November 21, 2019

Mr. Curtis B. Miller
Transmission Siting and Environmental Planner
Tri-State Generation and Transmission Association, Inc.
1100 W. 116th Ave.
Westminster, CO 80234

Sent via email

Re: **Pavement Condition Assessment of Haul Routes**
Vollmer Transmission Line and Substation Project, El Paso County, Colorado

Dear Mr. Miller,

The purpose of this letter is to document the results of the pre-construction pavement condition assessment (assessment) completed by Tetra Tech Inc. (Tetra Tech) for the Vollmer Transmission Line and Substation Project (Project) in El Paso County, Colorado. As requested by El Paso County and Tri-State,[1] Tetra Tech collected existing roadway conditions along approximately 2 miles of Project haul routes: Falcon Meadows Boulevard, between Woodmen Road, just north of Tercel Drive; and along Mohawk Road, between Woodmen Road and just north of Brule Road. The methodology for collection and processing is described below. A haul route map depicting the Project location and proposed haul routes is shown in Figure 1.

Pavement Assessment Methodology

Tetra Tech conducted the assessment on October 15, 2019, using a Mobile Mapping System (MMS). The MMS includes a 3D LiDAR sensor and seven cameras mounted to a truck. The system was driven at posted speeds to collect digital data within the data collection limits (i.e., along the haul routes). The data collected include survey-grade LiDAR data as well as high-resolution 360-degree imagery. Using this data collection methodology, American Society of Testing Materials (ASTM) road condition information could then be extracted to provide a measurable baseline of the existing conditions prior to the start of Project construction.

The collection process began by setting a survey control monument in the middle of the data collection limits to establish a permanent control point. A GPS was set up on the control monument and collected data over a 4-hour period provide a stable and accurate position for data collection.

Once the survey control monument had been established, the MMS collection of existing condition data began. To effectively ensure total site coverage within the data collection limits, the MMS was driven on each lane (i.e., northbound and southbound) of Mohawk Road and Falcon

[1] Tetra Tech collected additional roadway conditions data along Woodmen Road between Marksheffel and Meridian roads while traveling between the two haul routes but has not processed the data as it was not originally requested; this data will remain on file at Tetra Tech in the event Tri-State requests further work be completed.

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Meadows Boulevard. LiDAR data, as well as 360-degree imagery, was collected every 3 meters to ensure sufficient coverage of the data collection limits to assess existing conditions.

The collected data were then processed and aligned with individual drive lines into a complete registered Project dataset. Processing was accomplished by using common overlapping data in each drive pass and aligning that with the GPS data. With the data from each drive pass properly aligned to each other and the GPS data, the information was exported into LASer (LAS) point cloud file format. LAS is a universal point cloud format that can be imported into most AutoCAD and design software.

TopoDOT software was used to extract the ASTM data collected and processed using MicroStation. The LAS data were imported into MicroStation so that the road condition algorithm could be run on the data. The algorithm creates both a visual representation of the quality of the road as well as a quantifiable representation in an Excel file format that breaks the roadways down into sample sites and quantifies the level of pavement condition types (i.e., rutting, corrugation, pothole, bump, and depression). Table 1 provides the threshold for each of the pavement condition types. The threshold values are based off ASTM 6433 national roadway standards. The thresholds noted in the table correspond to Figure 2 which shows the collected data overlaid on the corresponding photograph that was collected concurrently with the Lidar data, and indicates pavement conditions and the thresholds (i.e., low, medium, high) for each occurrence.

Table 1: Thresholds for Roadway Pavement Conditions

Rutting Thresholds	**Feet (US)**
Low	0.019
Medium	0.035
High	0.072
Pothole/Bump Thresholds	
Depth/Height low	0.017
Depth/Height Medium	0.058
Depth/Height High	0.12
Pothole Diam Low	0.328
Pothole Diam Medium	0.656
Pothole Diam High	1.476
Corrugation Thresholds	
Low	0.014
Medium	0.026
High	0.064

Within each roadway segment the total volumetric of all the pavement condition types recorded are added together and averaged and provide a Pavement Condition Index rating (i.e. very poor, poor, fair, satisfactory, good).

The data collected during the October 2019 site visit, including panoramic images, will become the baseline to compare the post construction conditions of the haul routes. Electronic results of the data collection are included on an external hard drive and are being submitted under separate cover. Electronic file formats include KML, KMZ, Excel, and AutoCAD (.dwg). In the Excel files, a volumetric condition assessment is also included. A hard drive containing panoramic images will be sent to you under separate cover.

If you have any questions or require any additional information, please do not hesitate to contact me at (303) 980-3549.

Sincerely,
TETRA TECH, INCORPORATED

Bret Bienkowski
Mobile Mapping Survey Manager

cc: Jennifer Chester, Tetra Tech
Lori Davidson, Tetra Tech

Attachment:
Figure 1—Vicinity Map
Figure 2—Roadway Pavement Condition Example

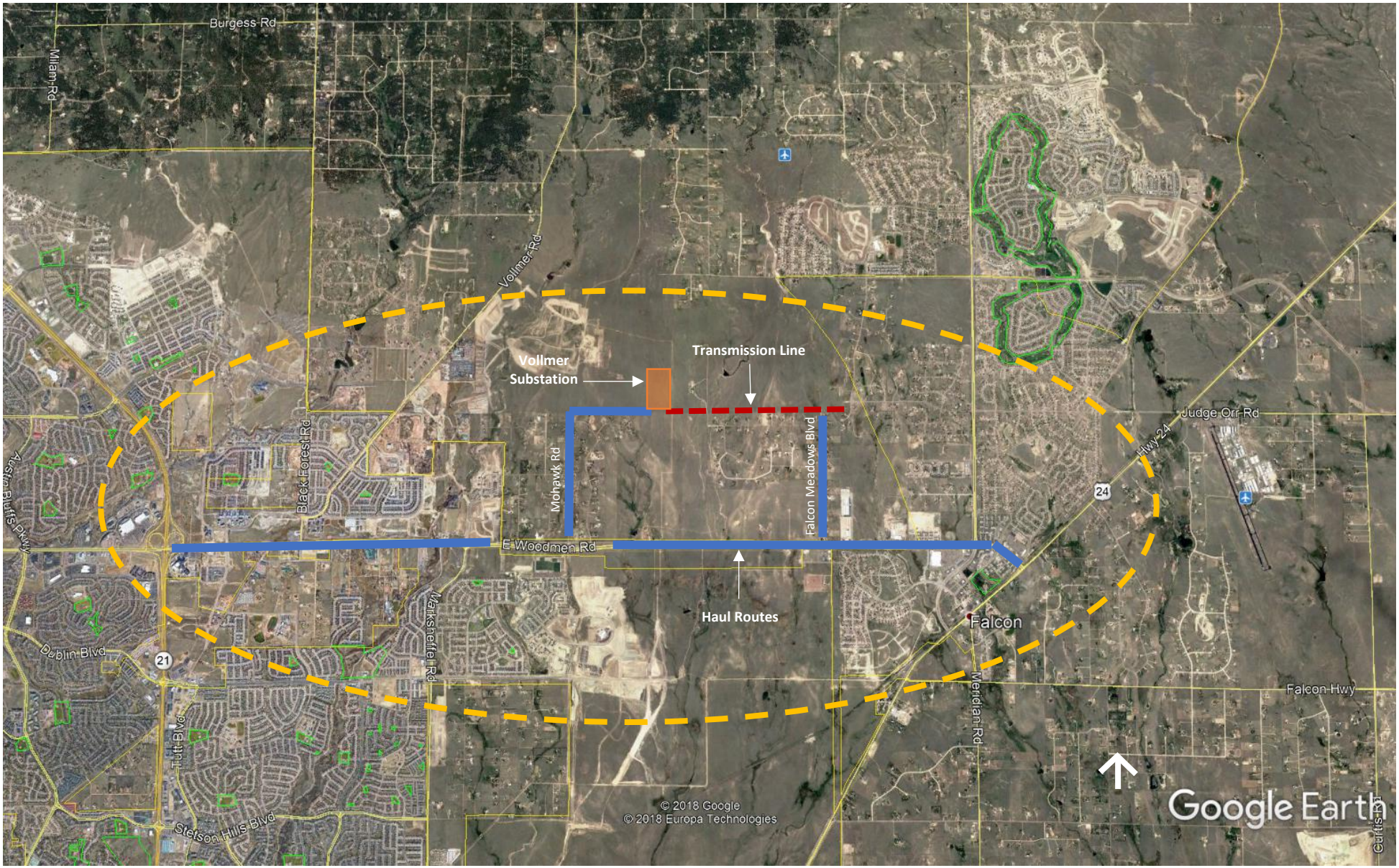

Figure 1 – Vicinity Map

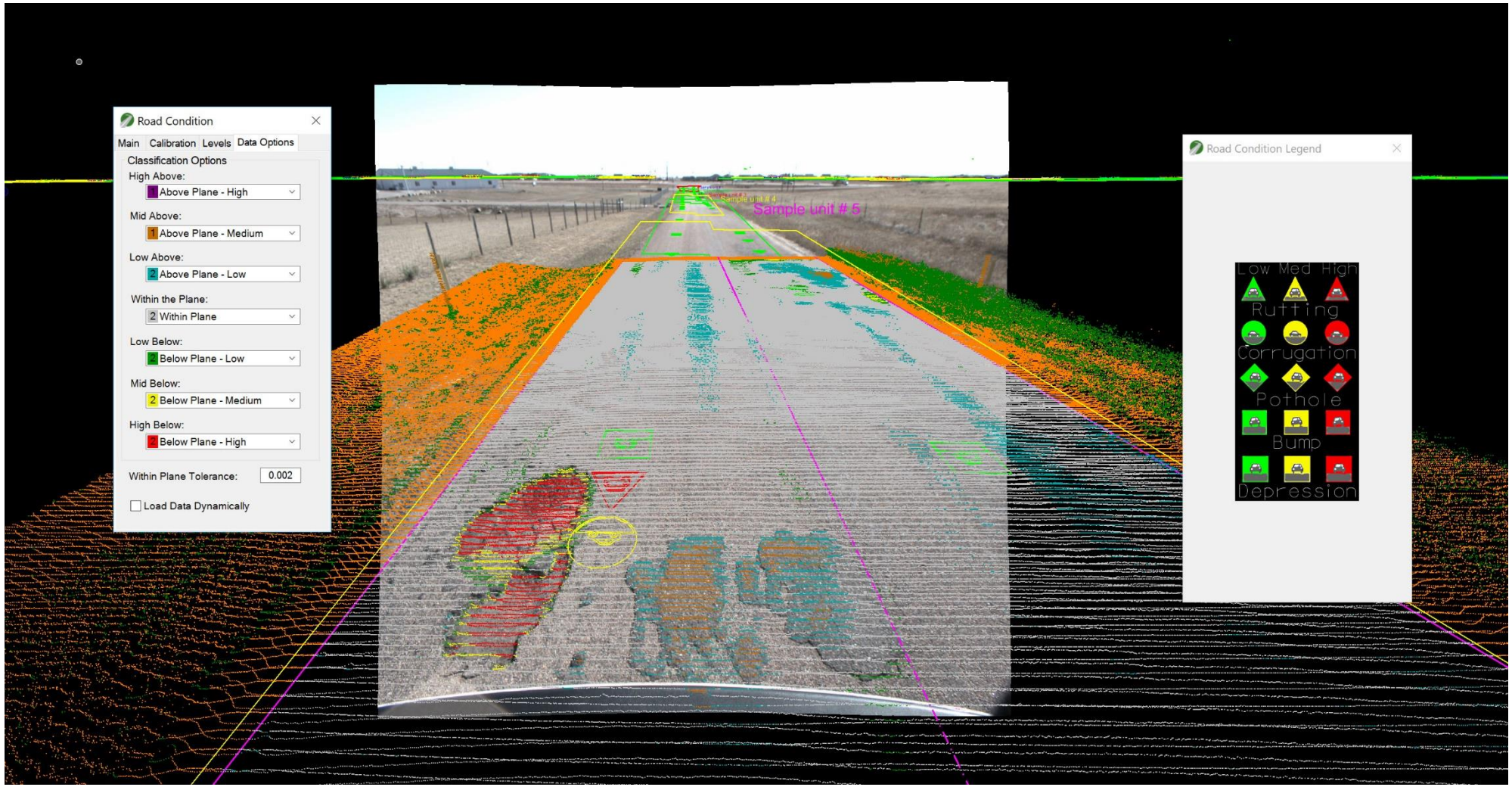

Figure 2 – Roadway Pavement Condition Example