet:**
 - **Spacing:** 2 test borings.

- **Depth:** 2 times the embankment depth. Core 10 feet into refusal materials in at least 20 percent of borings if refusal is encountered within the first 15 feet.
- **Fill Height > 30 feet, Fill Length > 600 feet:**
 - **Spacing:** Test borings typically spaced 300 to 500 feet apart, minimum of 3 borings.
 - **Depth:** 2 times the embankment depth. Core a minimum of 10 feet in at least 20 percent of borings if refusal is encountered within the first 15 feet.

2.4 Rock Cuts

- **Rock Cuts (1.5:1 or Flatter):**
 - **Spacing:** Test borings spaced 150 to 250 feet apart.
 - **Depth:** 5 feet below the ditch line.
 - **Note:** Geophysical testing may be used to better define lithology. Geophysical testing may reduce test borings by up to 30 percent.
- **Rock Cuts (Steeper than 1.5:1):**
 - **Spacing:** Test borings no more than 50 feet apart, with a minimum of 2 borings.
 - **Depth:** 5 feet below the ditch line.
 - **Note:** Geophysical methods are required to better define lithology.

2.5 Karst Features

- **Additional Test Borings:** Required to fulfill project needs.
- **Depth:** Auger refusal; core a minimum of 10 feet.
- **Note:** Geophysical testing may be necessary to better map karst features.

2.6 Potential Acid-Producing Materials (APM)

- **Spacing:** Test borings at 150 to 250-foot intervals.
- **Depth:** At least 5 feet below final grade and/or foundation elements for APM verification.
- **Note:** Geophysical methods may be needed to better map lithology (see Chapter on Acid-Producing Materials).

2.7 Culverts

- **Box Culverts:**
 - **Spacing:**
 - **New Culvert:** Minimum of 2 test borings per culvert, typically along centerline spaced at each end.

- **Extension:** 1 test boring at location of extension.
- **Depth:** At least 10 feet below the anticipated invert elevation or auger refusal. If auger refusal is encountered core a minimum of 5 feet into rock to verify refusal materials.
- **Note:** For culverts longer than 300 feet, additional borings may be required at intervals of 150 to 200 feet along the length of the culvert.

3. Structural Foundations

3.1 Bridge Test Borings

- **Abutments:**
 - **Spacing:** 1 test boring per abutment.
 - **Depth:** 100 feet or until auger refusal. Core a minimum of 10 feet to verify refusal materials.
- **Piers/Bents:**
 - **Spacing:** 1 test boring per pier/bent.
 - **Depth:**
 - **Shallow Foundations:** Core 10 feet of continuous rock below the anticipated foundation elevation.
 - **Piles:** 100 feet or auger refusal; core 10 feet of rock to verify refusal materials.
 - **Drilled Shafts:** 100 feet or auger refusal; core 20 feet into competent rock below the anticipated shaft tip elevation.

3.2 Retaining Walls

- **Fill Retaining Walls (CIP and MSE):**
 - **Spacing:** Minimum 2 borings per wall, typically spaced 100 to 200 feet apart.
 - **Depth:** Two times the wall height or auger refusal. If auger refusal is encountered core a minimum of 10 feet to verify refusal material in at least 30 percent of borings.
 - **Note:** Geophysical methods may be needed to better define lithology. With geophysical testing, test borings can be reduced by up to 30 percent.
- **Cut Retaining Walls (Soldier Pile, Anchor, Soil Nail):**
 - **Spacing:** Minimum 2 borings per wall, typically spaced 50 to 150 feet apart.

- **Depth:** At least 15 feet below the bottom of the wall and anticipated foundation element. If auger refusal is encountered, core rock to proposed depth. Extend borings into the bond zone for anchor and soil nail walls.
- **Note:** Geophysical methods are required to better define lithology, including at the bottom of the wall and within anticipated bond zones.

3.3 Noise Walls

- **Spacing:** At least 2 test borings per wall, typically spaced 300 feet apart.
- **Depth:** 30 feet into soil. If auger refusal is encountered, core 5 feet into refusal in at least 20 percent of borings.
- **Note:** Geophysical methods may be needed to better define lithology. If geophysical methods are used total number of borings may be reduced by up to 30 percent.

3.4 Sign Structures, High Mast Lighting, and Signal Foundations

- **Spacing:** 1 test boring per foundation.
- **Depth:** 30 feet into soil. Core 5 feet into refusal if encountered.