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CHAPTER EIGHTEEN

GEOTECHNICAL INFORMATION FOR DESIGN

Chapter Eighteen discusses the elements of geotechnical engineering which the designer will typically be required to address during the design of a project. Chapter Eighteen does not address the analyses and procedures conducted by a geotechnical consultant or the Office of Materials Management's Office of Geotechnical Services during its investigation. If questions arise, the designer should review the geotechnical report or contact the geotechnical engineer for guidance.

18-1.0 GEOTECHNICAL REPORT

All project geotechnical considerations should be made in accordance with Figure 18-1A, Policy for Geotechnical Investigation or Geotechnical Waiver.

If, after reviewing the Policy, the designer has determined that a geotechnical investigation is warranted, he or she should provide the Production Management Division's Office of Geotechnical Services with the information shown below, so that the Office can develop a geotechnical report.

1. Project location;

2. anticipated pavement treatment (i.e., resurface, rubblize, etc.) from the Engineer's Report or mini-scope; and

3. locations where the pavement will be widened.

If there is a change in scope after the above information is provided to the Office, the designer must immediately notify the Office.

The geotechnical report provides the data obtained during the geotechnical investigation. It also summarizes the engineering analyses conducted and provides recommended treatments for the various soils and conditions encountered on the project. The following sections discuss the information that may be included in a geotechnical report.

18-1.01 General Information

The geotechnical report will include the following general information.

1. Project Description. The report will identify the location of the project (including the beginning and ending stations), provide a project-identification description, and define the scope of the proposed construction.

2. Field Investigations. The report will summarize the field and laboratory investigation procedures used on the project. It will also include the date when the field investigations were conducted.

3. Environmental Conditions. Environmental conditions that could have affected the results (e.g., climatic conditions) will be included in the report.

4. Geological Information. The beginning of the report will include a general description of the geology and soils encountered on the project. It should also provide a description of the terrain including drainage patterns, ground water elevation, bedrock information, and other specific conditions that may have value in the design of a bridge, culvert, or other structure.

18-1.02 Detailed Geotechnical Conditions and Recommendations

This portion of the geotechnical report should provide a discussion on specific problems or conditions that may affect the design or construction of the project. The report will discuss the following.

1. Features. The report will provide a detailed description of the conditions found on the project, organized according to areas of similar soils and terrain features. It will identify the types of soils found, their strengths, and their locations.

2. Recommendations. The report will provide recommendations concerning potential design and construction problems for earthwork, pavement, bridges, retaining walls, culverts, sign supports, or other structures. Where applicable, the report should provide the recommendations as follows:

    a. special embankment construction;

    b. cut slopes in soil or rock;

    c. how to treat unsuitable materials in subgrades (e.g., removal, replacement, special treatment such as lime, cement, or flyash stabilization, etc.);

    d. rock swell factors;

e. special drainage installations;

f. use of special channel lining materials;

g. landslide corrections;

h. wet soils;

i. embankment construction using recycled waste materials;

j. embankment over landfill;

k. foundations; or

l. dewatering.

3. Field Equipment. The report will list where field monitoring equipment or devices including settlement plates, lateral stakes, settlement stakes, standpipe piezometers, or water monitoring boreholes are required. The report will list the following:

a. purpose or objective of the equipment;
b. proposed locations;
c. approximate schedule for the frequency of readings; and
d. special construction controls.

The designer must note the location and quantities of the field monitoring equipment to be installed. The equipment should be listed on the plans, in a tabular format, and in the schedule of pay items. Such equipment is described in the INDOT *Standard Specifications*.

4. Boring Logs. Boring logs will be included in the appendix of the geotechnical report. These will be based on field logs and laboratory test data. Boring logs are available in an electronic format for an in-house-designed project.

18-1.03 Test Data and Engineering Analyses

The report will summarize the field and laboratory investigation procedures used in the investigations. Results of the laboratory tests on various samples will be included in the appendix of the geotechnical report in a tabular format. Each sample will be identified according to its sample number, boring number, location, depth, and results from testing. Separate tabulations will be included for classification test results, strength test results, or other special test results.

The work described in this report section will include a review and correlation of the various test results for embankment stability, material placement, and other geotechnical engineering considerations. Sketches, assumptions, calculations, etc., will be provided in the appendix of the report. Some analyses that may be included are as follows:

1. settlement analysis;
2. sand drain analysis;
3. sliding block slope stability analysis;
4. rotational slope stability analysis;
5. bridge foundation analysis for each bridge foundation; or
6. retaining structure analysis.

18-1.04 Geotechnical Profile

The geotechnical profile, if required, shows the geotechnical information on a set of plans. The following is the applicable design and construction information that may be included in the geotechnical profile.

1. Soil Test Data. Soil test data will be tabulated on separate sheets. This may include the information as follows:

    a. laboratory sample number;
    b. field sample number;
    c. boring number;
    d. station;
    e. offset;
    f. depth of sample;
    g. pH;
    h. textural or grain size classification;
    i. AASHTO classification;
    j. test results obtained from mechanical analysis;
    k. liquid limit;
    l. plastic limit;
    m. plasticity index;
    n. maximum dry density;
    o. optimum moisture content;
    p. CBR;
    q. loss on ignition; or
    r. calcium and magnesium.

2. Boring Locations. The boring locations will be plotted on the plan view. Elevation of subsurface water during boring, at the completion of boring and 24 hours later, will be shown on the profile sheets. The location and depth from which test samples were obtained will be indicated and referenced to the Soil Test Data sheet.

3. Unsuitable Materials. The locations of unsuitable material will be shown on the plan and profile views or in the cross-section sheets. This may include peat, unstable soil, wet soils, etc.

4. Soundings. If soundings are made, these may be plotted on plan and profile or cross section sheets. The limits of peat or unsuitable material to be removed, the proposed grade line, rock line, etc., will be plotted on the sounding profile and cross section sheets.

18-1.05 Incorporation of Geotechnical Report Into Contract Documents

The geotechnical engineer will review the final check prints and geotechnical evaluation report summary, and transmit his or her findings to the designer. Figure 18-1B, Geotechnical Review of Final Check Prints, should be used. An editable version of this document appears on the Department's website, at www.in.gov/dot/div/contracts/design/dmforms/.

After the designer addresses concerns identified in the geotechnical engineer's review, a copy of the geotechnical evaluation report summary should be included in the documents intended for incorporation into the Contract Information Book. A report prepared by the Office of Geotechnical Services, excluding boring logs, drawings, and test data, should be included in its entirety into the Contract Information book, as the extent of the report's text is only a few pages.

The designer should place a quality paper copy of the Department-prepared geotechnical report or a geotechnical report summary into the contract-documents file as is done for the environmental permits.

18-2.0 APPLICATIONS

There are numerous areas throughout Indiana where special subsurface treatments should be considered. Figure 18-2A, Indiana Counties with Special Geotechnical Concerns, identifies the counties where the designer may encounter coal mine subsidence, peat, sink holes (karst areas) and slide conditions. The geotechnical report will most often identify special requirements, and it will recommend possible solutions. The following provides basic information and guidance for treatment of common geotechnical elements the designer may encounter.

18-2.01 Coal-Mine Subsidence

Coal-mine subsidence occurs once the effects of roof collapse in an underground coal mine reaches the surface or reaches structure foundations. Figure 18-2A identifies the counties where coal-mine subsidence is a concern. Effects on the surface include sinkholes, sags, and troughs. This may result in cracks, breaks, or settlement in buildings, roads, structures, and utilities, and may change surface and subsurface drainage.

For a mine less than 150 ft deep, roof collapse is very likely to cause surface effects. A mine deeper than 150 ft seldom shows sudden, dramatic, surface collapse such as sink holes, but generally causes sags and troughs and can cause cracks and breaks in structures, etc.

The added weight of a new embankment or structure can cause collapse of a coal-mine roof that had already been near the breaking point. Other factors such as drainage changes and earthquake acceleration coefficients (in structure design) increase the probability of more collapse and subsidence.

Subsidence prevention treatment for design of a bridge or structure on a deep foundation includes drilled shafts, predrilling to a depth below the mined elevation to set pile tips, or injection of grout to fill the voids to prevent collapse. Treatment for a roadway or embankment includes grout injection to prevent subsidence and use of lightweight fill. Post-construction treatment includes wedge-and-level patching to eliminate an abrupt dip. Sinkhole-type failures can be treated as a Karst sinkhole; see Section 18-2.07. Monitoring for subsidence can be done with settlement stakes and plates.

18-2.02 Erosion Control

Erosion can occur from both surface-water flow and subsurface seepage and drainage. Soil susceptibility to surface erosion is primarily a function of the water flow and the gradation and plasticity of the soils. There are several methods to protect soils from surface flows. Each site must be treated individually. The possible options include the following:

1. removing the erodible materials and replacing them with acceptable materials;
2. using slope encasement with cohesive soil;
3. using geotextile fabrics with riprap; see Section 18-2.08(05);
4. providing erosion mats;
5. planting vegetation;
6. reducing side slopes;
7. providing sediment basins;
8. constructing special drainage channels and ditches; or
9. providing closed drainage systems.

Chapter Thirty-seven provides additional guidance on the design of temporary erosion control methods during construction.

Erosion by subsurface flows may also be a problem if soil particles are transported by the water flow. Protection against subsurface erosion is treated with spring boxes or with granular filter materials or filter fabrics which have particles or perforations sized to satisfactorily pass the water flow without permitting movement or loss of the soil particles.

18-2.03 Geotextiles or Geogrids

Geotextiles or geogrids have been proven to be an effective solution to solving many geotechnical problems. They can be used as follows:

1. to stabilize weak and saturated subsoils under a pavement surface;

2. between pavement layers to reduce cracking and to provide a moisture barrier;

3. as a soil filter for subsurface drainage (e.g., underdrains along pavement, behind retaining walls);

4. as part of an erosion control system (e.g., under riprap, as a sediment fence);

5. as part of a soil retaining wall;

6. as slope reinforcement;

7. as a separator layer; and

8. to minimize differential settlement.

The geotechnical report should identify the locations where geotextiles or geogrids should be used. The designer should contact the Office of Geotechnical Services for specifications and guidelines on the design and placement of geotextiles or geogrids.

18-2.04 Landfill Treatment

A landfill is a man-made feature which generally provides unsuitable material for the roadway substructure. The geotechnical report should identify the location of landfills and any proposed treatment. If cost effective, the most desirable option will be to excavate the landfill and replace it with acceptable backfill. However, other options may be more feasible, including surcharging, using

lightweight fills, using geotextiles, or providing ground modifications (e.g., dynamic compaction, stone columns).

18-2.05 Landslide

The term landslide is used to denote the movement of a mass of rock, debris, or soil down a slope. The type of landslide can be further defined by characteristics such as the materials in the slide, speed of the landslide, or the type of movement. Figure 18-2A, Indiana Counties with Special Geotechnical Concerns, identifies the counties where landslides may be a problem. The geotechnical report will identify the sites where landslides may be a concern.

A landslide may occur under man-made conditions (e.g., adverse grading, adjacent construction, vibration from nearby vehicles) or natural conditions (e.g., erosion, earthquakes, precipitation and runoff). Because of the nature of soils and the geologic environment in which they are found will vary from site to site, acceptable mitigation procedures will be determined for each site. The designer should review the geotechnical report to determine the appropriate measures to mitigate the landslide potential.

18-2.06 Peat Treatment

Peat soils are those soils with a high organic content. Where the organic content is approximately 10% by weight, it typically poses a stability problem and will require special consideration. Two common solutions for treating peat soil are to completely remove and replace the peat soil with acceptable foundation materials, or to use lightweight materials to reduce settlement. Peat excavation consists of the necessary excavation and satisfactory disposal of peat, muck, marl, or any other similar unsuitable material in a peat deposit together with any overlaying material which is not used in embankment construction.

Where the ground water table is below the bottom of the peat deposit, normal excavation and embankment criteria as stated in the INDOT *Standard Specifications* will typically apply. Where the peat deposit is deep or the peat deposit is all or partially below the ground water table, special treatments as discussed in the geotechnical report and INDOT *Standard Specifications* will be required. The limits of peat removal for these sections will usually be established by the 1:1 slope as shown in Figure 18-2B, Peat Excavation, Backfill, and Disposal.

When showing peat treatment on the plans, the designer should consider the following.

1. Typical Section. Indicate the removal limits as shown in Figure 18-2B.

2. Plan and Profile Sheets. Show the profile for any peat deposit within the construction limits on the profile sheet. Show this profile with a short dashed line and label it as "Peat Profile on Center Line" or "Peat Profile ___ ft Lt. or Rt. of Center Line" as appropriate.

3. Cross Sections. Use solid lines to show the peat excavation limits and peat backfill (B borrow) limits on the applicable cross sections. Mark the first peat section in any series as such to define these limits. Include the end areas and volumes for peat removal on the cross sections.

4. Approval. Submit all peat disposal plans to the Office of Geotechnical Services for approval.

18-2.07 Sink Hole

18-2.07(01) General

A sink hole is caused by subsurface voids, which may continue to enlarge, in rocks (primarily limestone) that are subject to dissolution by the passage of moving groundwater. Figure 18-2A, Counties with Special Geotechnical Concerns, illustrates the counties where sink holes may be a concern. Sink holes should be anticipated in a carbonated rock terrain. Known sink-hole locations will be shown in the geotechnical report and environmental documents. During a field review, a sink hole can be identified as a roughly circular, closed depression at the ground surface. Another identifying feature is water is flowing into a depression with no outlet. Inspection of topographic mapping and aerial photographs will also assist in the confirmation of a sink hole.

The treatment for a sink hole will vary based on the location, size of the sink hole, and environmental considerations. A sink hole will typically be capped or installed with a chimney. A capped sink hole is filled with material (e.g., rocks, concrete, gravel) and sealed so that additional surface water cannot flow into the hole. See Figure 18-2C, Typical Sink Hole Cap. The chimney treatment encourages surface water to continue to flow into the hole. However, any surface water flowing into the sink hole must be filtered. The Office of Environmental Services should be consulted regarding the filter design and detention requirements. See Figure 18-2D, Typical Sink Hole Cap with Chimney.

18-2.07(02) Exploratory Excavation

Exploratory excavation consists of the excavation of overlying soil and rock layers to determine subsurface conditions (e.g., the existence of a sink hole or cavity) and to determine the exact location, extent and size of the sink hole or cavity. In determining the quantities that should be

shown in the plans for exploratory excavation, the designer should discuss the proposed treatment with the district construction engineer during the field check.

18-2.08 Slopes

18-2.08(01) Slope Stability

An earth slope of 2:1 or flatter will not require additional special considerations relative to stability. However, under restricted conditions a steeper slope may be required. Where a steeper embankment slope is proposed, riprap or other special material may be required to protect the slope from erosion and slippage. Figure 18-2E, Embankment Treatment, provides guidelines for determining the thickness of this material based on the embankment height. Before specifying a steep slope, the designer should review the geotechnical report or contact the Geotechnical Operations Team for additional guidance. Depending on the rock type, a rock cut may have faces which are nearly vertical. These are illustrated in Figure 18-2F, Typical Rock Cut Benching (< 10 ft); Figure 18-2G, Typical Rock Cut Benching (≥ 10 ft); and Figure 18-2H, Typical Soft/Weathered (Rippable) Rock Cut Benching.

18-2.08(02) Transverse Interceptor Drain

A transverse interceptor drain is typically used to collect subsurface water on an embankment where the roadway passes from a cut section to a fill section. A transverse interceptor drain is used to reduce the potential for slope slippage on the embankment. The geotechnical report should indicate where transverse interceptor drains are required. See Figure 18-2 I, Typical Transverse Interceptor Drainage.

18-2.08(03) Benching

Benching is used on an embankment to stabilize proposed fill on the existing slopes by excavating the existing material on the side slopes to eliminate a plane of weakness or to provide a greater mass of stable material at the toe of slope. Benching should be considered if the existing slope is 4:1 or steeper. The INDOT *Standard Specifications* provide the criteria for where benching should be provided on an embankment. See Figure 18-2J, Typical Benching Methods, for embankment benching.

Benching in a cut section is provided only in a rock cut to provide a debris-collection area for a rock slide. Figure 18-2G, Typical Rock Cut Benching (≥ 10 ft), and Figure 18-2H, Typical Soft/Weathered (Rippable) Rock Cut Benching, illustrate the benching procedure for a rock cut.

Where soft or weathered rock is encountered, the material is often rippable (machine workable) and does not require drilling or the use of explosives as is necessary for removing hard-rock material.

18-2.08(04) Fill on Unsuitable Foundation

Where a fill will be placed on soft, wet, or other unsuitable material (e.g., peat), these materials should be removed and replaced with acceptable backfill, if economically feasible. Section 18-2.06 discusses the treatment for peat or other similar materials. If it is not economically feasible to remove the unsuitable materials, the use of geotextile fabrics, lightweight fill, or other method may be required. These should be addressed in the geotechnical report. If not, the designer should contact the Geotechnical Operations Team for information.

18-2.08(05) Placement of Geotextile Under Riprap on Slope

Riprap is often placed on an embankment side slope to prevent future erosion problems or to correct existing erosion problems. One of the most cost-effective methods for stabilizing a shallow embankment failure is to remove the failed material and replace it with riprap. The embankment should be lined with a geotextile fabric before the riprap is placed. This includes such areas as follows:

1. soil slope steeper than 2:1 (below the riprap);
2. there are erodible soils at the interface of the riprap and existing embankment;
3. there is surface runoff flowing through the riprap; or
4. there is flow of subsurface water out of the embankment into the riprap.

Where riprap and geotextile fabric are required and where the slope is steeper than 2:1, benching should also be used to anchor the new fill material (riprap). Without benching, the new fill material may slide down the slope at the interface due to a decrease in shear strength of the soil and the infiltration of water. At least one bench be provided at mid-height of the slope for an embankment height of 10 ft or less. Provide an additional bench for each additional 10 ft of embankment height. Additional benches may be required depending on the size of the benches, steepness of the slope, or thickness of the riprap. The height and width of the bench will vary according to the steepness of the slope. The height will be in the range of 2 ft to 5 ft.

Where riprap is placed on an existing slope, providing a geotextile fabric under the riprap will facilitate drainage through the riprap without the loss of soil particles at the soil surface due to erosion. The geotextile fabric should be placed as shown on the INDOT *Standard Drawings.*

18-2.09 Special Soil Treatment

Special treatment of the subgrade may be required to prepare the soil for construction. The top 24 in. of subgrade below the pavement structure must be compacted to at least 100% of standard proctor. This may involve adding lime, cement, kiln dust, or fly ash to the subgrade; constructing drains; or replacing the unsuitable material with special borrow or aggregate. The designer should review the INDOT *Standard Specifications* for additional criteria. The Office of Pavement Engineering will make the final determination based on the results of the geotechnical investigations.

18-2.10 Structure

In order for the Office of Geotechnical Services to make suitable recommendations for a structure, it is essential that the designer provide as much information as practical (e.g., structure configuration, loads). If the designer anticipates the need for a working-stress capacity of more than 70 tons per pile, the designer should advise the Office of Materials Management at the preliminary field check. This working-stress capacity should be noted in the field check minutes. The planning and design of a structure (e.g., bridge, retaining wall, sign support, culvert) requires a determination of the strength of the proposed foundation material. For light to moderate loads, dense soils, rock, stiff clay, etc., may be adequate for a shallow foundation. Where there are clearly unsuitable materials or other considerations (e.g., scour potential), the designer may be required to design a deep foundation (e.g., piles) or remove the unsuitable material and replace it with acceptable backfill. The designer should review the geotechnical report to ensure that appropriate materials at the site are available for the proposed foundation design. Section 59-2.0 discusses the types of bridge foundations used and the criteria which influence the selection of a foundation type. Chapter Sixty-six discusses criteria for foundation design for a bridge structure.

Indiana Department of Transportation
Office of Geotechnical Engineering

Policy for Geotechnical Investigation or Geotechnical Waiver

Purpose: To establish a uniform policy regarding the need for a geotechnical investigation or a geotechnical waiver on a State or Local Public Agency (LPA) project utilizing Federal-Aid Funds.

Policy: Each project requires a geotechnical investigation with the exceptions noted below. The Office of Geotechnical Engineering or a Department-approved geotechnical consultant will conduct all geotechnical investigations. The Office of Geotechnical Engineering must approve a consultant report before the report is used in the design.

Exceptions: A project satisfying the following conditions may qualify for a geotechnical waiver. However, subgrade recommendations may still be required.

1. Preventative-Maintenance Type Project.
   a. Chip Seal, Crack Sealing, Microsurface, Single Lay HMA Mill and Overlay, or Functional HMA Overlay.
   b. PCCP Joint Sealing, Retrofit Joint Transfer, etc.

2. Rehabilitation-Type Project: Shoulder widening up to 2 ft on existing pavement with less than 2 ft of cut or fill.

3. Bridge maintenance or repair that does not include foundation work.

4. Pipe structure smaller than 36 in. diameter or pipe extension of shorter than 5 ft length.

However, if the project is in an area that contains known isolated problematic soils such as peat, marl, etc., or if the project includes fills of greater than 2 ft, a geotechnical waiver will not be granted.

Waiver Request: The project manager or the LPA design consultant must submit a request for approval with the supporting data to the Office of Geotechnical Engineering, no later than the preliminary field check.

The waiver request will include the following:

1. Project Scoping Report;
2. plans and cross sections – one set; and
3. six to ten existing-pavement photographs.

No Geotechnical Investigation or Waiver is Required: The following types of projects will not require a geotechnical investigation or geotechnical waiver.

1. Bridge Painting;
2. Pavement Marking;
3. Landscaping/Enhancement;
4. Traffic Signals;
5. Guardrails;
6. Small Signs;
7. Wedge and Level;
8. Mowing;
9. Lighting Maintenance; or
10. other project with no earthwork, foundations, or retaining walls.

Approval: The Manager of the Office of Geotechnical Engineering will either approve or deny the geotechnical waiver in writing to the project manager within 5 days.

POLICY FOR GEOTECHNICAL INVESTIGATION OR GEOTECHNICAL WAIVER

Figure 18-1A

GEOTECHNICAL REVIEW OF FINAL CHECK PRINTS

Route:
Des:
Bridge File:
Over:
Project No.:
Date of Geotechnical Report:
Date of Addenda to Geotechnical Report:

I have reviewed the Final Check Prints and the geotechnical summary for the project described above.

☐ The Final Check Prints and the special provisions are consistent with the Geotechnical Report and its addenda. No changes are required.

☐ The Final Check Prints and the special provisions are not consistent with the Geotechnical Report and its addenda. The following must be addressed.

☐ The geotechnical summary as submitted by the designer is satisfactory to include in the Contract Information book.

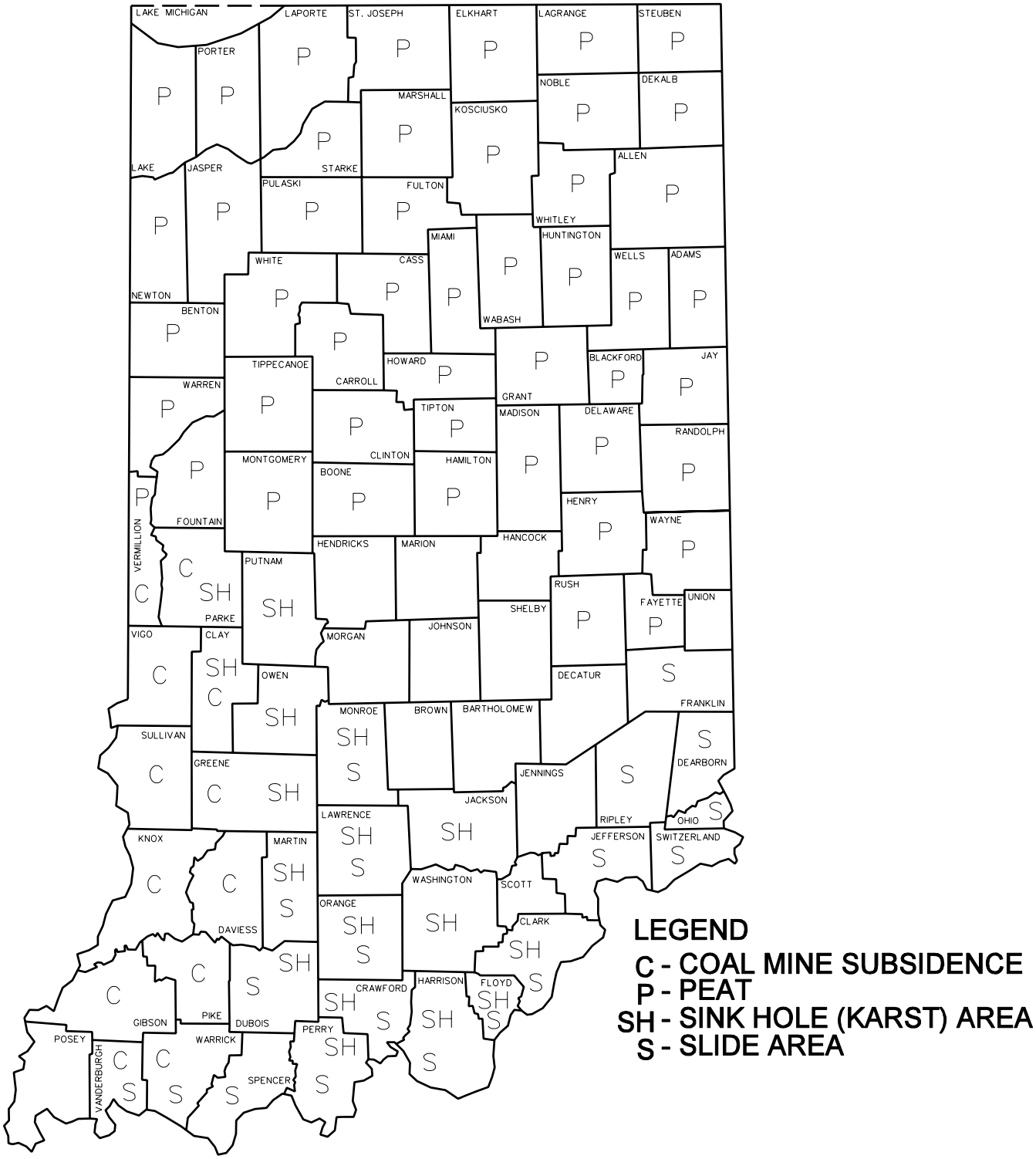
☐ The geotechnical summary as submitted by the designer is not satisfactory. The following must be addressed.

_____

Signature of Geotechnical Engineer

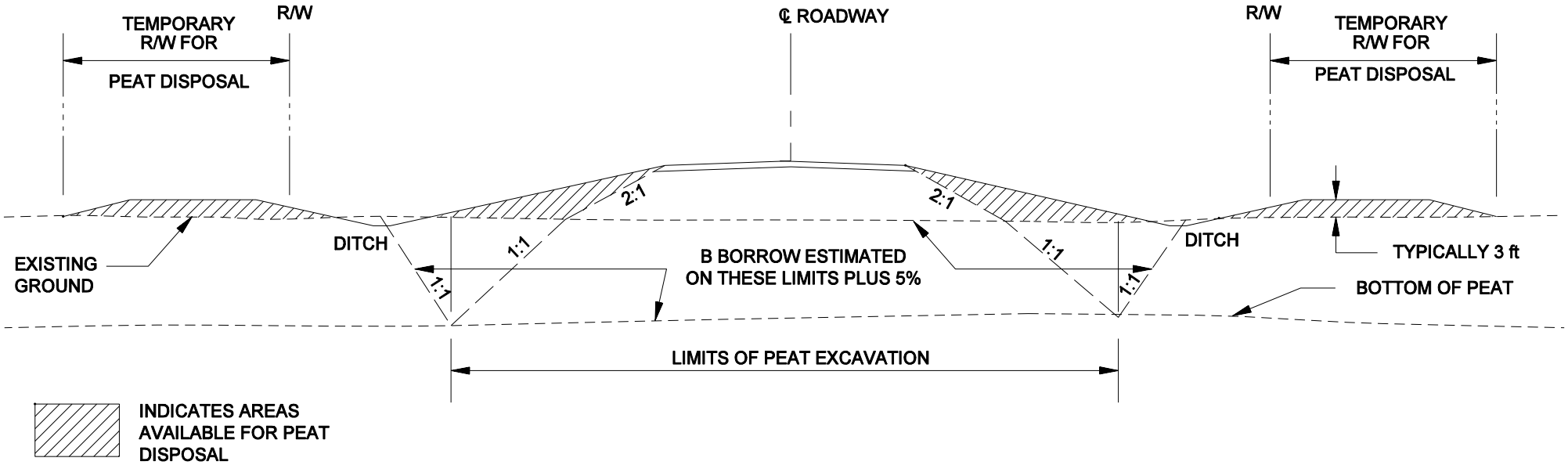
INDOT entity or consultant

date



INDIANA COUNTIES WITH GEOTECHNICAL CONCERNS

Figure 18-2A

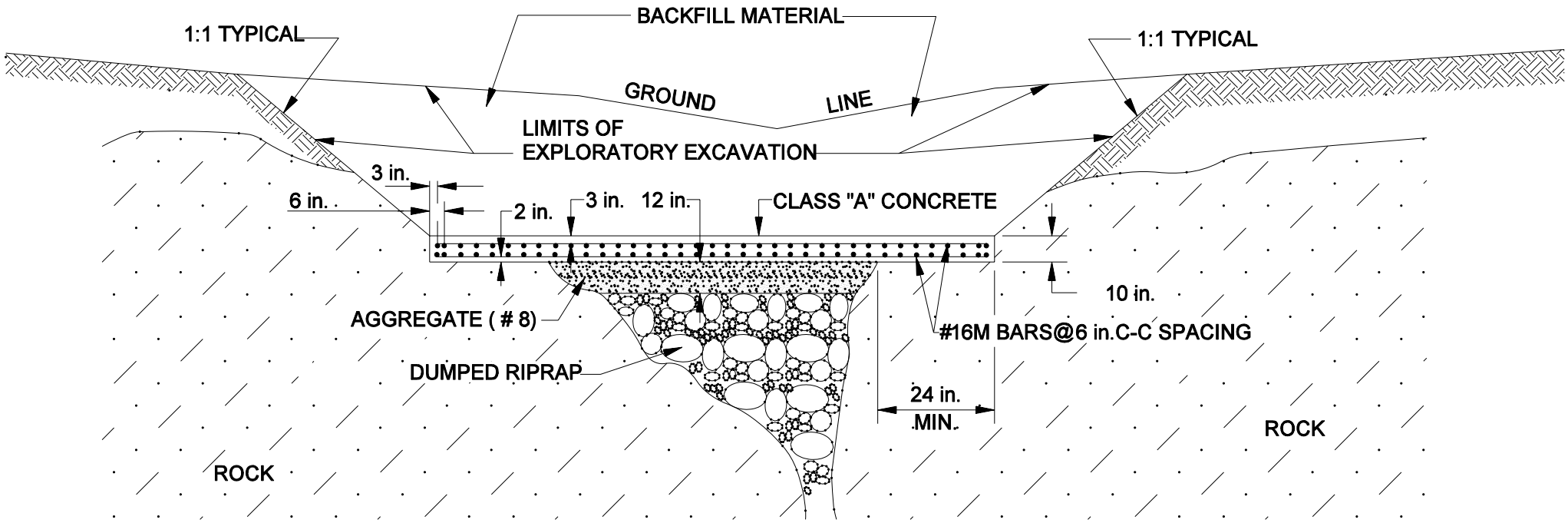


NOTES:

1. Typically, the 2:1 slope will begin at the shoulder break.
2. The B borrow quantities are determined to a point 2.0 ft above the ground water elevation.
3. Do not show the dashed lines illustrated above to determine B borrow quantities on the cross seaction.
4. Temporary right -of-way for peat disposal will typically be established equally on either side of the roadway.

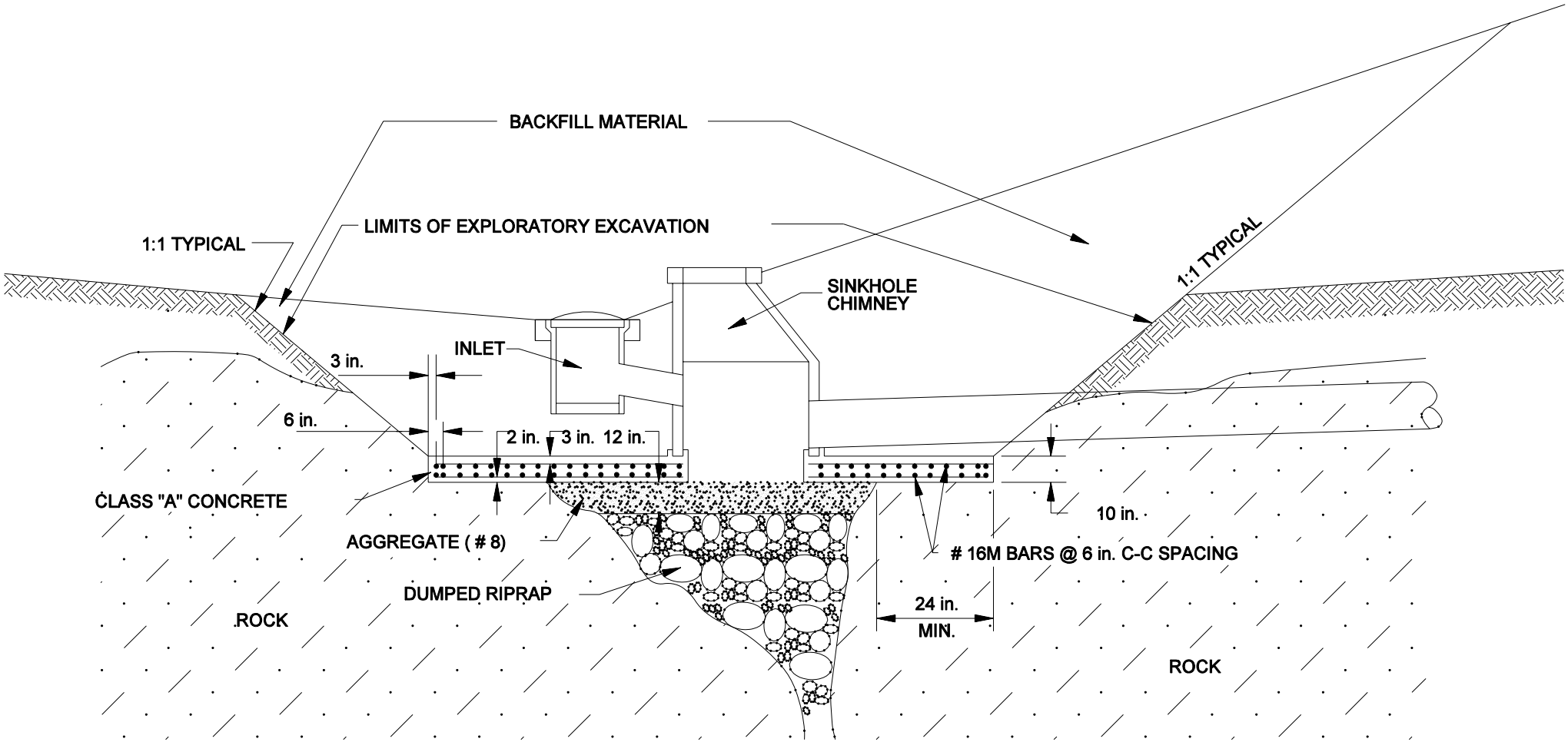
PEAT EXCAVATION, BACKFILL AND DISPOSAL

Figure 18-2B



TYPICAL SINK HOLE CAP

Figure 18-2C

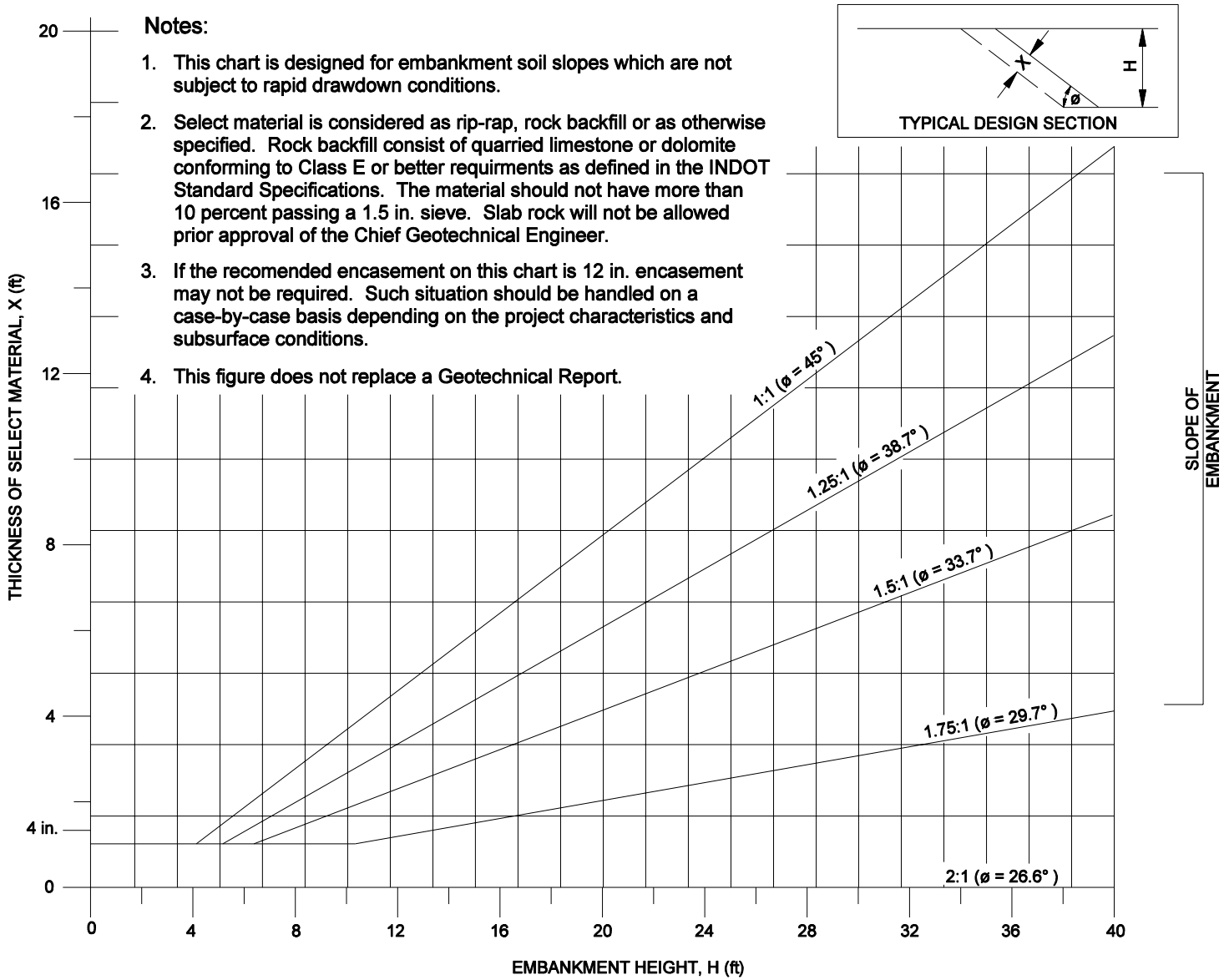


TYPICAL SINK HOLE CAP WITH CHIMNEY

Figure 18-2D

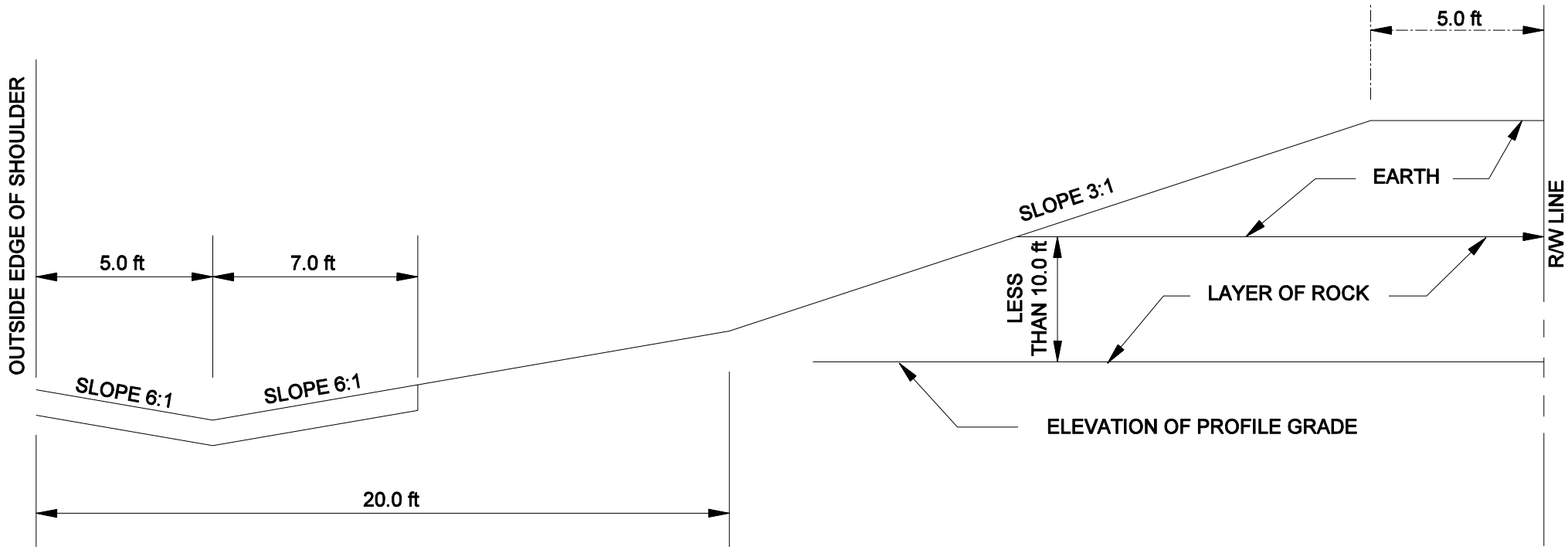
Notes:

1. This chart is designed for embankment soil slopes which are not subject to rapid drawdown conditions.
2. Select material is considered as rip-rap, rock backfill or as otherwise specified. Rock backfill consist of quarried limestone or dolomite conforming to Class E or better requirments as defined in the INDOT Standard Specifications. The material should not have more than 10 percent passing a 1.5 in. sieve. Slab rock will not be allowed prior approval of the Chief Geotechnical Engineer.
3. If the recomended encasement on this chart is 12 in. encasement may not be required. Such situation should be handled on a case-by-case basis depending on the project characteristics and subsurface conditions.
4. This figure does not replace a Geotechnical Report.



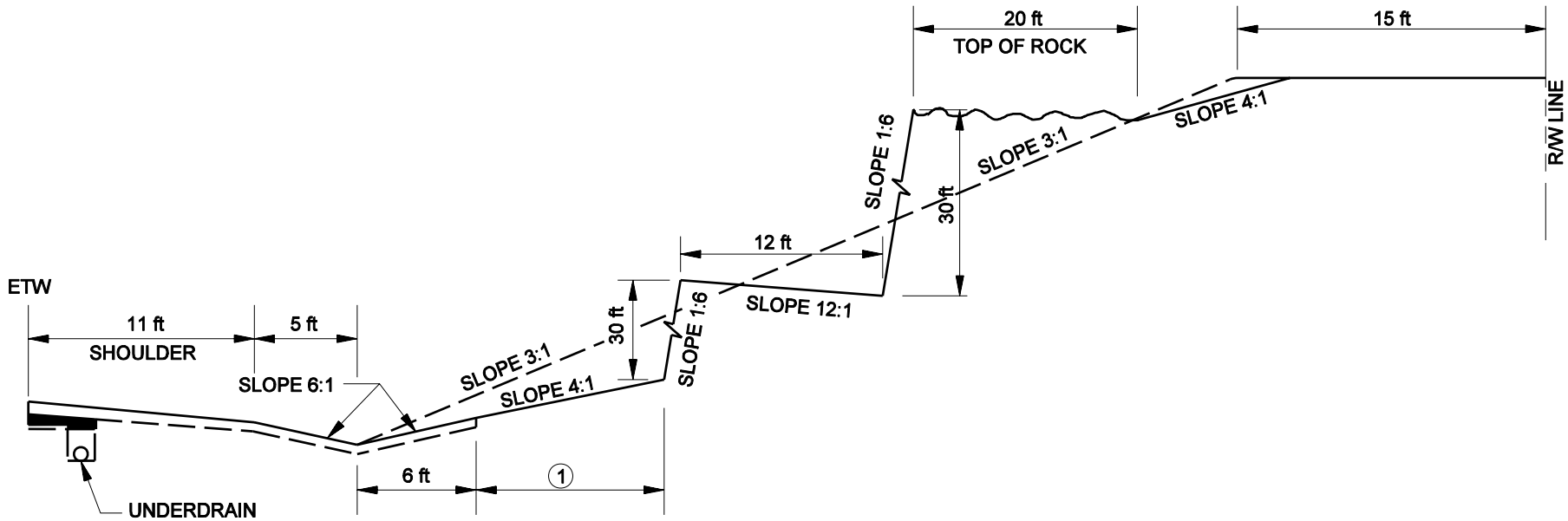
EMBANKMENT TREATMENT

Figure 18-2E



TYPICAL ROCK CUT BENCHING
(< 10.0 ft)

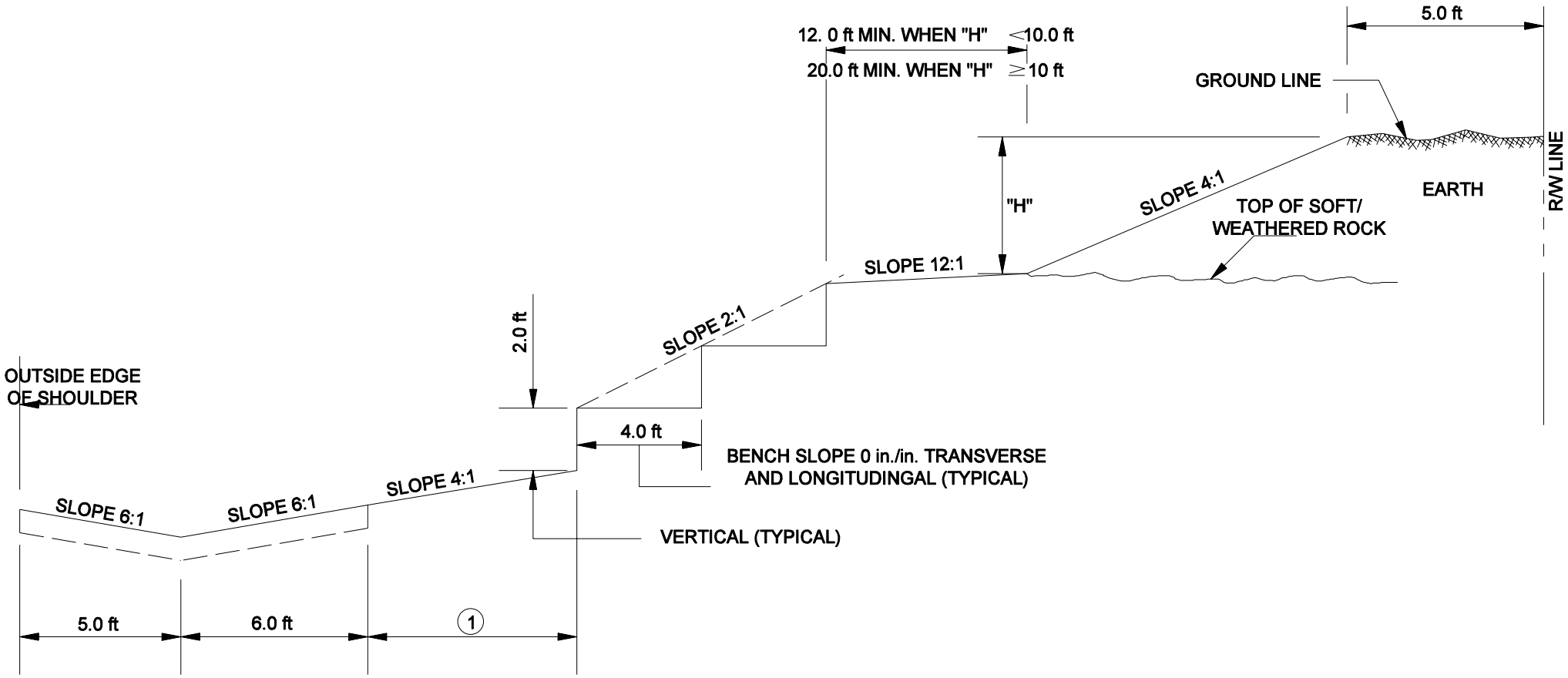
Figure 18-2F



① See Chapter Forty-nine for the applicable clear zone criteria or Chapter Fifty-five for the applicable obstruction-free zone criteria.

TYPICAL ROCK CUT BENCHING
(≥ 10 ft)

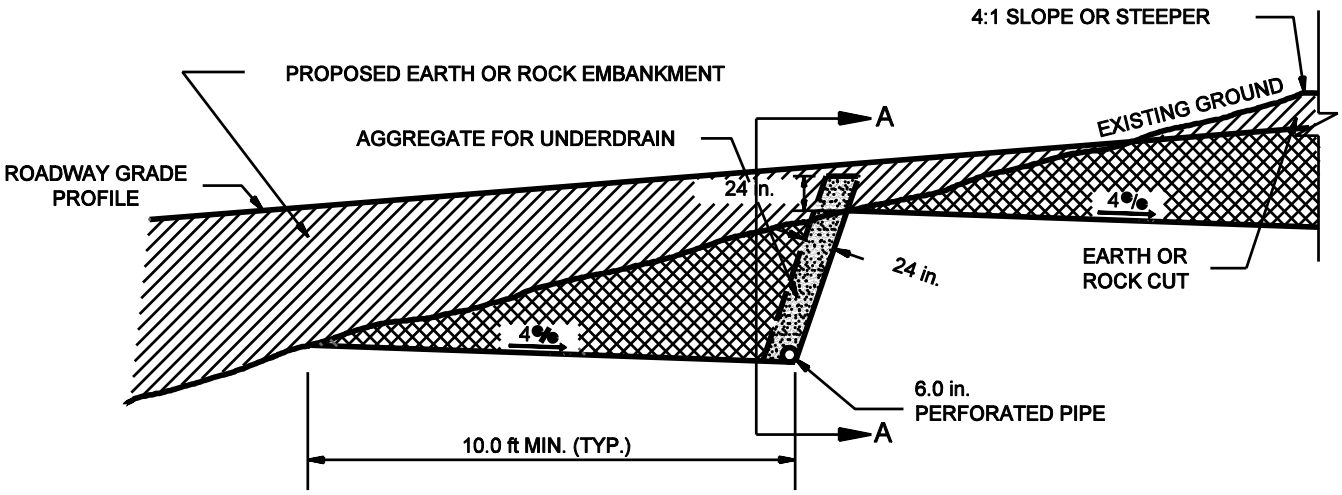
Figure 18-2G



1 See Chapter Fourty-nine for the applicable clear zone or Chapter Fifty-five for the applicable obstruction-free zone criteria.

TYPICAL SOFT/WEATHERED (RIPPABLE) ROCK CUT BENCHING

Figure 18-2H



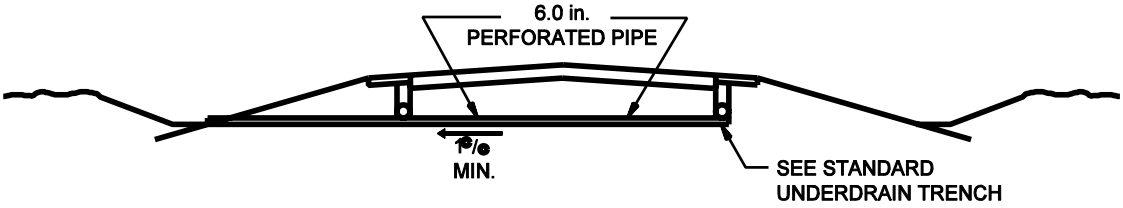
LEGEND

EARTH OR ROCK EMBANKMENT

EARTH AND/OR ROCK EXCAVATION

NOTE: BENCHING IS REQUIRED WHERE THE EXISTING GROUND IS STEEPER THAN 4:1 SLOPE.

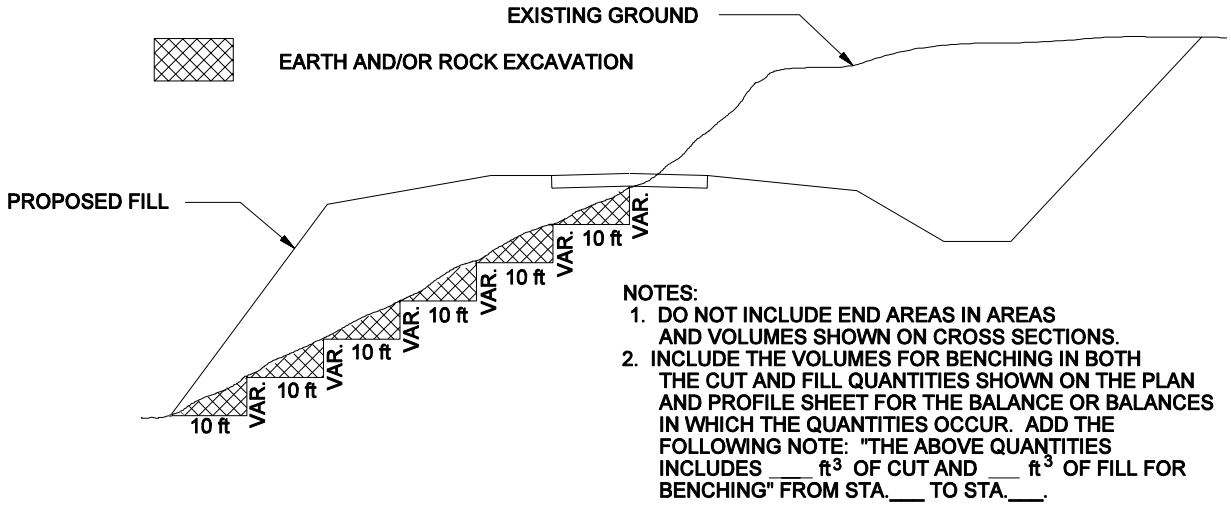
PROFILE VIEW



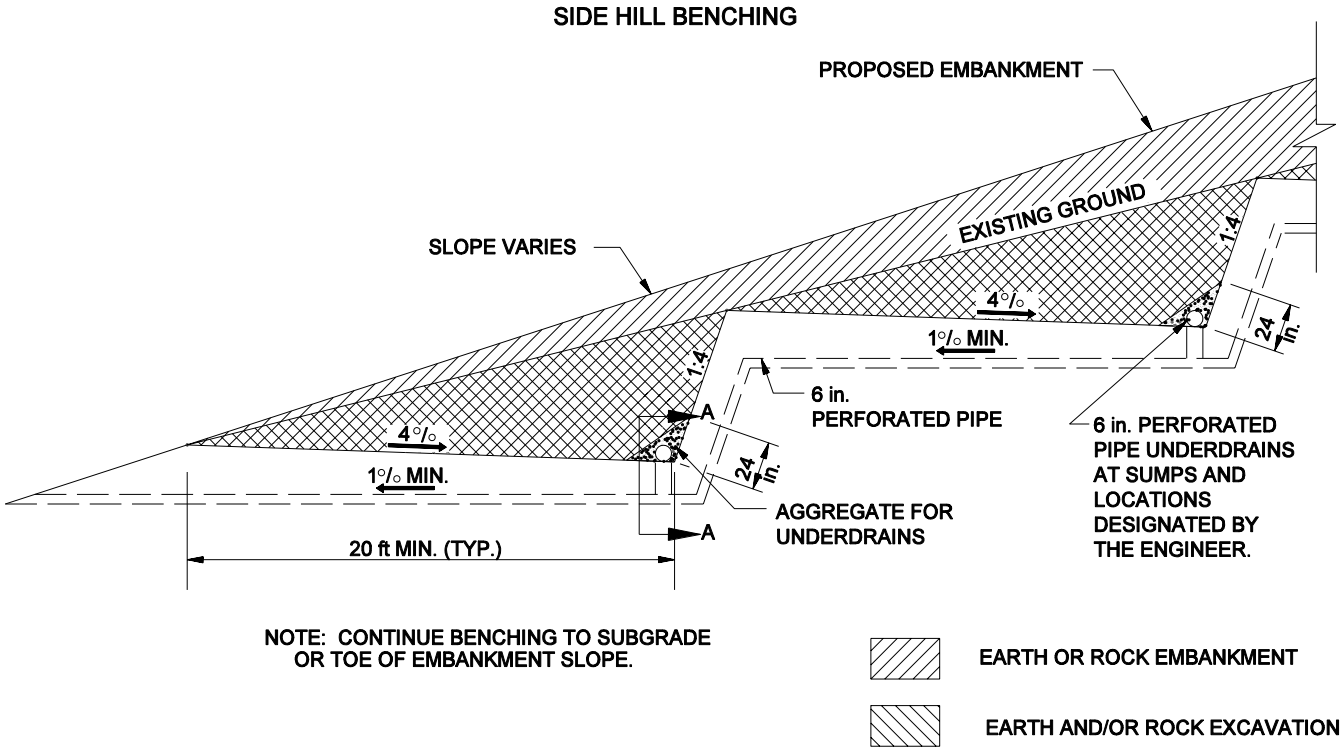
SECTION A-A

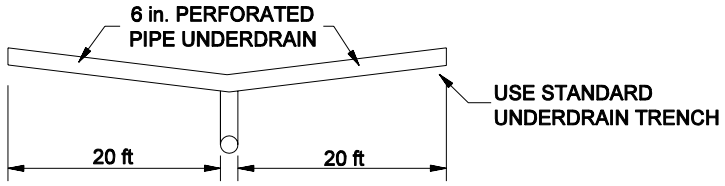
TYPICAL TRANSVERSE INCEPTOR DRAINAGE

Figure 18-2I



SIDE HILL BENCHING





SECTION A-A

BENCHING WHEN WATER IS ENCOUNTERED

TYPICAL BENCHING METHODS

Figure 18-2J