TECHNICAL MEMORANDUM

DATE August 1, 2025 **Project No.** 31405712.6646

TO Callie Ewald, PE
Vermont Agency of Transportation

CC

FROM Melissa E. Landon, PhD, PE **EMAIL melissa.landon@wsp.com**

SUMMARY OF GEOPHYSICAL BEDROCK SURFACE INVESTIGATION
BRIDGE NO. 4 REPLACEMENT ON VT 100A OVER PINEY HOLLOW BROOK, PLYMOUTH, VT
PLYMOUTH ER P23-1(327)

INTRODUCTION

WSP USA, Inc., (WSP) is pleased to submit this Technical Memorandum to the Vermont Agency of Transportation (VTrans) to summarize the geophysical investigation performed to identifying bedrock variability, specifically at the proposed culvert inlet and along the proposed culvert structure for replacement of Bridge No. 4 carrying Vermont Route (RT) 100A over Piney Hollow Brook in Plymouth, Vermont. This memorandum summarizes the results of the geotechnical investigation of the bedrock surface from the Geotechnical Data Report[1] provided to WSP by VTrans and the scope of work developed following review of the Work Order Request[2]. This memorandum constitutes the completion of our proposed scope of work from our proposal submitted[3] to VTrans on May 21, 2025, and subsequent work authorization #WA00037 budget adjustment dated May 27, 2025, under our On-Call Geotechnical Services Agreement with VTrans (Contract No. PS0836) dated November 1, 2020.

BEDROCK ELEVATIONS FROM GEOTECHNICAL BORINGS

The Geotechnical Data Report[1] indicates that bedrock is located at 23.0 feet bgs (EL. 1207.6 feet) at P-102 on the RT 100A southbound side of the project and 9.9 feet bgs (EL. 1221.0 feet) and 31.0 feet bgs (EL. 1200.9 feet) at B-102 and P-101, respectively on the RT 100A northbound side of the project. Cobbles and boulders were encountered in B-101 on RT 100A southbound between 14 feet and 19 feet bgs and hard drilling below 19 feet bgs (EL. 1212.6 feet), however bedrock was not confirmed by rock coring. The soils encountered in B-101 and B-102 consist of gravels and sands and concrete and cobbles and boulders were encountered. Figure 1 shows the boring location plan from the Geotechnical Data Report. [1]

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[1] Denardo, Eric. to Young, R., Memorandum, July 17, 2024, "Plymouth ER P23-1(327) – Geotechnical Data Report", 11 pp.

[2] Work Order Request (WOR) for Geotechnical Engineering Services, Plymouth ER P23-1(327), Dated 5/7/2025, from Callie Ewald, Geotechnical PM

[3] WSP USA, Inc. Proposal for Geotechnical and Geophysical Services, Bridge No. 4 Replacement on VT 100A Over Piney Hollow Broo, Plymouth, VT, Plymouth ER P23-1(327), submitted May 21, 2025.

GEOLOGIC SETTING

Regional Surficial Geology

Overburden geology of the Plymouth area consists of glacial and glaciolacustrine deposits. These deposits are comprised of glacial till, glacial outwash, and areas of alluvium and colluvium. These surficial deposits overlie the metamorphic bedrock that includes schist and phyllite. The thickness of the overburden can vary significantly, with deeper deposits found in valleys and thinner layers or exposed bedrock at higher elevations, both found in the area surveyed as part of this investigation. Specific to the area of investigation, these deposits range in thickness from 0 feet near the bedrock outcrops along the east side of RT 100A north of Piney Hollow Brook to more than 30 feet as encountered at boring P-101.

Regional Bedrock Geology

The bedrock geology of Plymouth, Vermont, primarily consists of Late Proterozoic to Devonian metasedimentary rocks (i.e., schist and phyllite) that have undergone some degree of faulting and fracturing. The area is also known to contain thrust zones including the Champlain thrust and Hinesburg thrust zone. These act as structural boundaries and influence the localized geologic structure present within the work area. Bedrock outcrops present within the work area are consistent with the bedrock lithology encountered in the borings where bedrock cores were recovered.

GEOPHYSICAL INVESTIGATION

Methods

Ground-penetrating radar (GPR) was used in an effort to identify the bedrock surface at the proposed abutment locations and evaluate the existing limits of rock excavation. GPR is often used to detect a variety of metallic, non-metallic, natural, and manmade targets to include underground utilities, burial plots, disturbed soils, sinkholes, and voids. GPR emits a series of high-frequency, high amplitude EM pulses (radio waves) from a transmitting antenna into the ground. When the EM pulses encounter materials that differ in electrical properties, a portion of the energy is reflected back to a receiving element (antenna) at the surface. These reflections are collected as digital images and fed to a portable computer, which then displays a real-time continuous "picture", or profile, of the subsurface that can be used to help pinpoint the location of the subsurface feature.

For greater vertical and lateral resolution, the frequency of the emitted radar wave can be increased. However, greater accuracy and resolution is achieved at the expense of depth of penetration. Depth of penetration is also dependent upon the geologic conditions of the soils in which the investigation is being performed. The radar waves may be absorbed or scattered depending on the properties of the soil, particularly electrical conductivity. Electrically resistive material such as unsaturated, coarse-grained sediments optimize GPR signal penetration, whereas exploration depths are limited by relatively conductive material such as saturated or fine-grained sediments, clay-rich soils, ash, or reinforced concrete. Based on boring log information provided by VTrans in preparation of the scope of work, we determined that the overburden materials encountered during drilling would facilitate the use of GPR to further evaluate subsurface bedrock conditions in the work area.

WSP employed a Geophysical Survey Systems, Inc. (GSSI) 200 MHz HyperStacking (HS) antenna. GPR profiles were positioned along RT 100A (Figure 2) to facilitate the desired depth of investigation and resolution and located based on previously borings completed by others. GPR depth of signal penetration varied due to subsurface soil conditions, with the average depth being approximately 25 feet with some areas being greater than 30 feet.

Results

In general, the GPR profiles collected within the survey area were able to further define some of the subsurface bedrock conditions present. As illustrated in Figure 3a and Figure 3b, there is discernable topography along the interpreted bedrock surface with only minor variations between the interpreted surface and the depth to bedrock as encountered in the borings. Of note is the area located at B-102 where shallow refusal was encountered, and coring resulted in recovery of what was described as concrete and steel fragments. This information suggests that bedrock was not encountered and is supported by the extension of the interpreted bedrock surface south from P-102 where bedrock was encountered at a depth of 23 feet. This depth to bedrock is consistent with a GPR reflector as identified in Figure 3a on Lines 1, 4, and Line 6 and in Figure 3b on Lines 10, 11, 14, and 16. Based on the results, depth to bedrock south of the culvert is approximately 24 feet to 27 feet below ground surface (bgs) and bedrock north of the culvert is approximately 18 feet to 22 feet bgs.

The offset in bedrock between the north and south sides of the culvert could be associated with the structural geologic conditions of the area; however, the GPR signal penetration could not be achieved directly over this area. The interpreted limits of existing excavation and backfill around the culvert is based on a discontinuity in subsurface GPR reflectors (strata) and was in an area of limited signal resulting from the presence of the existing infrastructure (i.e., reinforced concrete). The vertical accuracy of the GPR data varies with increased depth of the target (i.e., bedrock). It is estimated that the accuracy may be a foot or less where shallower bedrock was encountered (B-102) up to an estimated 2 feet where deeper bedrock/refusal was recorded (B-101, P-101, P-102).

SUMMARY

The collected and interpreted GPR data were generally consistent with information presented in the borings; however, some variations in the interpreted bedrock surface exist. This includes the interpreted offset in the bedrock surface north and south of the current culvert and the depth to refusal encountered in B-102. The overburden lithology encountered during drilling is interpreted to be consistent with the observed GPR signal with signal penetration consistent with coarser-grained material (i.e., sand) as silt and clay would limit signal penetration. The interpreted bedrock surface was based on the interpreted GPR profile data, boring logs, and observations made in the field at the time of data collection (i.e., bedrock outcrops).

CLOSING AND LIMITATIONS

WSP has prepared this Technical Memorandum for the exclusive use of VTrans for specific application to the replacement of Bridge No. 4 carrying RT 100A over Piney Hollow Brook in Plymouth, Vermont. We performed the geophysical site investigation and compiled our interpretations in accordance with generally accepted geology and geophysics practices in this geographical area and under similar time and financial constraints. Our interpretations are based, in part, on information obtained from the referenced field explorations completed at the discrete locations described in the memorandum and from experience gained performing similar surveys with similar objectives and geologic conditions. Variations in the nature and extent of field conditions between explorations should be expected. WSP makes no other warranty, either express or implied.

WSP appreciates the opportunity to provide our geotechnical services to VTrans for this project. Please contact us if you have any questions.

Sincerely,

WSP USA, Inc.





Christopher F. Buckman, PG, LG
Assistant Vice President, Geologist

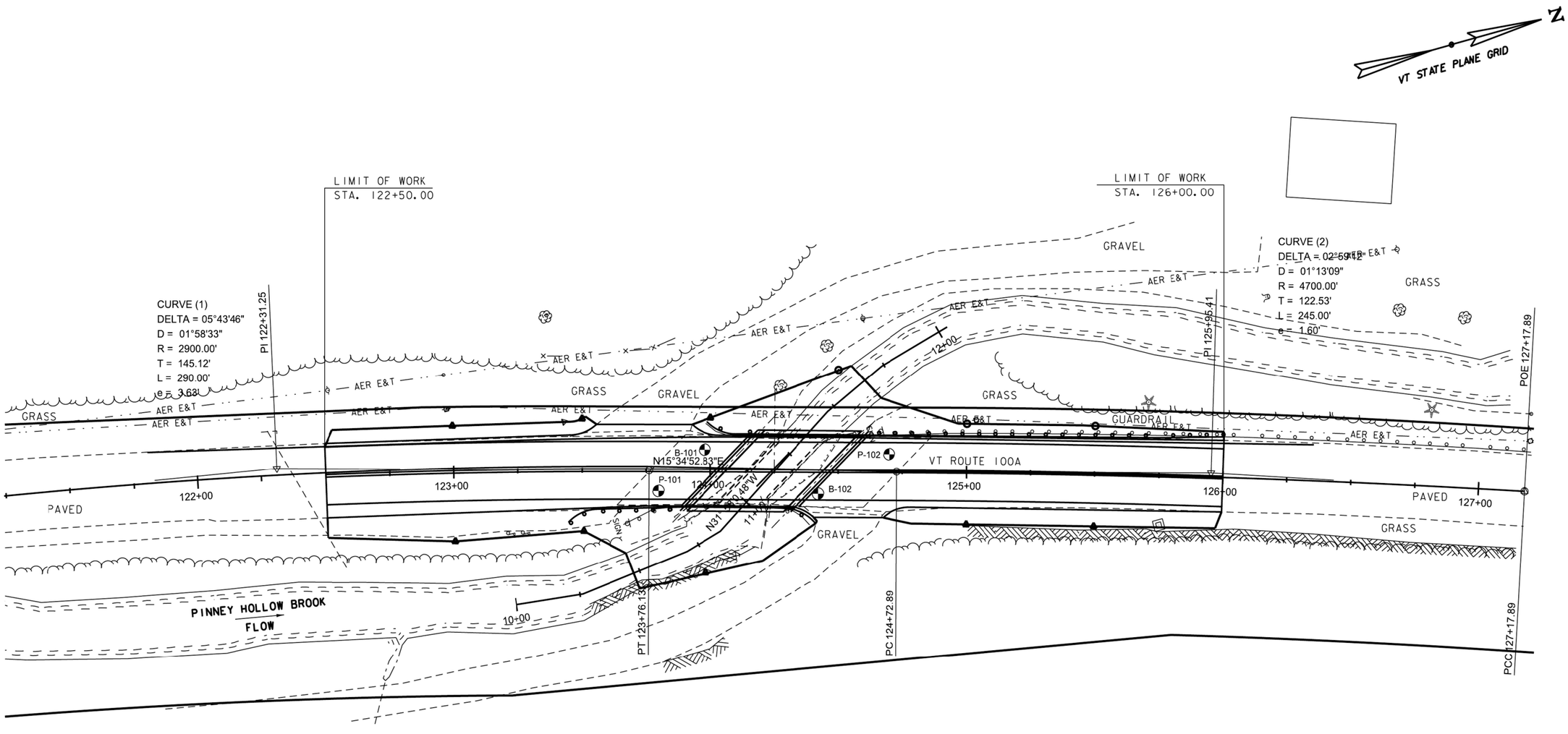
Melissa E. Landon, PhD, PE
Assistant Vice President, Geotechnical Engineer

MEL/CFB/JDL

Attachments: Figure 1: Boring Location Plan
Figure 2: Ground Penetrating Radar Survey Lines
Figure 3a: Interpreted GPR Profiles – Lines 1, 4, and Line 6
Figure 3b: Interpreted GPR Profiles – Lines 10, 11, 14, and 16

https://wsponlinenam.sharepoint.com/sites/us-vtrans-plymouth-b/shared documents/600 deliverables/plymouth er p23-1(327) geophysics investigation memo wsp 20250801.docx

Attachments



BORING LAYOUT

BORING CHART

HOLE NO.	STATION	OFFSET (FT)	NORTHING (FT)	EASTING (FT)	APPROX. GROUND SURFACE ELEV. (FT)	APPROX. BEDROCK ELEV. (FT)
B-101	123+98	8.0 LT	382222.8	1584661.2	1231.6	-
B-102	124+42	8.6 RT	382261.3	1584689.1	1230.9	1221.0
P-101	123+73	9.3 RT	382195.7	1584671.6	1231.9	1200.9
P-102	124+70	6.6 LT	382291.9	1584681.9	1230.6	1207.6

0 20 40
SCALE IN FEET

GREEN INTERNATIONAL AFFILIATES, INC.
CIVIL AND STRUCTURAL ENGINEERS

PROJECT NAME:	PLYMOUTH
PROJECT NUMBER:	ER P23-1(327)
FILE NAME: $FILES$	PLOT DATE: $$$$DATE$$$
PROJECT LEADER: A. TSOUKALAS	DRAWN BY: L. BYERS
DESIGNED BY: C. WU	CHECKED BY: S. SACCO
BORING LAYOUT	SHEET SET= OF TTLSET

NOTES:

Ground penetrating radar profiles were collected using a GSSI 200HS 200 MHz antenna.

GPR records were processed using RADAN 7 Software.

Site feature locations were recorded using a Juniper Geode differential global positioning system (DGPS).

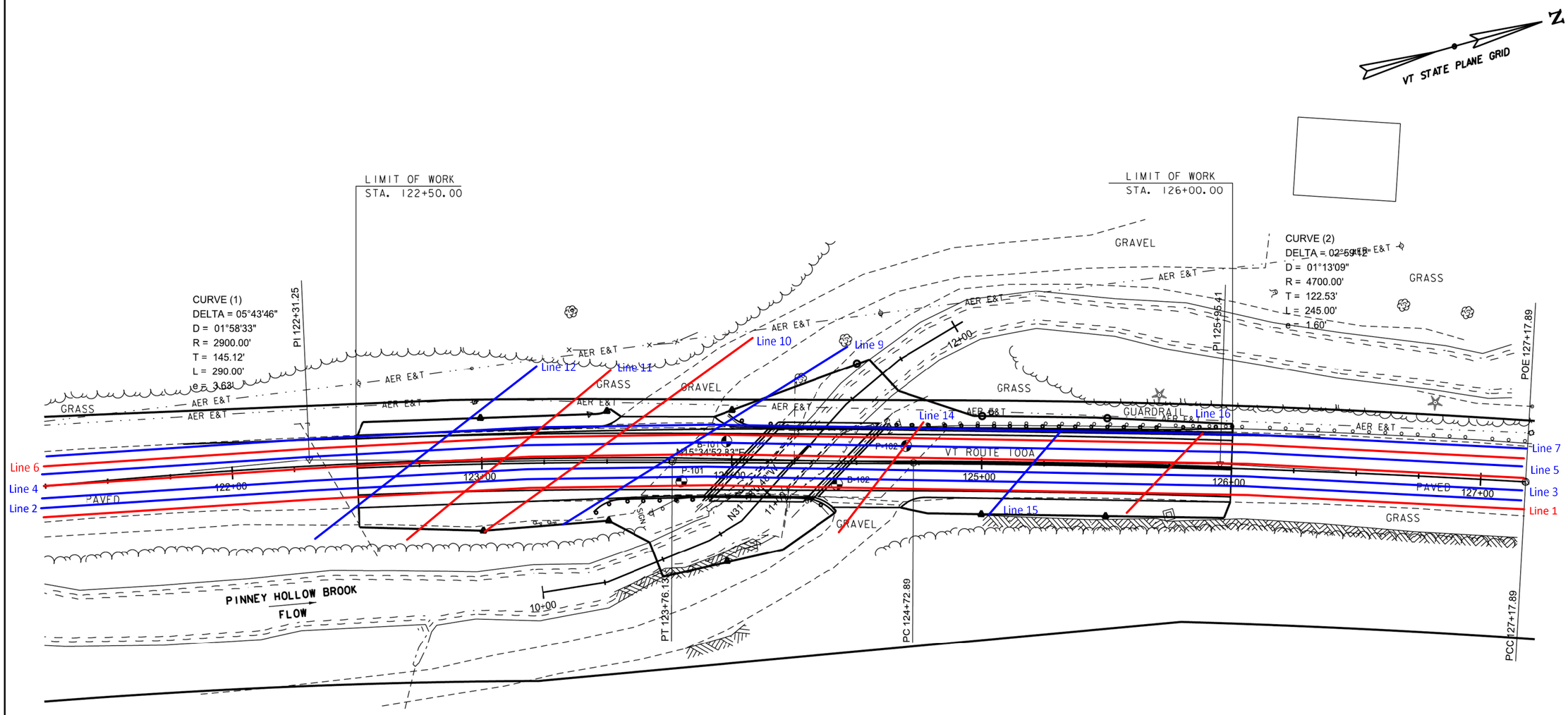
WSP USA Inc.
Maine Mill Square, Suite 200
Portland, ME 04101

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Boring Layout Site Plan
Bridge No. 4 RT 100A - Piney Hollow Brook
Plymouth, Vermont
July 2025

SCALE:	DATE:	PROJECT NUMBER:
AS SHOWN	07/28/2025	31405712.6646

DRAWING NUMBER:
FIGURE 1
SHEET NUMBER:
1 OF 1



BORING LAYOUT

BORING CHART

HOLE NO.	STATION	OFFSET (FT)	NORTHING (FT)	EASTING (FT)	APPROX. GROUND SURFACE ELEV. (FT)	APPROX. BEDROCK ELEV. (FT)
B-101	123+98	8.0 LT	382222.8	1584661.2	1231.6	-
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P-102	124+70	6.6 LT	382291.9	1584681.9	1230.6	1207.6

GPR Profile Location

Selected GPR Profile (Figures 3a/3b)

0 20 40
SCALE IN FEET

GREEN INTERNATIONAL AFFILIATES, INC.
CIVIL AND STRUCTURAL ENGINEERS

PROJECT NAME:	PLYMOUTH
PROJECT NUMBER:	ER P23-1(327)
FILE NAME: $FILES$	PLOT DATE: $$$$DATE$$$$
PROJECT LEADER: A. TSOUKALAS	DRAWN BY: L. BYERS
DESIGNED BY: C. WU	CHECKED BY: S. SACCO
BORING LAYOUT	SHEET SET# OF TTLSET

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GPR Profile Location Plan
Bridge No. 4 RT 100A - Piney Hollow Brook
Plymouth, Vermont
July 2025

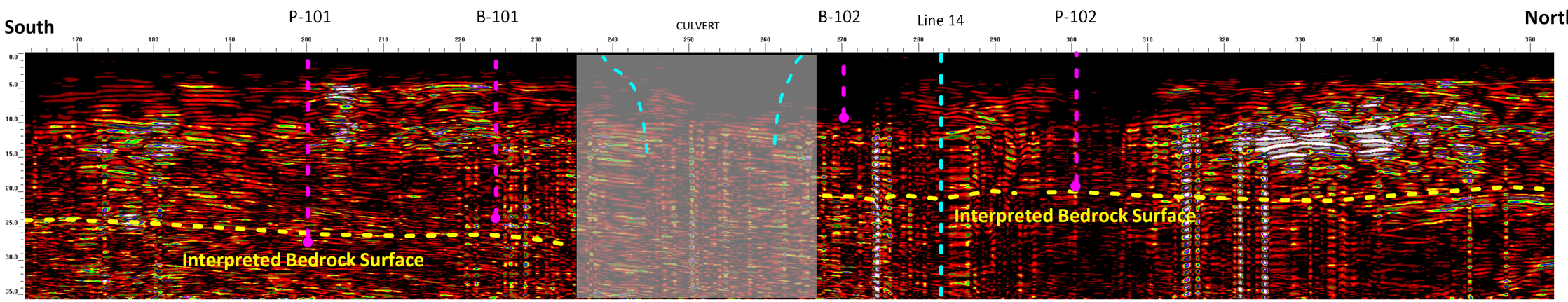
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AS SHOWN	07/28/2025	31405712.6646

DRAWING NUMBER:

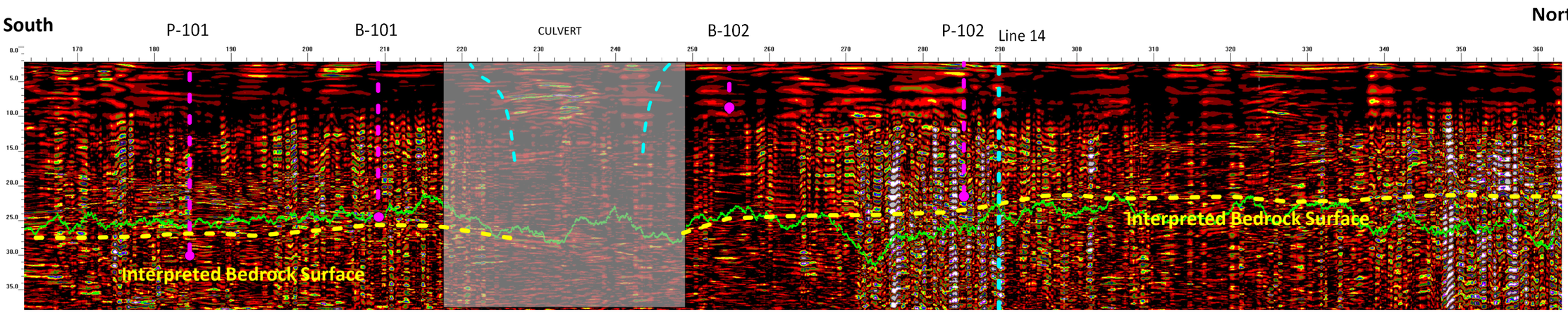
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SHEET NUMBER:

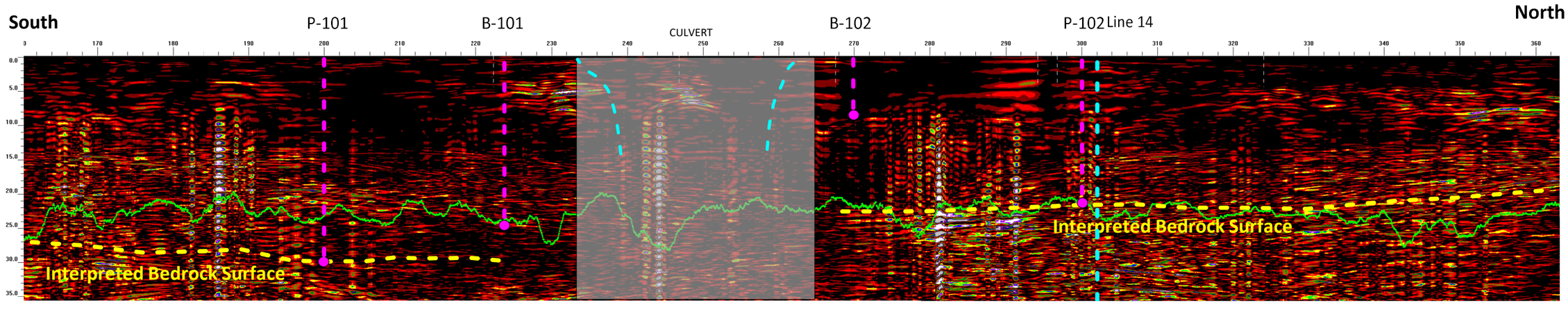
1 OF 1



Line 1



Line 4



Line 6

LEGEND

- Depth to Bedrock/Refusal
- Interpreted Limits of Excavation

NOTES:

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Interpreted GPR Profiles: Selected Examples
North-South Oriented Transects
Bridge No. 4 RT 100A - Piney Hollow Brook
Plymouth, Vermont

SCALE:	DATE:	PROJECT NUMBER:
AS SHOWN	07/28/2025	31405712.6646

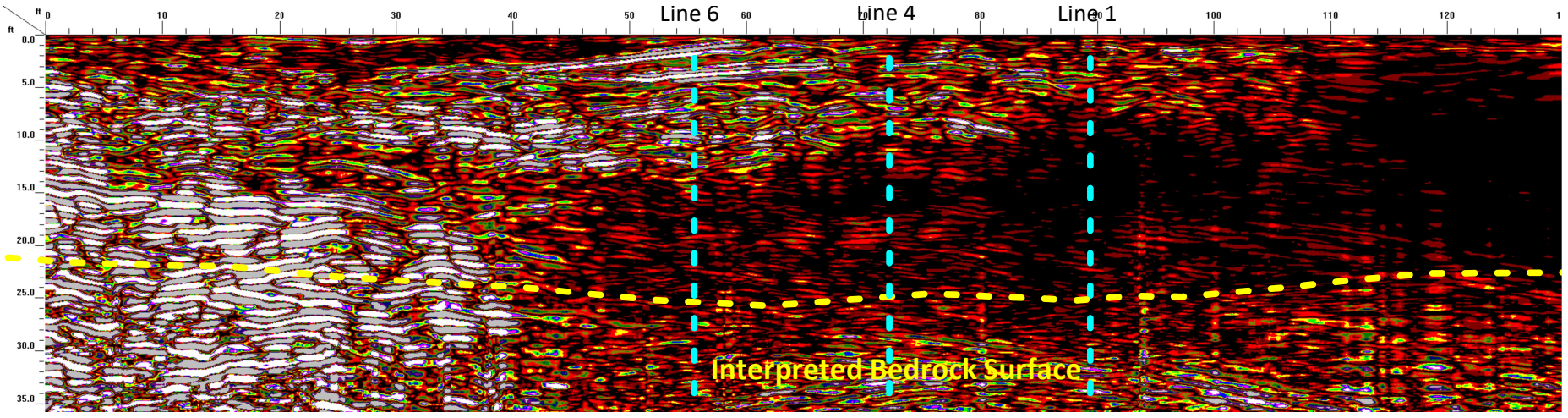
DRAWING NUMBER:

FIGURE 3a

SHEET NUMBER:

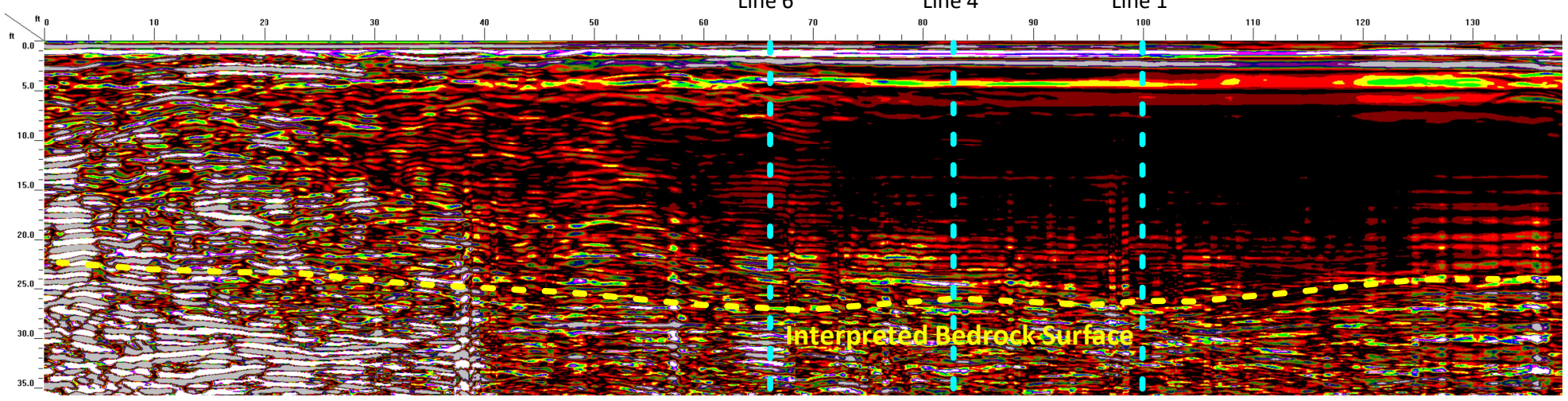
1 OF 1

West East



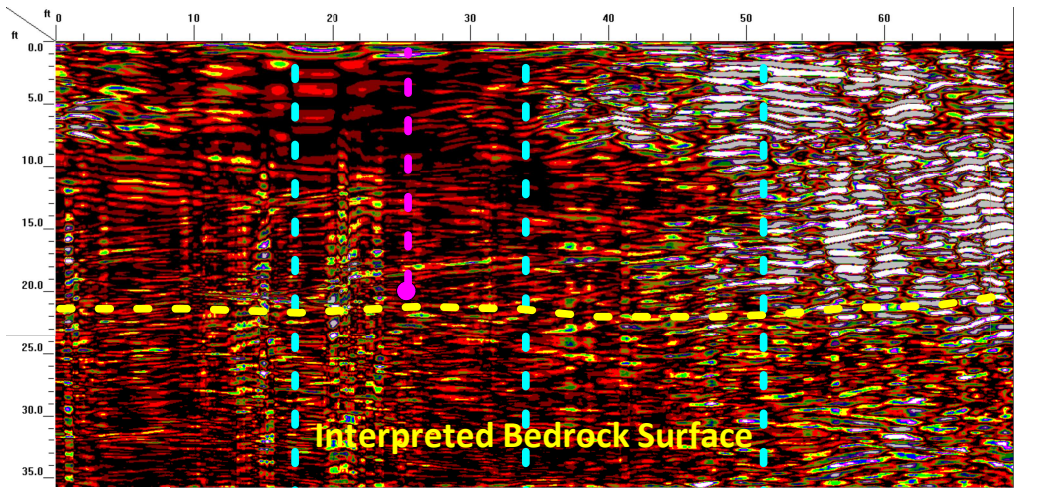
Line 10

West East



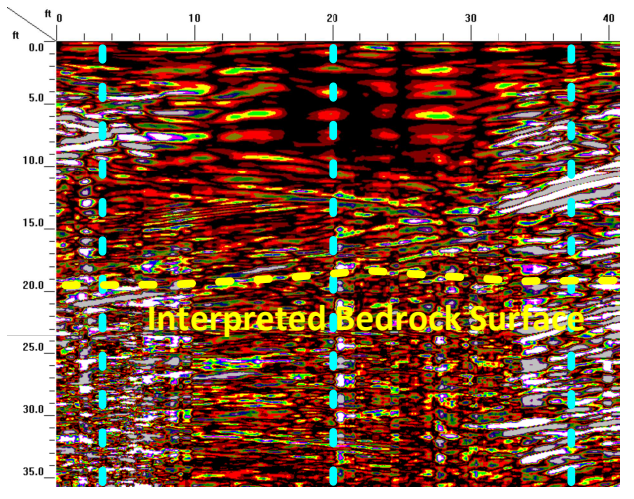
Line 11

West East



Line 14

West East



Line 16

LEGEND

Depth to Bedrock/Refusal

Interpreted Limits of Excavation

FIGURE 3b

DRAWING NUMBER:

SHEET NUMBER: 1 OF 1

Interpreted GPR Profiles: Selected Examples
East-West Oriented Transects
Bridge No. 4 RT 100A - Piney Hollow Brook
Plymouth, Vermont

SCALE:	DATE:	PROJECT NUMBER:
AS SHOWN	07/28/2025	31405712.6646

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Portland, ME 04101

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