DAM SAFETY

POLICY MEMORANDUM #24

TO: Dam Owners, Operators, and Engineers

FROM: Stormwater, Dam Safety, and Flood Management Program
Water and Science Administration

DATE: January 16, 2026

SUBJECT: Geotechnical and Geologic Site Investigation Guidance

Background

An adequate assessment of geologic and geotechnical conditions is imperative for a safe dam design and construction. Over 50 percent of all dam failures in the USA can be linked to geologic and geotechnical problems according to information provided by the Association of State Dam Safety Officials (ASDSO). The geologic and geotechnical problems range from construction delays and foundation defects caused by inadequate investigation to internal erosion failure through the embankment (piping).

Geotechnical investigations and analyses are cited in COMAR 26.17.04.05 and USDA, Natural Resource Conservation Service, Maryland Conservation Practice, Standard Pond Code 378, January 2000 (MD378), though details are not included. Accordingly, this Policy Memorandum provides general guidance on site investigations and subsurface characterization that is expected for the design of dams and small ponds.

Each dam site may have its own unique set of geologic and geotechnical challenges. Similarly, the site investigation and design requirements are different for dams of different size, purpose and hazard potential classification. It is expected that a registered professional engineer practicing in the geotechnical discipline will determine the specific scope of the geotechnical investigation and analyses to be site and project specific to address the complexity of site conditions and design requirements of the proposed dam project.

General

A geotechnical site investigation and analysis is required for:

- New dams and small ponds;

- Spillway (principal and/or auxiliary) replacement or significant repairs for existing dams and small ponds;
- Repair projects that address seepage or stability issues at dams and small ponds;
- Projects where embankments are being raised by earth fill or parapet walls;
- Projects where drains or filters are replaced or newly installed at dams and small ponds; and
- Any other project as deemed necessary by the MDE Dam Safety program or the project engineer.

For all dams and small ponds the geotechnical site investigation should begin with the following steps:

- For existing structures, obtain as-built drawings, geotechnical reports and other relevant information from dam owner, MDE Dam Safety program, or local Soil Conservation District (SCD).
- Use available information to perform desktop screening of the dam and reservoir site for potential geologic or man-created hazards (e.g., karst, active or abandoned mines, faults, pipelines or buried utilities, UXO, etc.)
- Perform physical reconnaissance of reservoir and dam site. Inspect and measure/map/record features such as seeps, bedrock outcrops, sinkholes, stability of existing cut slopes, existing structures. Identify locations for boreholes.
- Obtain site geologic maps (surficial and bedrock, as available)
- Review current and historic aerial photography to examine site historic uses that may impact dam (e.g., controlled or uncontrolled filling)

Geotechnical Site Characterization

Geotechnical site characterization generally consists of a coordinated series of geotechnical boreholes, in situ testing, and excavated trenches or test pits to characterize existing soil and rock strata along with field and/or laboratory testing to determine material properties. Hand augers and published soils maps are generally not sufficient to adequately characterize the subsurface conditions.

Permits/Authorizations: Drilling into, in close proximity to, or through embankment dams and levees and their foundations may pose significant risk to the structures. When planning an investigation or remediation program, the data needs must be weighed against the potential risks of damage created by the drilling process. Accordingly, any site characterization program that involves drilling on an existing dam requires permitting by the MDE Dam Safety Permits Division. To obtain a permit to drill into, in close proximity to, or through embankment dams and levees the following information is required:

- Engineer-in-Charge Affidavit and resume of experience;
- Well Drillers License and resume of experience;
- Drilling Program Plan which identifies the drilling methods, borehole termination methods, a summary identification of potential risks to the embankment or foundation and commensurate risk mitigation measures, and emergency procedures;

- Boring location plan, with anticipated termination depths indicated;
- Laboratory testing plan with anticipated tests indicated; and
- Current Emergency Action Plan (High and Significant hazard dams only)

Approvals to drill into, in close proximity to, or through small pond embankments may be required at the discretion of the appropriate review entity. Drilling at the site of a proposed dam or small pond does not require permitting/approvals. For proposed dams it is recommended that the drilling scope of work be provided to MDE Dam Safety Permits Division for review and comment prior to mobilization to the site to lessen the chance of additional mobilizations becoming necessary during the permit application review process.

Subsurface Investigation Planning and Execution: A document that may serve as guidance and a checklist in planning a geotechnical investigation is the ASTM Standard D420, Standard Guide to Site Characterization for Engineering Design and Construction Purposes. This document covers all aspects of site investigation from reconnaissance of the project area, exploration plan, equipment, methods, testing, classification of soil to report preparation.

A summary of recommended practices is provided below. Appropriate engineering judgement must be applied to ensure the investigation is adequate for the proposed structure.

Boreholes: Boreholes should be extended to a depth sufficient to adequately characterize the foundation materials, with attention directed towards identification of pervious/impervious layers and soft or unsuitable soils. When the boreholes extend to bedrock, coring of the bedrock should be performed following ASTM Standard D2113 to assess its quality and characteristics. Boreholes that encounter bedrock should extend a minimum of ten (10) feet into rock. Extending the borehole deeper is recommended in highly fractured or jointed rock.

- Drilling must be completed by a licensed Maryland well driller.
- Drilling must be conducted under the supervision of a Licensed Professional Engineer experienced in geotechnical or geological engineering for dams.
- The use of water or drilling fluid must be carefully considered, and is strongly advised against, except where necessary for rock coring or to stabilize flowing sands. Hollow stem augers are the preferred method for advancing the borehole.
- Borehole abandonment at existing and new dams must be completed by placing a neat cement (or cement-bentonite) grout into the borehole using the tremie method.
- The standard penetration test must follow ASTM Standard D1586. Standard penetration resistance (SPT N or N value) is the number of blows of a 140 lbm hammer falling 30 in. required to produce 1-foot of penetration of a specified (standard) 2-in. outside diameter, 13 /8-in. inside diameter sampler into soil, after an initial 0.5 feet seating. A penetration test that does not meet these requirements is not a SPT and the penetration resistance must not be reported as a SPT N-value or N-value and care must be taken with its use for correlating soil properties. Published correlations for SPT N-value cannot be used for non-SPT blow count numbers. If SPT N-values are used for the assessment of liquefaction potential, the SPT N-values must be normalized according to ASTM Standard D6066.

- Continuous, or semi-continuous (two (2) samples per five (5) feet) SPT sampling is recommended.
- Soil classification should follow the Unified Soil Classification System as provided in ASTM Standard D2487.
- Rock samples should be collected following the procedures outlined in ASTM Standard D2113. Rock Quality Designation (RQD) determination of rock core must follow ASTM Standard D6032.
- Water levels in boreholes and test pits must be measured and shown accordingly on the logs. The water level must be recorded during drilling and after the ground water table is stabilized (typically 24 hours). Both water levels must be provided on borehole logs along with the time of measurement.
- Installation of at least two (2) piezometers is recommended when boreholes are advanced in support of the design of a new High or Significant hazard dam, or modification/repair of an existing High or Significant hazard dam (typically just downstream of core and at downstream toe). Piezometers should be finished with lockable standpipes. The elevation of the ground surface adjacent to the standpipe, the top of standpipe, and top of piezometer must be surveyed with an accuracy of 0.01 feet +/-. Use of data logging vibrating wire piezometers is acceptable, but where the instrument is to remain after construction is complete – the engineer must prepare an operation and monitoring plan for the owner of the dam and provide any necessary equipment required to measure or download the water level data.
- Field tests with equipment such as pocket penetrometer and torvane are not generally acceptable for deriving design parameters.
- The borehole logs must record the depths of any problems such as borehole instability (cave in, squeezing hole, flowing sands), cobbles, lost drilling fluid, lost ground, obstruction, fluid return color changes and equipment problems
- Recommended test boring locations and depths are provided below:

Location	Recommended Minimum Quantity	Lateral Tolerance from Design Location	Recommended Borehole Termination Depth
Riser	1	Approx. 25 ft	20 ft below bottom of riser
Plunge Pool/Stilling Basin[1]	1	Approx. 25 ft	20 ft below bottom of plunge pool/basin
Embankment	Min. of one (1) boring at crest and one (1) boring at downstream toe for every 250 feet embankment length. For dams over 50 feet height, add one (1) boring at upstream toe per 250 feet length.	--	Boring should extend below "base" of dam to depth at least equal to the height of the dam. Extend a min. 10 ft in bedrock if encountered.
Abutments[2]	1 at each	--	See Embankment
Emergency/Auxiliary Spillway	One (1) at control section and for dams over 20 feet, one (1) at downstream end of spillway channel	--	Control Section: At least to bottom of plunge pool. Downstream End: At least 10 ft below channel bottom
Weir Walls / Weir Spillways	Under 10 ft length: One (1) Ten (10) to 50 feet long: Two (2) Greater than 50 feet length: Min. of three (3) borings with maximum spacing of 50 feet	--	Boring should extend to depth below weir foundation equal to weir height, but no less than 10 feet below weir foundation.
Borrow Areas:	As deemed necessary by the engineer		
Reservoir Area:	As deemed necessary by the engineer		

1: Where spillway conduit length is 60 ft or less, 1 boring may be adequate for riser/plunge pool.
2: Abutment borings may not be necessary for small ponds.

Cone penetration tests (CPT) can be used to supplement site characterization but may not be used to eliminate drilling and SPT sampling entirely. CPT soundings must be performed and results provided according to ASTM Standard D5778. Electronic data must be provided along with CPT logs and interpretations.

Flat Dilatometer tests (DMT) can be used to supplement site characterization but may not be used to eliminate drilling and SPT sampling entirely. DMT soundings must be performed and

results provided according to ASTM Standard D6635. Electronic data must be provided along with DMT logs and interpretations.

Field Shear Vane (FSV) tests can be used to supplement site characterization but may not be used to eliminate drilling and SPT sampling entirely. FSV soundings must be performed and results provided according to ASTM Standard 2573 Equipment calibration data must be submitted. FSV data must be normalized based on accepted methods (e.g., Bjerrum).

Field permeability tests are recommended for larger high and significant hazard dams. Details of the test method, calculations and interpretation must be included along with the results.

Test Pits or Trenches: Test pits or trenches may be an appropriate tool to investigate site geology and geotechnical characteristics such as soil stratification, bedrock orientation and to collect bulk or block samples. Test pits and trenches must be logged. Collection of block samples must be performed according to ASTM Standard D7015. Test pits within a dam footprint must be abandoned by excavating the side slopes to 1H:1V or flatter and replacing the excavated soil in lifts no more than eight (8) inches loose thickness and compacted to the satisfaction of the engineer supervising the excavation.

Geologic Site Characterization

Geophysical survey methods may be used to supplement borehole and outcrop data and to interpret the soil and bedrock profile between boreholes. Use of geophysical data and limited initial drilling and SPT sampling (or test pits) can be used to plan a phased geotechnical/geologic site investigation program. ASTM Standards D6429 and D5753 provide guidance on planning and selection of geophysical methods. Refer also to Table 12.5-1 “The Application, Advantages, and Limitations of Selected Geophysical Methods” found in USBR, Design Standards No. 13, Embankment Dams, Chapter 12: “Foundation and Earth Materials Investigation Phase 4 (Final)”, 2012. The geotechnical report must explain the test method and interpretation of the test results.

Laboratory Testing

A sufficient number of lab tests should be performed to permit characterization of the envelope of engineering properties of each material affecting the construction of the dam. Laboratory test results should be tabulated and presented in the Geotechnical Report for easy reference to each test result with respect to the dam element or material zone represented by the test. Laboratory tests must include index testing required to classify all soils in accordance with the Unified Soil Classification System (USCS).

The following laboratory testing considerations should be applied as appropriate for the size and hazard classification of the dam, as well as any issues being evaluated (for existing dams). In general, empirical relationships or typical values provided in literature can often be applied for low hazard dams and smaller significant hazard dams in lieu of additional laboratory testing.

- The test program should allow direct determination of the drained shear strength and undrained shear strength parameters needed for slope stability and bearing capacity analyses. Simple Direct Shear tests performed at conventional strain rates without pore pressure measurements are not appropriate for determining the drained strength of soils that do not drain quickly.

- Consolidation/swell tests should be performed on undisturbed and/or remolded samples, as appropriate, of all soils or rock that could affect the stability of the dam or appurtenant structures through settlement or heave. Test conditions should reflect the anticipated loading conditions.

- Foundation soils and soils to be used for embankment fill should be tested to evaluate the potential for dispersive behavior, corrosivity/reaction with metal structures, and alkali-aggregate reaction with concrete.

- Permeability tests for foundation, abutment, and embankment materials should be conducted under laboratory conditions that represent the anticipated loading conditions for the materials. Permeability tests should be conducted on both undisturbed and remolded samples, as appropriate for the dam design.

Geotechnical Report

A geotechnical report is required that evaluates the suitability of the foundation, stability of the dam, and addresses issues regarding suitability and quantity of material available for construction of the dam as designed. Designers should refer to the guidance in the Design Review Job Aid for Small Pond and Dam Applications provided on the Departments website. The geotechnical report shall include, but not be limited to, the following:

- A geotechnical/geological assessment of the dam and reservoir site is required for all dams. The assessment shall address at a minimum regional geologic setting; local and site geology; and other potential geological hazards posed by the site and proposed construction.
- Provide discussion/narrative on local geohazards or problematic soils that may affect the dam (e.g., sinkholes, karst, active or abandoned mines, uncontrolled fills, dispersive soils, marine clays, corrosive conditions, highly permeable layers). Provide recommendations to mitigate risks caused by geohazards that have been identified.
- Provide discussion/narrative or calculations regarding potential for seepage through or below embankment. Discuss necessary cutoff depths/elevations and or means to control seepage.
- Provide discussion/narrative or calculations regarding slope stability.
- Provide discussion/narrative or calculations regarding ultimate and allowable bearing strength for structures (e.g., riser, endwall, spillways). Provide recommendations for acceptable subgrade materials and provisions for protection and stabilization of subgrade.
- Provide discussion/narrative or calculations regarding potential for immediate and long-term settlement of the embankment and structures.
- Provide discussion/narrative on control of groundwater during construction and steps

necessary to protect the subgrade soils
- Records of all boring logs.
- Standard index tests and soil classification of all materials.
- Filter diaphragm compatibility calculations, including pipe diameter and perforation sizing.

Additional Information

Questions about this policy or other items relating to ponds and dams can be directed to the Chief of the Dam Safety Permits Division at 410-537-3552.