TETRA TECH

Geotechnical Investigation for Fulford-Ganges Road from Cranberry Road to Seaview Avenue, Salt Spring Island, BC

PRESENTED TO

Ministry of Transportation and Infrastructure

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ACRONYMS & ABBREVIATIONS

Acronyms/Abbreviations	Definition
AASHTO	American Association of State Highway and Transportation Officials
BCGS	British Columbia Geological Survey
EGBC	Engineers and Geoscientists of British Columbia
ESAL	Equivalent Single Axle Loads
LRFD	Load Resistance Factored Design
MoTI	Ministry of Transportation and Infrastructure
MPMDD	Modified Proctor Maximum Dry Density
NBCC	National Building Code of Canada
NR Can	Natural Resources Canada
SPT	Standard Penetration Test
SN_f	Structural Number

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1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Ministry of Transportation and Infrastructure (MoTI) to provide geotechnical and pavement recommendations to assist with the planning and design for the section of Fulford-Ganges Road from Cranberry Road to Seaview Avenue in Salt Spring Island, BC (the Site). The location of the Site is shown on Figure 1. The section of Fulford-Ganges Road within the project limits is approximately 1.5 km long and falls within the MoTI Maintenance Service Area 1 – South Island region.

This project's scope included site-reconnaissance, subsurface investigation, laboratory testing, analysis of the collected data, preparation of a summary of the collected data, development of geotechnical recommendations, development of pavement rehabilitation recommendations and preparation of a pavement design report. The scope of work was prepared based on discussions between Mr. Vipin Sharma of Tetra Tech and Mr. Rampaul Dulay of Stantec Consulting, and Mr. Salem Bahamdun of MoTI.

1.1 Project Description

Fulford-Ganges Road runs from Fulford Harbour (Salt Spring Island) Ferry Terminal in the south at HRP 0.00 km to Ganges Harbour Airport (YGG) in the north at HRP 14.172 km. The geotechnical exploration for this project extended from Cranberry Road (HRP 12.310) to Seaview Avenue (HRP 13.822) for an approximate length of about 1.5 km.

The existing Fulford-Ganges Road within the project limits generally has one lane in each direction. It is understood that the MoTI is carrying out the Fulford-Ganges Road Improvement project, to construct geometric improvements and rehabilitating the existing pavement.

MoTI retained Tetra Tech in 2020 under the MoTI's South Coast "As and When" Contract No. 156CS0927 to provide a pavement evaluation and rehabilitation option for the Fulford-Ganges Road from Garner Road to Seaview Avenue. The pavement recommendations were provided in an Issued for Use Report dated April 24, 2020.

The Fulford-Ganges Road has areas where the paved surface is narrower than would be constructed under MoTI's current standards. The Fulford-Ganges Road Improvements project also includes increasing the road's width to meet the current geometric road standards. It is understood that the MoTI intends to widen the existing roadway to construct 1.5 m wide shoulders on either side. The scope of work for this assignment included carrying out the geotechnical exploration to support the geotechnical and pavement recommendations for widening the road embankment.

The MoTI provided Tetra Tech with revised 70% detailed design drawings for the Fulford – Ganges Road Improvement (Project No. 16873-0001).

1.2 Project Scope

The project's scope of work included the following:

- Site-reconnaissance of the pavement within the project limits;
- Review of the available background information including traffic data, historical rehabilitation information and any other data provided by the MoTI;
- Completion of BC Onecall notifications and hiring an independent utility locating contractor to clear proposed borehole locations of underground utilities;

- Auger drilling within the embankment slope and the proposed toe of the slope within the widening areas to determine existing subgrade soil conditions;
- Completion of laboratory testing on select samples from the drilling program;
- Preparation of a summary of geotechnical borehole exploration in the report;
- Estimating traffic loading conditions for the pavement design analysis;
- Compiling and reviewing the field data to develop geotechnical and pavement design recommendations for widening;
- Virtual Meeting with MoTI and Stantec to discuss the findings of the geotechnical investigation and pavement recommendations for the project; and
- Preparation of a Pavement Design Report as per Tetra Tech's proposal 704-PTRN.PAVE03225-01.

2.0 BACKGROUND REVIEW

Review of the background documents for information pertinent to the geotechnical condition of the Site was completed and is summarized in the following subsections.

2.1 Surficial Geology Maps

A review of the British Columbia Geological Survey MapPlace 2 (BCGS) web-based Surficial Geology Map indicates that the surficial geology at the Site consists of undifferentiated bedrock (i.e. no mapped surficial geology units according to BCGS).

2.2 Bedrock Geology Maps

A review of the BCGS web-based Bedrock Geology Map indicates that the bedrock geology at the Site consists of undivided sedimentary rocks of the Upper Cretaceous Nanaimo Group.

2.3 Review of Traffic Data

2.3.1 Initial Traffic Count Data

Tetra Tech used the traffic count data provided by the MoTI for calculation of the design traffic for inclusion in the pavement design. MoTI collected the traffic count data on Fulford-Ganges Road between Beddis Road and Bittancourt Road from August 4, 2021 to August 7, 2021, for four days. Table 2-1 provides the collected daily traffic count data.

Table 2-1: Daily Traffic Count Data

Row Labels	Northbound Traffic	Southbound Traffic	Two Way ADT
August 4, 2021	3,502	5,763	9,265
August 5, 2021	3,749	5,864	9,613
August 6, 2021	3,655	5,681	9,336
August 7, 2021	3,433	5,030	8,463

The Average Daily Traffic (ADT) for the four days was calculated to be 9,170 vehicles per day. Based on the review of traffic count at nearby traffic count stations, we understand that the ADT for the summer months is generally higher than the Average Annual Daily Traffic (AADT). Therefore, the measured ADT of 9,170 was adjusted to allow for the lower daily traffic volumes in the winter months. To allow for this, AADT of 7,800 was calculated (equal to 85% of the ADT values measured in summer months) and considered during the calculation of the design traffic for the roadway.

The amount of commercial traffic was calculated based on the length of the vehicle and the corresponding vehicle class. The *BC TDP Standard Length Bins* provided in *BC Ministry of Transportation and Infrastructure Traffic Reports User Documentation* was used for vehicle class distribution based on vehicle length. The traffic under vehicle class 4 to vehicle class 13 was grouped as truck traffic. Table 2-2 provides the BC TDP Standard Length Bins.

Table 2-2: BC TDP Standard Length Bins

Bin	Range (m)	Vehicle Class Descriptions
1	0.00 – 6.00	Motorcycles (FHWA 13 axle class 1), passenger cars (class 2), and light single-unit trucks (class 3)
2	6.00 – 12.50	Buses (class 4), two axle, 6 tire single unit trucks (class 5), three axle single unit trucks (class 6), four axle single unit trucks (class 7)
3	12.50 – 22.50	4 or less axles, single trailer truck (class 8); five axle single trailer truck (class 9); six or more axle single trailer truck (class 10)
4	22.50 – 35.00	B-trains (class 8, 9, 10); five axle, multi trailer truck (class 11); six axle, multi trailer truck (class 12); seven axle, multi trailer truck (class 13)
5	35.00 – 999.00	Multi-Trailer (class 13)
Source: *BC Ministry of Transportation and Infrastructure Traffic Reports User Documentation*		

The average commercial traffic on the northbound lane is 5.7% and on the southbound lane is 2.8%, with an average percentage of commercial traffic of 3.9%. A truck factor of 1.0 Equivalent Single axle Load (ESAL)/Truck was used in the calculation of the 20-year design ESALs. A 20-year analysis period was used as per MoTI's Pavement Structure Design Guidelines (Technical Circular T-01/15). The calculated 20-year design ESAL's of 1.35 million corresponds to a "Type B" Medium to High Volume Road, as per MoTI's Technical Circular T-01/15.

2.3.2 Second Traffic Count

MoTI carried out second traffic count within the project limits at Fulford-Ganges Road between Dean Rd and Drake Rd from October 29, 2021 to November 11, 2021 for a period of eight days. Table 2-3 provides the collected daily traffic count data.

Table 2-3: Daily Traffic Count Data

Row Labels	Northbound Traffic	Southbound Traffic	Two Way ADT
October 30, 2021	4,162	4,369	8,531
October 31, 2021	3,226	3,393	6,619
November 1, 2021	4,143	4,473	8,616
November 2, 2021	4,211	4,671	8,882
November 3, 2021	4,186	4,540	8,726
November 4, 2021	4,343	4,689	9,032
November 5, 2021	4,645	4,901	9,546
November 6, 2021	3,678	3,961	7,639

The traffic count data summarized above indicate average daily traffic of 8,449 vehicles. This new data appears to be reasonable and as expected.

2.3.3 Design Traffic

Based on the review of the short-term traffic data collected in August and in October/November 2021, the AADT of 7,800 discussed above, was considered appropriate for the roadway segment. Therefore, the calculated ESALs of 1.35 million for the 20-year analysis period was considered appropriate and used in the design of pavement structure.

2.4 Climate Data Review

The closest Environment Canada weather recording station was located at Saltspring St. Mary's L (Climate ID # 1016995) located approximately 10.85 km north of the project limits at an elevation of 15.70 m above mean sea level. This weather station reports Canadian Climate Normals from 1981 to 2010. The climate data from this weather station is summarized in Table 2-4.

Table 2-4: Climate Data

Weather Station	Average Annual Precipitation (mm)	Mean Annual Temperature (ºC)	Winter[1] and Summer[2] Mean Monthly Temperature (°C)	Extreme temperature (°C)[3]
Saltspring St. Mary's L (#1016995)	756	11.4	4.4 to 18.7	-5.5 to 28.5

[1]- The Winter Average Monthly Temperature is based on the daily average temperatures in December, January and February.
[2] - The Summer Average Monthly Temperature is based on the daily average temperatures in June, July and August.
[3] - The Extreme Average Monthly Temperatures are based on the daily average temperatures all year.

The weather data from this station indicated that the area receives annual precipitation of 756 mm, which includes 694 mm of rainfall and 62 cm of snowfall. According to the C-SHRP Environmental Zones plan, the roadway is located in a Wet-No-Freeze environmental zone.

This climate data was used to assess Performance Grade (PG) binder grade selection for the roadway segment. Asphalt binder selection recommendations are provided in Section 6.8.4.

3.0 GEOTECHNICAL EXPLORATION METHODS

Tetra Tech undertook a geotechnical exploration as outlined in the following subsections.

3.1 Utility Locate

Prior to drilling activities, Tetra Tech completed ground disturbance notifications (i.e., BC1Call) for the Site. Proposed borehole locations were cleared on-site by Kelly's First Call Locating.

3.2 Drilling

For the geotechnical exploration, a total of ten boreholes were completed. Six of the boreholes were completed on the road and four were completed off the road between the ditch and road. Due to setbacks from utilities, five of the boreholes that were completed on the road were placed in the southbound lane (only 21BH10 was in the northbound lane), and all four of the boreholes that were completed off the road were placed on the west side of the road. The target depth for drilling was generally considered to be 3.0 mbgs with the option to drill deeper if warranted by the encountered conditions (i.e. if very loose soils were encountered such as in 21BH09). One of the boreholes (21BH03) encountered early refusal of the auger at 2.1 mbgs on a suspected cobble in the till-like soil. The locations of the boreholes are presented in Figure 2. The boreholes were advanced using a B29 Truck Mount Auger Drill owned and operated by Drillwell Enterprises. Standard Penetration Tests (SPTs) were completed congruently with drilling.

Borehole locations were selected to investigate the subsurface conditions targeting the shoulders of the road in areas where road widening/land acquisition were expected to occur based on the MoTI Construction – Grading and Paving Drawings (Project No. 16873-0001, Land Acquisition Plans). Six of the boreholes ended up on the road surface rather than the shoulder of the road due to required setbacks from utilities.

3.3 Laboratory Testing

Laboratory testing consisted of five sieve analyses and fourteen moisture content determinations. The laboratory testing results are presented in Appendix C.

4.0 GEOTECHNICAL DESCRIPTION OF THE SITE

4.1 Soil Conditions

Complete descriptions of conditions encountered are provided in the borehole logs attached in Appendix B. The soil conditions encountered during the drilling investigation are summarized in Table 4-1 below. Borehole locations are shown in Figure 2.

Table 4-1: Summary of Soil Conditions

Soil/Material Type	21BH01	21BH02	21BH03	21BH04	21BH05	21BH06	21BH07	21BH08	21BH09	21BH10
ASPHALT (top layer in good condition)	110 mm	160 mm	100 mm	N.E.	N.E.	140 mm	N.E.	N.E.	40 mm	40 mm
ASPHALT (lower layer or layer(s) in deteriorated condition)	N.E.	50 mm	100 mm	N.E.	N.E.	50 mm	N.E.	N.E.	150 mm	190 mm
GRAVEL (FILL)	N.E.	N.E.	N.E.	50 mm	50 mm	N.E.	50 mm	50 mm	N.E.	N.E.
SAND or SAND and GRAVEL (FILL), trace to some silt	0.1 to 0.5 m	0.2 to 0.5 m	0.2 to 0.6 m	0.1 to 0.4 m	0.1 to 0.2 m	0.2 to 0.4 m	0.1 to 0.3 m	0.1 to 1.5 m	0.2 to 4.1 m	0.2 to 0.3 m
SAND or SILT or SILT and SAND (TILL-LIKE), trace to some gravel	0.5 to 3.0 m	0.5 to 3.0 m	0.6 to 2.1 m	0.4 to 3.0 m	0.2 to 3.0 m	0.4 to 3.0 m	0.3 to 3.0 m	1.5 to 3.0 m	4.1 to 7.5 m	0.3 to 3.0 m

N.E. – Not encountered

4.2 Groundwater Conditions

No groundwater was observed in any of the boreholes during this geotechnical exploration. If required, seasonal fluctuation of groundwater levels at the Site would need to be determined through additional geotechnical exploration. It is likely that perched groundwater may exist on the till-like soils during months with more precipitation. Additionally, the till-like soils were observed to be very moist at 21BH01, indicating that seasonal groundwater may be present in the till-like soils in this area of the Site.

4.3 Site Seismicity

Calculated peak ground and selected spectral accelerations for selected frequencies (in units of gravitational acceleration, g) at three landmarks along the length of the Site are shown in Table and Table for 1 in 475 Seismic Event and a 1 in 2,475 Seismic Event, respectively. Accelerations are calculated by Natural Resources Canada (NR Can) Seismic Hazard Calculator and are interpolated from NR Can Seismic Hazard Maps. The accelerations provided are the 2015 National Building Code of Canada (NBCC) values and are unfactored.

Table 4-2: Selected Ground Accelerations for a 1 in 475 Seismic Event

Landmark	Seaview Ave	Charlesworth Rd	Cranberry Rd
PGA	0.260	0.261	0.263
Sa (0.05 s)	0.312	0.313	0.316
Sa (0.1 s)	0.477	0.479	0.483
Sa (0.3 s)	0.612	0.615	0.619
Sa (0.5 s)	0.530	0.532	0.536
Sa (1.0 s)	0.277	0.279	0.281
Sa (2.0 s)	0.154	0.155	0.156

Table 4-3: Selected Ground Accelerations for a 1 in 2,475 Seismic Event

Landmark	Seaview Ave	Charlesworth Rd	Cranberry Rd
PGA	0.480	0.482	0.485
Sa (0.05 s)	0.580	0.582	0.586
Sa (0.1 s)	0.886	0.889	0.895
Sa (0.3 s)	1.133	1.137	1.145
Sa (0.5 s)	1.019	1.023	1.030
Sa (1.0 s)	0.577	0.580	0.586
Sa (2.0 s)	0.344	0.345	0.348

4.4 Liquefaction Potential

Liquefaction occurs when pressures increase in the soil-air-liquid matrix that causes the matrix to lose internal stability and behave as a liquid. Liquefaction can occur due to seismic forces or from rapid changes to pore water pressures. For liquefaction to occur, the soil needs to be saturated, have a high void ratio, and have a particular grain size distribution. Generally, liquefaction occurs in loose granular or fine-grained soils below groundwater level.

Liquefaction is generally not considered a risk at the Site based on the consistency of the till-like soils. However, the fill soils used across the Site were characterized as very loose in some areas. As discussed in Section 5.2, seasonal fluctuation of the groundwater could result in the fill soils at the Site becoming susceptible to liquefaction.

5.0 PAVEMENT DESIGN

The pavement design structure methodology, as outlined in the MoTI's *Pavement Structure Design Guidelines Technical Circular T-01/15* (Technical Circular), was used for the design of the pavement structure. The design input values recommended by the Technical Circular and American Association of State Highway and Transportation Officials (AASHTO) guidelines and used in the analysis and design of the pavement structure are summarized in Table 5-1.

Table 5-1: AASHTO Pavement Design Criteria

Criteria	Value	Rationale
Reliability	85%	Suggested level of reliability in AASHTO 93 for various functional classification.
Serviceability		In accordance with generally accepted pavement engineering principles and AASHTO practice. (MoTI Technical Circular T-01/15).
Initial Serviceability Index (P_i)	4.2	
Terminal Serviceability Index (P_t)	2.5	
Serviceability Loss (ΔPSI)	1.7	
Overall Standard Deviation (S_o)	0.45	
Subgrade Resilient Modulus (M_r)	55 MPa	This value was selected based on review of the encountered subgrade soils from boreholes and laboratory testing.
Design Traffic (20-Year ESALs)	1.35 Million	Based on the traffic count data provided by the MoTI.
Structural Layer Coefficients (α)	New Asphalt Concrete – 0.40 Reclaimed Material – 0.08 New Granular Base – 0.14 Existing Subbase – 0.08	In accordance with generally accepted pavement engineering principles and AASHTO practice. (MoTI Technical Circular T-01/15).

The required AASHTO Structural Number to carry future traffic (SN_f) was calculated using the design parameters. Based on the input parameters presented for Fulford-Ganges Road, the required SN_f of 87 was calculated to meet the design ESALs.

6.0 DISCUSSION AND RECOMMENDATIONS

The following subsections detail preliminary geotechnical discussion and recommendations. Detailed geotechnical design is outside of the scope of the document; however, Tetra Tech is available to provide detailed geotechnical design, if required.

6.1 Site Preparation

Initial preparation should include stripping unsuitable, deleterious materials (unidentified soft spots, excessive organics, etc.) to expose suitable subgrade materials. The granular fill soils encountered directly beneath the asphalt and gravel shoulders at the Site is expected to be considered as suitable subgrade over most of the Site. If unsuitable/deleterious materials or conditions (unidentified soft spots, excessive organics, etc.) are encountered in the granular fill than stripping to the till-like soils will be recommended. The till-like soil is considered to be a suitable subgrade and is expected at an average depth of 0.4 meters below ground surface (mbgs) over most of the Site (between 21BH01 and 21BH07). Engineered Fill, as described in Section 6.2, should be used to achieve design grades in the event that stripping of unsuitable materials is required.

Till-like soils were encountered at a depth of 4.1 mbgs in 21BH09 at the culvert and slope area (discussed in Section 6.6) with very loose granular fill soils above. The very loose fill soils in this area will need to be sub excavated and replaced with Engineered Fill as described in Section 6.2.

Till-like soils which underly the Site may be susceptible to softening from moisture. Therefore, qualified geotechnical personnel should observe all subgrade surfaces prior to backfilling to confirm local areas of loose soils or moisture

impacted soils are not present. If loose areas or moisture impacted areas are discovered, these should be sub-excavated and backfilled with granular material as described above.

As all boreholes were located on the road and gravel shoulder, we did not encounter topsoil. The existing granular fill was observed to contain inclusions of ash and brick (in 21BH03) and trace to some silt in all boreholes and occasionally trace organics; this may not be desirable for landscaping. Environmental characterization of the existing soils for reuse on-site after excavation has not been completed.

6.2 Engineered Fill

Engineered Fill should consist of an approved, well-graded granular soils with a maximum particle size of 75 mm and less than 10% fines, placed in horizontal lifts not exceeding 300 mm and compacted to a minimum of 95% Modified Proctor Maximum Dry Density (MPMDD) at a moisture content ±2% of optimum. Each lift should be tested to confirm adequate compaction before subsequent lifts are placed. Thicker lifts may only be used if test results confirm that materials and equipment used are such that the required density can be achieved.

6.3 Suitability of Soils for Reuse

The fines content in samples tested in the existing granular fill were 5.1%, 13%, and 14%. Generally, well graded granular soil with under 10% fines is considered suitable as Engineered Fill (as discussed in Section 6.2). The test results of the existing granular fill at the Site indicate that most of the granular fill is not considered suitable. Confirmatory testing of additional samples could be completed to provide a more accurate estimate and/or qualified personnel could make the judgement at the time of excavation based on bulk material observations and/or additional testing. The fines content in samples tested in the existing till-like soils were 23% and 54%, therefore the till-like soils are not considered suitable for reuse as Engineered Fill.

6.4 Excavations

Any excavations must comply with industry best practices and WorkSafeBC regulations. The final responsibility for all excavation cut slopes resides with the contractor and should account for site-specific conditions and observations made at the time of the excavation. Where excavations take place adjacent to existing structures or utilities, temporary shoring measures may be required. Tetra Tech should be contacted to review the excavation methodology and need for shoring with the contractor prior to excavation. Some difficulty in excavating into the till-like soil (if required) should be anticipated.

6.5 Cut and Fill Slopes

Temporary slopes should not be cut steeper than 1H:1V at the Site, with the possibility of using steeper slopes to be confirmed on Site by a qualified engineer. Maximum slope for permanent slopes and embankments will be dependant on type of earth retaining method used, slope material encountered, and/or erosion protection used.

In the dense till-like soils, near vertical cuts may be possible under the guidance of an experienced geotechnical engineer. These near vertical cuts could be temporary, or if proper slope erosion protection measures are implemented (e.g. armouring or soil nails with shotcrete) than they could be permanent. Construction techniques such as slot cutting, and temporary shoring could be used under the guidance of an experienced geotechnical engineer in areas where soils aren't dense and require a steeper than 1H:1V cut. Maximum slope of permanent embankment will be dependant on type of earth retaining method used and/or slope material encountered and/or erosion protection used.

6.6 Qualitative Slope Stability Assessment

During the field program on June 23, 2021, Tetra Tech made the following qualitative observations regarding the slopes and existing culvert located near 21BH09 (between approximately 115+0 and 116+0 on the 70% detailed design drawings):

- The culvert water entry point is a stone cut culvert, and the exit point is a round steel pipe culvert. The stone cut culvert and steep pipe culvert appear to be connected;
- The steel pipe culvert shows signs of deformation;
- The steel pipe appears to be founded directly on the till-like soils;
- A geotextile membrane and rip rap were observed on the east side slope. The exposed sections of geotextile were in a deteriorated state;
- SPTs conducted at 21BH09 indicate that very loose zones exist within the fill soils that comprise the slope and fill overlying the culvert; and
- Erosion has caused undercutting on the west side and a steep incision into the native till-like soils near the base of the slope on the east side.

Photos of the slopes in this area and the culvert are appended to this report. Based on the above observations, the current conditions of the slope and culvert pose a risk to the project. The detailed design of a retaining wall or slope solution for this area is outside the scope of this document. However, in general, it is expected that remediation of this area may involve:

- Removal and replacement of the very loose fill soils with Engineered Fill;
- Removal of the existing culvert and detailed design and installation of a new culvert;
- Detailed slope and/or retaining wall design; and
- Reinforcement of the undercut and incised soil beyond the toes of the slope on both the west and east sides.

Tetra Tech expects that, after remediation and redesign as outlined above, the new slope/embankments for this area could utilize 1.5H:1V slopes with potentially small toe walls in order to reduce the clearing and grubbing as well as property acquisitions.

6.7 Embankment and Retaining Walls

Tetra Tech understands that retaining walls may be required for road widening purposes. The precise location, construction methods, and dimensions of the retaining wall are unknown at the time of writing this report. Regarding the potential use of retaining walls, Tetra Tech can make the following general comments:

- Retaining walls should be founded on the till-like soils or Engineered Fill on till-like soils;
- The following parameters are considered acceptable for preliminary retaining wall design at the Site:
  - At-Rest Earth Coefficient: 0.5;
  - Active Earth Coefficient: 0.3;
  - Unit Weight of Soil: 21 kN/m^3;

- Bearing Capacity of Foundation (assuming excavation to underlying competent soil): 250 kPa;
- Any retaining wall design using these parameters should be reviewed by a qualified geotechnical engineer and may require additional site exploration to validate the parameters; and
- Note that the parameters presented are unfactored (i.e., characteristic values). Suitable geotechnical resistance (scaling) factors should be applied for Load Resistance Factored Design (LRFD), or the results should be compared to an appropriate Factor of Safety (FoS) for working stress-based design (WSD).

The Engineers and Geoscientists of British Columbia (EGBC) Professional Practice Guidelines for Civil and Transportation Infrastructure Retaining Wall Design (EGBC, 2020) specifies that any retaining walls higher than 1.2 m require detailed geotechnical design unless failure would have the potential to impact life safety. Detailed design is outside of the scope of this document; however, Tetra Tech is available to provide detailed geotechnical design services if required.

6.8 Site Drainage

Lateral movement of water on the till-like contact may lead to excess water accumulating in lower slope areas. Drains should be used to dissipate excess seepage in these areas. We expect that the Site receives significant amounts of seepage and runoff, mainly from the west of the Site. The MoTI Construction – Grading and Paving Drawings include Drainage Plans which indicate that riprap ditches and culverts will be used for drainage and have been designed by others. Due to the relatively impermeable nature of till-like soils, drainage should not rely on infiltration into these soils.

6.9 Pavement Recommendations

The MoTI had requested Tetra Tech to evaluate the feasibility of rehabilitating the project section of the roadway using Full Depth Reclamation (FDR) as a feasible rehabilitation strategy. The MoTI also intends to upgrade the existing roadway to current geometric design standards by widening the roadway.

The rehabilitation option considered feasible for the existing roadway and widening areas is discussed in the following sections.

6.9.1 Full Depth Reclamation and Reconstruction

Based on the review of the pavement structures from the completed borehole logs and observations made during the field reconnaissance, consideration should be given to reclaiming the existing pavement layers to a depth of 400 mm. The reclaimed material should be spread to widen the roadway to the new geometric design standards.

The following minimum pavement structure is recommended for the construction of the road:

- 120 mm Asphalt Concrete Pavement;
- 200 mm Crushed Granular Base; and
- 80 mm of Reclaimed Material.

This approach will maintain the existing grades of the roadway and minimize the need to raise the grade of sideroads and driveways along the project route.

The expected service life of this rehabilitation option is anticipated to range from 18 to 20 years.

Other Considerations:

- The reclaimed material should have a maximum ratio of 50:50 (or a higher percentage for granular); in other words, the reclaimed material should contain a maximum of 50% of asphalt concrete.
- It should be noted that few of the borehole logs indicated ACP thickness of greater than 200 mm. For those areas, reclamation depth will need to be adjusted to maintain the blending ratio. Alternatively, some granular material will need to be imported and blended with the reclaimed material to maintain the blending ratio.
- Any organic or unsuitable material encountered during the reclamation process should be replaced with suitable imported fill material approved by the geotechnical engineer.
- The FDR option will provide ease of construction of the shoulder widening and reuse of the reclaimed material as a sub-base layer.

6.9.2 Subgrade Preparation

For widening areas, prior to the placement of reclaimed materials, the prepared subgrade should be proof-rolled to identify any soft areas. Any soft areas identified during proof roll should be reworked or sub-excavated to a minimum depth of 300 mm and backfilled with imported fill material and compacted to a minimum of 98% of SPMDD.

Topsoil or organic material should not be present within the footprint of the proposed roadways.

6.9.3 Granular Base and Subbase Construction

The WGB and SGSB shall conform to requirements of 25 mm WGB and SGSB, respectively, as per Section 202 of MoTI's latest SSHC. The placement of base and subbase materials should be carried out as per Section 202 of the MoTI's latest SSHC. The aggregate should be spread and compacted in individual layers, where maximum thickness of compacted layer shall not exceed 150 mm. The base and subbase aggregate should be compacted to a minimum 100% of the Standard Proctor Density obtained by the current ASTM D698.

6.9.4 Asphalt Binder and Asphalt Mix Type

The use of a 16 mm Class 1 Medium Mix as per Section 502 of the Ministry's 2016 Standard Specifications for Highway Construction is recommended for the project.

Based on the climate, consideration should be given to using PG 58-28 asphalt cement, which provides the reliability of 98% for high temperature and 90% for low temperature. Alternatively, Group A 120-150 asphalt cement could also be used.

6.10 Construction Considerations

6.10.1 General

Construction joints should not be located within the wheel paths.

6.10.2 Suitable Construction Period

The historical climate data for the weather station (Salt Spring St. Mary's L) is shown in Figure 6-1. Based on the Standard Specifications for Highway Construction, asphalt mix should only be placed when the ambient air temperature is above 5°C. Therefore, as shown in Figure 6-1, the ideal weather for construction has historically occurred between April and mid-October.

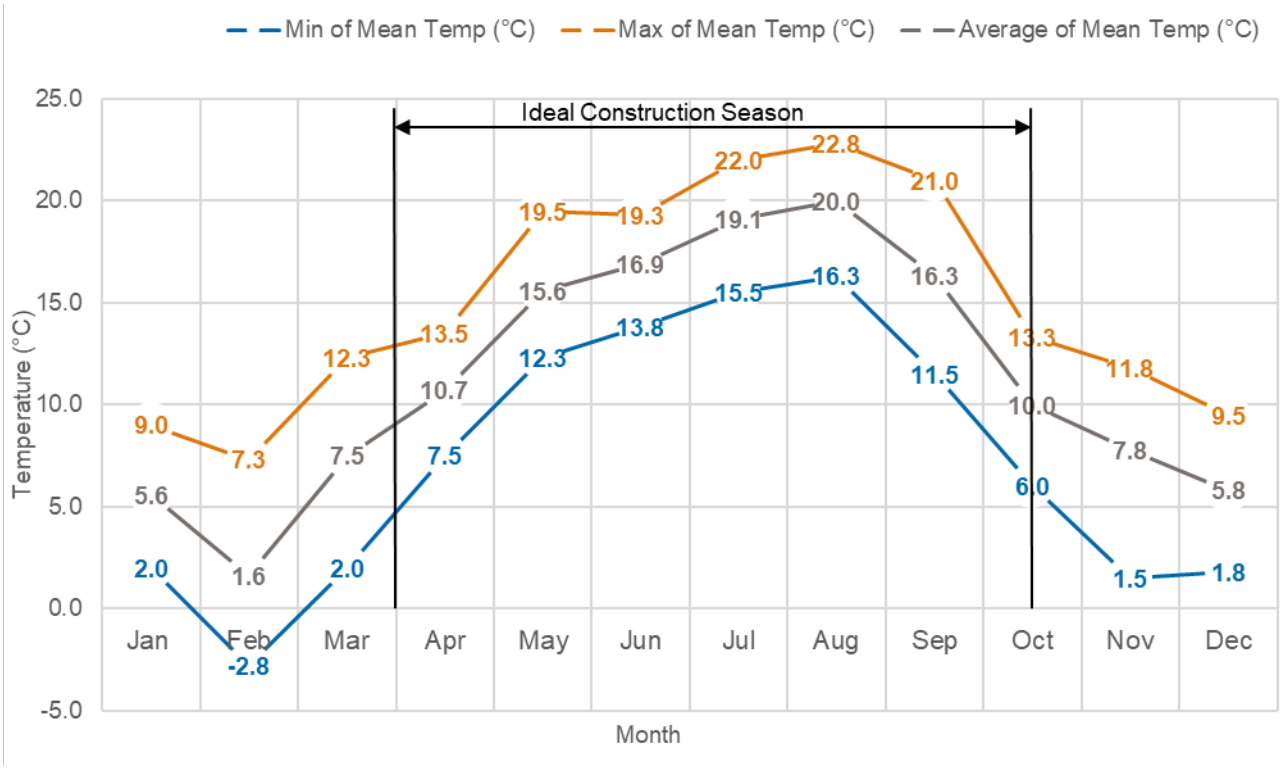

Figure 6-1: Weather Data and Historically Preferable Construction Season

Construction during the early spring and late fall seasons have an increased risk of adverse weather conditions that could make achieving the specified in-place compaction difficult and adversely affect the integrity of the finished product. Additionally, early-season construction may have conditions where frost is still present in the road prism.

7.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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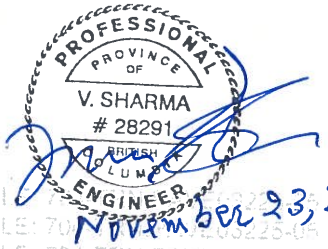
November 23, 2021



November 23, 2021

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/cy

PERMIT TO PRACTICE
TETRA TECH CANADA INC.
PERMIT NUMBER: 1001972

8.0 REFERENCES

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FIGURES

LEGEND

- Project Location
- Main Road
- Local Road
- Ferry
- Power Line
- Building
- Park
- Residential Area
- Contour (20 m)
- Watercourse
- Waterbody
- Wetland
- Wooded Area

NOTES
Base data source: CanVec 1:50,000.

STATUS
ISSUED FOR USE

GEOTECHNICAL INVESTIGATION FULFORD GANGES RD SALTSPRING ISLAND, BC

Project Location Plan

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	Ministry of Transportation & Infrastructure

Scale: 1:50,000
1 0.5 0 1
Kilometres

FILE NO. PAVE03225-05_Fig01_SiteLocation.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DS	SL	KS	0

DATE November 17, 2021
PROJECT NO. TRN.PAVE03225-05

TETRA TECH

Figure 1

Q:\Vancouver\GIS\TRANSPORTATION\PAVE\PAVE03225-05\Maps\PAVE03225-05_Fig01_SiteLocation.mxd modified 2021-11-17 by Darren.Schouls

Q:\Vancouver\GIS\TRANSPORTATION\PAVE\PAVE03225-05\Maps\PAVE03225-05_Fig02_BoreholePlan.mxd modified 2021-11-17 by Darren.Schouls

LEGEND

- Borehole Location
- Project Location

Base Data

- Main Road
- Local Road
- Watercourse

NOTES
Base data source:
CanVec 1:50,000 (2019)
Imagery from ESRI; Maxar (2020)

STATUS
ISSUED FOR USE

GEOTECHNICAL INVESTIGATION FULFORD GANGES RD SALTSPRING ISLAND, BC

Borehole Location Plan

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	Ministry of Transportation & Infrastructure

Scale: 1:6,000
100 50 0 100
Metres

TETRA TECH

FILE NO.
PAVE03225-05_Fig02_BoreholePlan.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DS	SL	KS	0

DATE	PROJECT NO.
November 17, 2021	TRN.PAVE03225-05

Figure 2

PHOTOGRAPHS

Photo 1	Looking southeast. View of the slope on west side of culvert/road
Photo 2	Looking east. View of undercutting (stone cut culvert entry point on west side of culvert/road)
Photo 3	Looking east. View inside of stone cut culvert
Photo 4	Looking south. View of the slope on east side of culvert/road
Photo 5	Looking east. View of the incised till-like soil near tow of slope on east side of culvert/road
Photo 6	Looking west. View inside round steel pipe culvert showing evidence of deformation

Photo 1: Looking southeast. View of the slope on west side of culvert/road

Photo 2: Looking east. View of undercutting (stone cut culvert entry point on west side of culvert/road)

Photo 3: Looking east. View inside of stone cut culvert

Photo 4: Looking south. View of the slope on east side of culvert/road

Photo 5: Looking east. View of the incised till-like soil near tow of slope on east side of culvert/road

Photo 6: Looking west. View inside round steel pipe culvert showing evidence of deformation

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

DESIGN REPORT

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

Any unauthorized use of the Professional Document is at the sole risk of the user. TETRA TECH accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by TETRA TECH during the performance of the work are TETRA TECH's professional work product and shall remain the copyright property of TETRA TECH.

The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the Document, if required, may be obtained upon request.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless so stipulated in the Design Report, TETRA TECH was not retained to explore, address or consider, and has not explored, addressed or considered any environmental or regulatory issues associated with the project specific design.

1.8 CALCULATIONS AND DESIGNS

TETRA TECH may have undertaken design calculations and prepared project specific designs in accordance with terms of reference that were previously set out in consultation with, and agreement of, TETRA TECH's client. These designs have been prepared to a standard that is consistent with current industry practice. Notwithstanding, if any error or omission is detected by TETRA TECH's Client or any party that is authorized to use the Design Report, the error or omission should be immediately drawn to the attention of TETRA TECH.

1.9 GEOTECHNICAL CONDITIONS

A Geotechnical Report is commonly the basis upon which the specific project design has been completed. It is incumbent upon TETRA TECH's Client, and any other authorized party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the geotechnical information that was reasonably acquired to facilitate completion of the design.

If a Geotechnical Report was prepared for the project by TETRA TECH, it may be included in the Design Report as appropriate. The Geotechnical Report contains Limitations that should be read in conjunction with these Limitations for the Design Report.

1.10 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This report has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX B

BOREHOLE LOGS

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure

Borehole No: **21BH01**

Project: Geotechnical Investigation	Project No: 704-TRN.PAVE03225-05
Location: Fulford Ganges Road	Ground Elev: 8 m
Saltspring Island, BC	UTM: 463249.4 E; 5411022.29 N; Z 10

Depth (m)	Method	Core Diameter (mm)	Soil Description	Graphical Representation	Sample Type	Sample Number	Field Vane (kPa) Post-Peak / Peak (10 20 30 40); Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0								8
	Solid stem auger		ASPHALT 110 mm.					
			SAND (FILL), gravelly, some silt, trace cobbles, damp, compact (inferred), brown; subrounded gravel, medium to coarse sand.			G1	●	
1			SAND (TILL-LIKE), silty, some gravel, trace organics, damp, compact (inferred), grey; inclusions of roots.					7
						G2	●	
2			At 1.5 m becomes trace gravel, very moist.					6
						G3	●	
3			End of borehole at 3.0 m. - Target depth reached. - No groundwater observed upon completion. - Backfilled with bentonite, cuttings and patched with cold mix asphalt. - Borehole locations were measured in the field with a handheld GPS and are estimated to be accurate to +/- 5 m. - Borehole elevations were estimated based on Google Earth and are estimated to be accurate to +/- 2 m.					5
4								4
5								3
6								2
7								1
8								0
9								-1
10								-2

TETRA TECH

Contractor: Drillwell	Completion Depth: 3 m
Drilling Rig Type: B29 Auger	Start Date: 2021 June 23
Logged By: KS	Completion Date: 2021 June 23
Reviewed By: AW	Page 1 of 1

Borehole No: **21BH02**

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure

Project: Geotechnical Investigation	Project No: 704-TRN.PAVE03225-05
Location: Fulford Ganges Road	Ground Elev: 26 m
Saltspring Island, BC	UTM: 463171.01 E; 5410867.37 N; Z 10

Depth (m)	Method	Core Diameter (mm)	Soil Description	Graphical Representation	Sample Type	Sample Number	Field Vane (kPa) Post-Peak / Peak (10 20 30 40); Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0			ASPHALT - First layer 160 mm - Second layer 50 mm (deteriorated condition)					26
			SAND and GRAVEL (FILL), trace silt, damp, compact (inferred), brown; angular to subangular gravel.			G1		
1	Solid stem auger		SAND (TILL-LIKE), silty, trace gravel, damp, compact (inferred), brown and grey; some dark mottling.			G2		25
2								24
						G3		
3			End of borehole at 3.0 m. - Target depth reached. - No groundwater observed upon completion. - Backfilled with cuttings and patched with cold mix asphalt. - Borehole locations were measured in the field with a handheld GPS and are estimated to be accurate to +/- 5 m. - Borehole elevations were estimated based on Google Earth and are estimated to be accurate to +/- 2 m.					23
4								22
5								21
6								20
7								19
8								18
9								17
10								16

TETRA TECH

Contractor: Drillwell	Completion Depth: 3 m
Drilling Rig Type: B29 Auger	Start Date: 2021 June 23
Logged By: KS	Completion Date: 2021 June 23
Reviewed By: AW	Page 1 of 1

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure

Borehole No: **21BH03**

Project: Geotechnical Investigation	Project No: 704-TRN.PAVE03225-05
Location: Fulford Ganges Road	Ground Elev: 40 m
Saltspring Island, BC	UTM: 463310.41 E; 5410637.28 N; Z 10

Depth (m)	Method	Core Diameter (mm)	Soil Description	Graphical Representation	Sample Type	Sample Number	Field Blowcount (blows/300 mm) □ SPT	Field Vane (kPa) Post-Peak ◇ Peak ◆	Plastic Limit / Moisture Content / Liquid Limit	Elevation (m)
0							20 40 60 80	10 20 30 40	20 40 60 80	40
1	Solid stem auger		ASPHALT - First layer 100 mm - Second layer 100 mm (deteriorated condition) SAND (FILL), gravelly, some silt, trace organics, occasional cobble, damp, compact, brown; ash and brick fragment inclusions. SPT at 0.2 m: 23/13/7/NA (N=20) - Recovery = 88% - Spoon deflected on suspected cobble, had to terminate test due to unacceptable deflection.			SPT-1 G1				39
2	SPT		SILT and SAND (TILL-LIKE), trace gravel, damp, brown and grey, very dense. SPT at 1.5 m: 11/18/43/46 (N=61) - Recovery = 100%			SPT-2				38
3			End of borehole at 2.1 m. - Refusal of auger encountered at 1.5 m on suspected cobble. - No groundwater observed upon completion. - Backfilled with cuttings and patched with cold mix asphalt. - Borehole locations were measured in the field with a handheld GPS and are estimated to be accurate to +/- 5 m. - Borehole elevations were estimated based on Google Earth and are estimated to be accurate to +/- 2 m.							37
4										36
5										35
6										34
7										33
8										32
9										31
10										30

TETRA TECH

Contractor: Drillwell	Completion Depth: 2.1 m
Drilling Rig Type: B29 Auger	Start Date: 2021 June 23
Logged By: KS	Completion Date: 2021 June 23
Reviewed By: AW	Page 1 of 1

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure

Borehole No: **21BH04**

Project: Geotechnical Investigation	Project No: 704-TRN.PAVE03225-05
Location: Fulford Ganges Road	Ground Elev: 49 m
Saltspring Island, BC	UTM: 463377.5 E; 5410508.14 N; Z 10

Depth (m)	Method	Core Diameter (mm)	Soil Description	Graphical Representation	Sample Type	Sample Number	Field Vane (kPa) Post-Peak / Peak (10 20 30 40); Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0			GRAVEL, dry, grey; angular gravel.					49
			SAND (FILL), some gravel, some silt, damp, loose to compact (inferred), brown.			G1		
			SAND (TILL-LIKE), silty, some gravel, moist, compact (inferred), brown.					
1	Solid stem auger		At 0.9 m becomes SILT and SAND.			G2		48
						G3		
2			At 1.5 m becomes dense (inferred).					47
3						G4		46
			End of borehole at 3.0 m. - Target depth reached. - No groundwater observed upon completion. - Backfilled with cuttings and patched with cold mix asphalt. - Borehole locations were measured in the field with a handheld GPS and are estimated to be accurate to +/- 5 m. - Borehole elevations were estimated based on Google Earth and are estimated to be accurate to +/- 2 m.					45
4								
5								44
6								43
7								42
8								41
9								40
10								39

TETRA TECH

Contractor: Drillwell	Completion Depth: 3 m
Drilling Rig Type: B29 Auger	Start Date: 2021 June 23
Logged By: KS	Completion Date: 2021 June 23
Reviewed By: AW	Page 1 of 1

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure

Borehole No: **21BH05**

Project: Geotechnical Investigation	Project No: 704-TRN.PAVE03225-05
Location: Fulford Ganges Road	Ground Elev: 60 m
Saltspring Island, BC	UTM: 463426.4 E; 5410371.64 N; Z 10

Depth (m)	Method	Core Diameter (mm)	Soil Description	Graphical Representation	Sample Type	Sample Number	Field Vane (kPa) Post-Peak / Peak (10 20 30 40) / Plastic Limit, Moisture Content, Liquid Limit (20 40 60 80)	Elevation (m)
0			GRAVEL, dry, compact (inferred), grey; angular gravel.					60
			SAND (FILL), some gravel, some silt, damp, compact (inferred), brown.					
			SILT (TILL-LIKE), sandy, trace gravel, damp, compact (inferred), brown.			G1		
1	Solid stem auger							59
			At 1.5 m becomes SILT and SAND, trace gravel, dry to damp, compact to dense (inferred), brown; subrounded to subangular gravel, fine to medium sand.			G2		
2								58
3			End of borehole at 3.0 m. - Target depth reached. - No groundwater observed upon completion. - Backfilled with cuttings and patched with cold mix asphalt. - Borehole locations were measured in the field with a handheld GPS and are estimated to be accurate to +/- 5 m. - Borehole elevations were estimated based on Google Earth and are estimated to be accurate to +/- 2 m.					57
4								56
5								55
6								54
7								53
8								52
9								51
10								50

TETRA TECH

Contractor: Drillwell	Completion Depth: 3 m
Drilling Rig Type: B29 Auger	Start Date: 2021 June 23
Logged By: KS	Completion Date: 2021 June 23
Reviewed By: AW	Page 1 of 1

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure

Borehole No: **21BH06**

Project: Geotechnical Investigation	Project No: 704-TRN.PAVE03225-05
Location: Fulford Ganges Road	Ground Elev: 70 m
Saltspring Island, BC	UTM: 463479.69 E; 5410244.11 N; Z 10

Depth (m)	Method	Core Diameter (mm)	Soil Description	Graphical Representation	Sample Type	Sample Number	Field Vane (kPa) Post-Peak / Peak (10 20 30 40); Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0								70
	Solid stem auger		ASPHALT - First layer 140 mm - Second layer 50 mm (deteriorated condition)			G1		
			SAND and GRAVEL (FILL), trace silt, damp, compact (inferred), brown.					
1			SILT and SAND (TILL-LIKE), trace gravel, trace organics, dry to damp, compact (inferred), brown and grey; fine subrounded gravel, mottled grey.			G2		69
2								68
3			End of borehole at 3.0 m. - Target depth reached. - No groundwater observed upon completion. - Backfilled with cuttings and patched with cold mix asphalt. - Borehole locations were measured in the field with a handheld GPS and are estimated to be accurate to +/- 5 m. - Borehole elevations were estimated based on Google Earth and are estimated to be accurate to +/- 2 m.					67
4								66
5								65
6								64
7								63
8								62
9								61
10								60

TETRA TECH

Contractor: Drillwell	Completion Depth: 3 m
Drilling Rig Type: B29 Auger	Start Date: 2021 June 23
Logged By: KS	Completion Date: 2021 June 23
Reviewed By: AW	Page 1 of 1

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure

Borehole No: **21BH07**

Project: Geotechnical Investigation	Project No: 704-TRN.PAVE03225-05
Location: Fulford Ganges Road	Ground Elev: 78 m
Saltspring Island, BC	UTM: 463558.83 E; 5410085.74 N; Z 10

Depth (m)	Method	Core Diameter (mm)	Soil Description	Graphical Representation	Sample Type	Sample Number	Field Vane (kPa) Post-Peak / Peak (10 20 30 40); Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0			GRAVEL, dry, compact (inferred), grey; fine angular gravel.					78
			SAND and GRAVEL (FILL), trace silt, damp, compact (inferred), brown; fine gravel.					
			SAND (TILL-LIKE), silty, trace gravel, damp, compact to dense (inferred), brown and grey; mottled grey.					
1	Solid stem auger					G1		77
			At 1.5 m becomes SILT, sandy, trace gravel, damp, very stiff (inferred), grey; fine subrounded gravel.					
2						G2		76
3			End of borehole at 3.0 m. - Target depth reached. - No groundwater observed upon completion. - Backfilled with cuttings and patched with cold mix asphalt. - Borehole locations were measured in the field with a handheld GPS and are estimated to be accurate to +/- 5 m. - Borehole elevations were estimated based on Google Earth and are estimated to be accurate to +/- 2 m.					75
4								74
5								73
6								72
7								71
8								70
9								69
10								68

TETRA TECH

Contractor: Drillwell	Completion Depth: 3 m
Drilling Rig Type: B29 Auger	Start Date: 2021 June 23
Logged By: KS	Completion Date: 2021 June 23
Reviewed By: AW	Page 1 of 1

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure

Borehole No: **21BH08**

Project: Geotechnical Investigation	Project No: 704-TRN.PAVE03225-05
Location: Fulford Ganges Road	Ground Elev: 90 m
Saltspring Island, BC	UTM: 463649.71 E; 5409922.37 N; Z 10

Depth (m)	Method	Core Diameter (mm)	Soil Description	Graphical Representation	Sample Type	Sample Number	Field Vane (kPa) Post-Peak / Peak (10 20 30 40); Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0								90
	Solid stem auger		GRAVEL, dry, compact (inferred), grey; fine angular gravel.					
			SAND (FILL), some gravel, trace silt, trace organics, moist, compact to dense (infered), brown and grey; mottled grey, fine subangular gravel, root inclusions.			G1		
1								89
			SILT and SAND (TILL-LIKE), some gravel, damp, dense (inferred), grey; coarse and fine gravel.					
2						G2		88
3			End of borehole at 3.0 m. - Target depth reached. - No groundwater observed upon completion. - Backfilled with cuttings and patched with cold mix asphalt. - Borehole locations were measured in the field with a handheld GPS and are estimated to be accurate to +/- 5 m. - Borehole elevations were estimated based on Google Earth and are estimated to be accurate to +/- 2 m.					87
4								86
5								85
6								84
7								83
8								82
9								81
10								80

TETRA TECH

Contractor: Drillwell	Completion Depth: 3 m
Drilling Rig Type: B29 Auger	Start Date: 2021 June 23
Logged By: KS	Completion Date: 2021 June 23
Reviewed By: AW	Page 1 of 1

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure

Borehole No: 21BH09

Project: Geotechnical Investigation	Project No: 704-TRN.PAVE03225-05
Location: Fulford Ganges Road	Ground Elev: 102 m
Saltspring Island, BC	UTM: 463704.59 E; 5409789.09 N; Z 10

Depth (m)	Method	Core Diameter (mm)	Soil Description	Graphical Representation	Sample Type	Sample Number	Field Blowcount (blows/300 mm) □ SPT	Field Vane (kPa) Post-Peak ◇ Peak	Plastic Limit / Moisture Content ● / Liquid Limit	Elevation (m)
0							20 40 60 80	10 20 30 40	20 40 60 80	102
			ASPHALT - First layer 40 mm - Second layer 150 mm (deteriorated condition)			G1		●		
1			SAND and GRAVEL (FILL), some silt, trace organics, damp to moist, very loose to compact, brown; fine subrounded gravel, inclusions of wood pieces.							101
			SPT at 1.5 m: 3/2/1/0 (N=3) - Recovery = 38% - Wood piece stuck in spoon.			SPT-1	□			
2										100
			At 2.5 m becomes some gravel.			G2		●		
3			SPT at 3.0 m: 5/8/8/6 (N=16) - Recovery = 79%			SPT-2	□			99
4	Solid stem auger		SAND (TILL-LIKE), silty, some gravel, damp, compact to dense, brown and grey.			G3		●		98
			At 4.5 m becomes trace gravel, dry to damp, mottled brown. SPT at 4.5 m: 2/10/20/50+ (N=30) - Recovery = 0% - Gravel clast stuck in spoon.			SPT-3	□			
5						G4				97
6										96
						G5		●		
7										95
8			End of borehole at 7.5 m. - Target depth reached. - No groundwater observed upon completion. - Backfilled with cuttings and patched with cold mix asphalt. - Borehole locations were measured in the field with a handheld GPS and are estimated to be accurate to +/- 5 m. - Borehole elevations were estimated based on Google Earth and are estimated to be accurate to +/- 2 m.							94
9										93
10										92

TETRA TECH

Contractor: Drillwell	Completion Depth: 7.5 m
Drilling Rig Type: B29 Auger	Start Date: 2021 June 23
Logged By: KS	Completion Date: 2021 June 23
Reviewed By: AW	Page 1 of 1

BRITISH COLUMBIA
Ministry of Transportation & Infrastructure

Borehole No: **21BH10**

Project: Geotechnical Investigation	Project No: 704-TRN.PAVE03225-05
Location: Fulford Ganges Road	Ground Elev: 18 m
Saltspring Island, BC	UTM: 463204.72 E; 5410964.69 N; Z 10

Depth (m)	Method	Core Diameter (mm)	Soil Description	Graphical Representation	Sample Type	Sample Number	Field Vane (kPa) Post-Peak / Peak (10 20 30 40); Plastic Limit / Moisture Content / Liquid Limit (20 40 60 80)	Elevation (m)
0								18
1	Solid stem auger		ASPHALT - First layer 40 mm - Second layer 110 mm (deteriorated condition) - Third layer 80 mm (deteriorated condition) SAND and GRAVEL (FILL), trace silt, damp, compact (inferred), brown. SILT and SAND (TILL-LIKE), some gravel, damp to dry, compact (inferred), brown and grey; mottled grey.			G1		17
2						G2		16
3			End of borehole at 3.0 m. - Target depth reached. - No groundwater observed upon completion. - Backfilled with cuttings and patched with cold mix asphalt. - Borehole locations were measured in the field with a handheld GPS and are estimated to be accurate to +/- 5 m. - Borehole elevations were estimated based on Google Earth and are estimated to be accurate to +/- 2 m.					15
4								14
5								13
6								12
7								11
8								10
9								9
10								8

TETRA TECH

Contractor: Drillwell	Completion Depth: 3 m
Drilling Rig Type: B29 Auger	Start Date: 2021 June 23
Logged By: KS	Completion Date: 2021 June 23
Reviewed By: AW	Page 1 of 1

APPENDIX C

LAB TEST RESULTS

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Fulford Ganges Road Geotechnical Investigation	Sample No.:	314
Project No.:	704-TRN.PAVE03225-05	Date Tested:	July 5, 2021
Client:	BC Ministry of Transportation & Infrastructure	Tested By:	EE/JD
Project Engineer:	Andrew Walker, Kurt Schluessel	Page:	1 of 1

B.H. Number	Sample Number Depth (m)	Moisture Content (%)	Visual Description of Soil
21BH01	G3 @ 2.7m	20.9	SAND, silty, trace gravel, very moist, grey
21BH04	G1 @ 0.2 m	4.0	SAND, some gravel, some silt, damp, brown
21BH04	G2 @ 1.0 m	12.2	SAND, silty, some gravel, moist, brown
21BH04	G3 @ 1.4 m	16.2	SILT and SAND, some gravel, moist, brown
21BH08	G1 @ 0.5 m	9.9	SAND, some gravel, trace silt, moist, brown
21BH08	G2 @ 2.0 m	7.4	SILT and SAND, some gravel, trace clay, damp, grey
21BH09	G2 @ 2.5 m	8.6	SAND, some gravel, some silt, damp, brown
21BH09	G3 @ 4.3 m	11.2	SAND, silty, some gravel, moist, brown
21BH09	G5 @ 6.5 m	9.4	SAND and SILT, trace gravel, damp, grey

Reviewed By: Kevin Summerhayes ASc.T.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Fulford Ganges Road Geotechnical Investigation

Project Number: 704-TRN.PAVE03225-05

Date Tested: July 5, 2021

Borehole Number: 21BH01

Depth: G1 @ 0.2 m

Soil Description: SAND, gravelly, some silt, damp, brown

Cu:

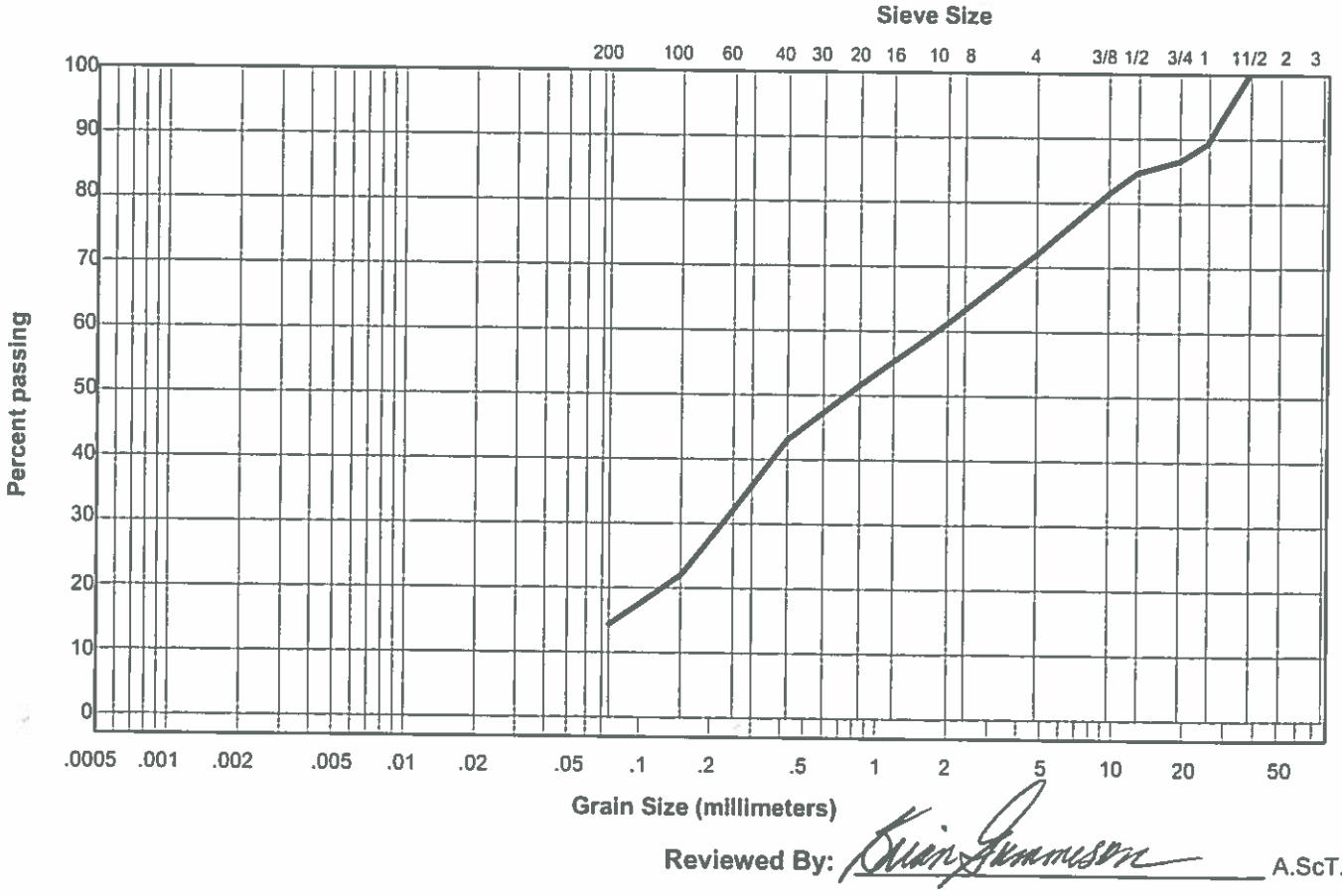
Cc:

Natural Moisture Content: 6.4%

Remarks:

Sieve Size (mm)	Percent Passing
37.500	100
25.000	89
19.000	87
12.500	85
9.500	81
4.750	72
2.000	61
0.850	52
0.425	43
0.250	32
0.150	22
0.075	14

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: _____ A.ScT.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Fulford Ganges Road Geotechnical Investigation

Project Number: 704-TRN.PAVE03225-05

Date Tested: July 5, 2021

Borehole Number: 21BH01

Depth: G2 @ 1.3 m

Soil Description: SAND, silty, some gravel, trace organics, moist, grey

Cu:

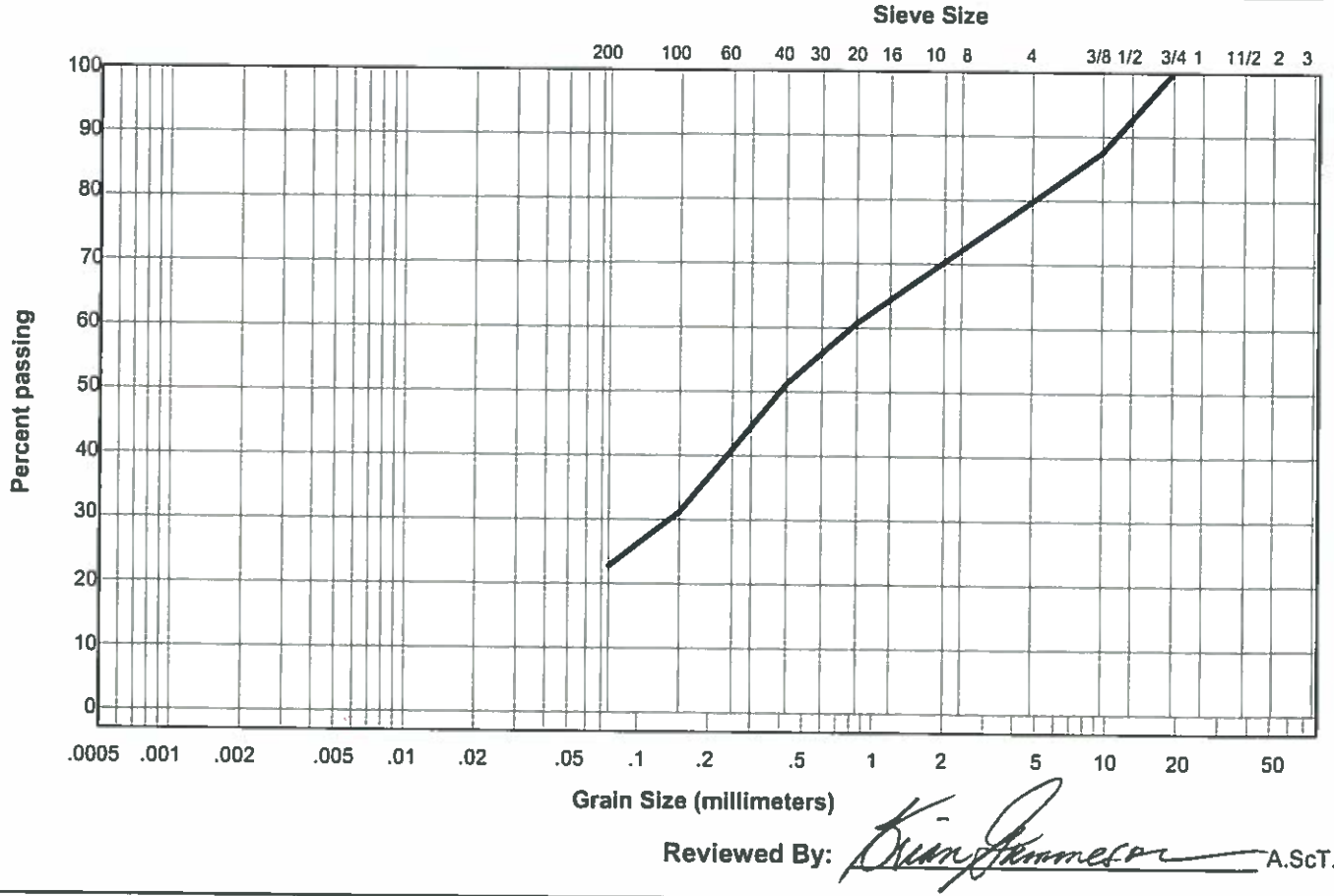
Cc:

Natural Moisture Content: 12.7%

Remarks:

Sieve Size (mm)	Percent Passing
19.000	100
12.500	92
9.500	87
4.750	80
2.000	70
0.850	61
0.425	51
0.250	41
0.150	31
0.075	23

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: A.ScT.

TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

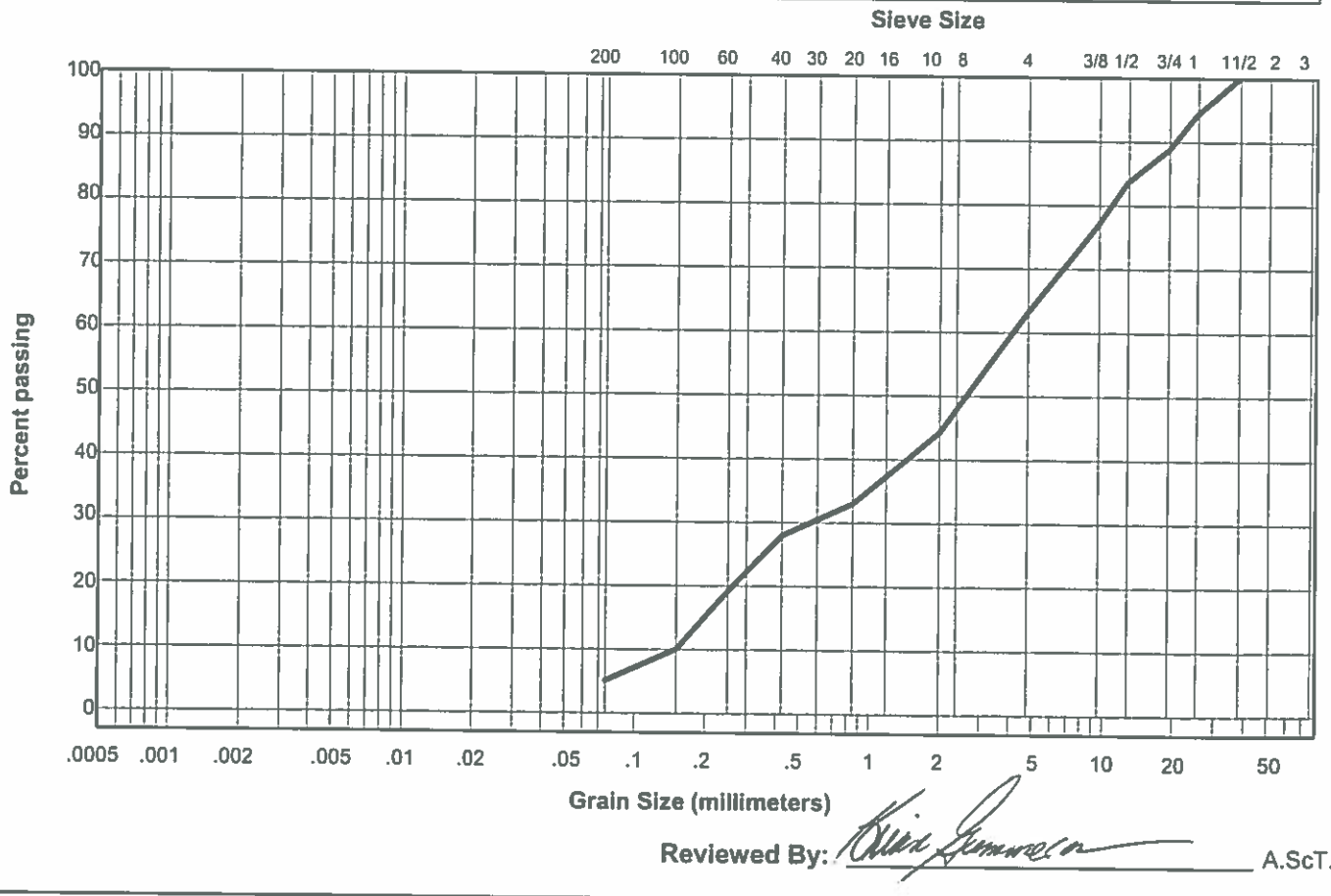
ASTM C136 & C117

Project: Fulford Ganges Road Geotechnical Investigation

Project Number: 704-TRN.PAVE03225-05
Date Tested: July 5, 2021
Borehole Number: 21BH06
Depth: G1 @ 0.3 m
Soil Description: SAND and GRAVEL, trace silt, moist, brown
Cu: 27.5
Cc: 0.5
Natural Moisture Content: 4.3%
Remarks:

Sieve Size (mm)	Percent Passing
37.500	100
25.000	94
19.000	89
12.500	84
9.500	77
4.750	63
2.000	44
0.850	33
0.425	28
0.250	19
0.150	10
0.075	5.1

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Fulford Ganges Road Geotechnical Investigation

Project Number: 704-TRN.PAVE03225-05

Date Tested: July 5, 2021

Borehole Number: 21BH06

Depth: G2 @ 0.8 m

Soil Description: SILT and SAND, trace gravel, moist, brown

Cu:

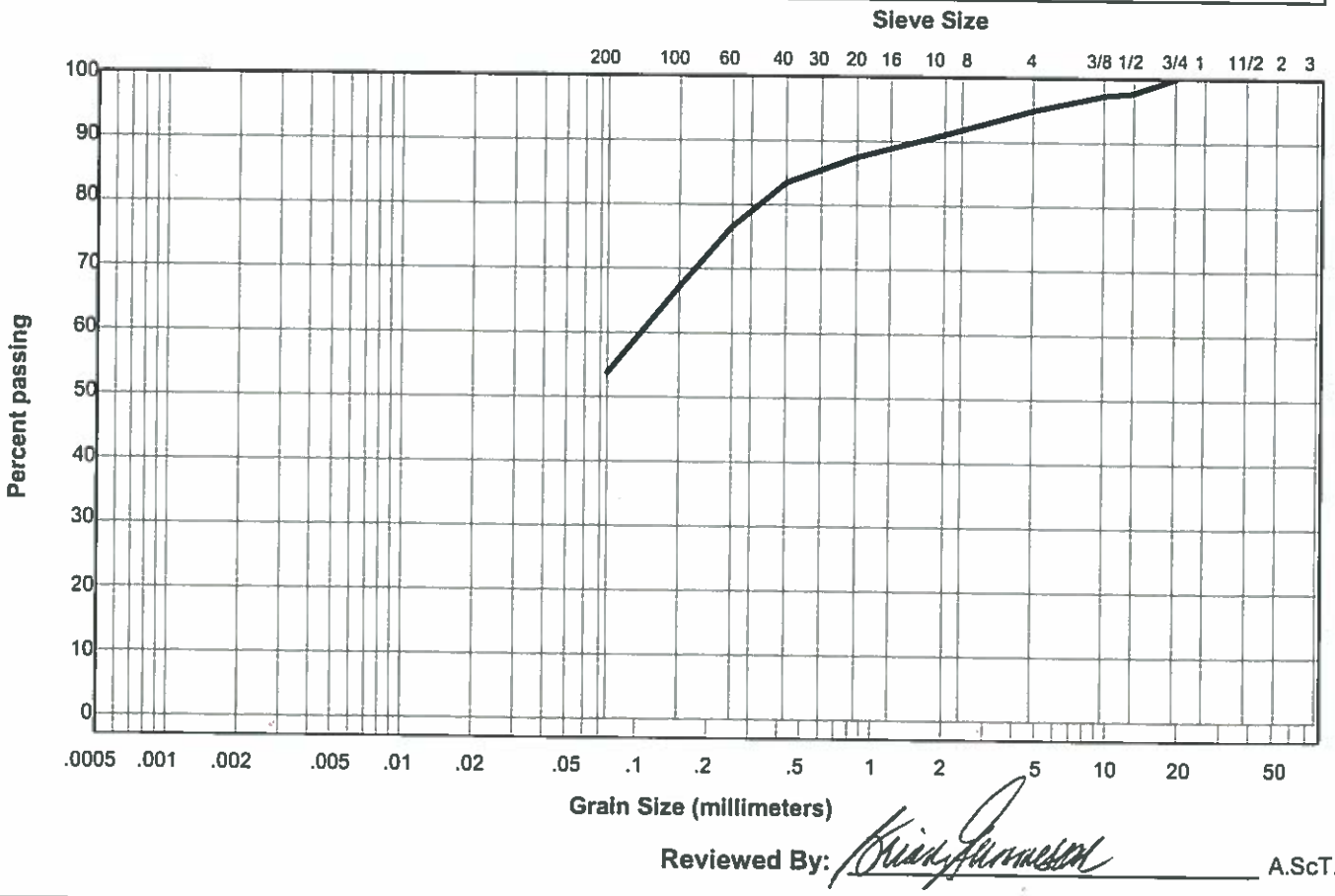
Cc:

Natural Moisture Content: 15.1%

Remarks:

Sieve Size (mm)	Percent Passing
19.000	100
12.500	98
9.500	97
4.750	95
2.000	91
0.850	88
0.425	83
0.250	77
0.150	67
0.075	54

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

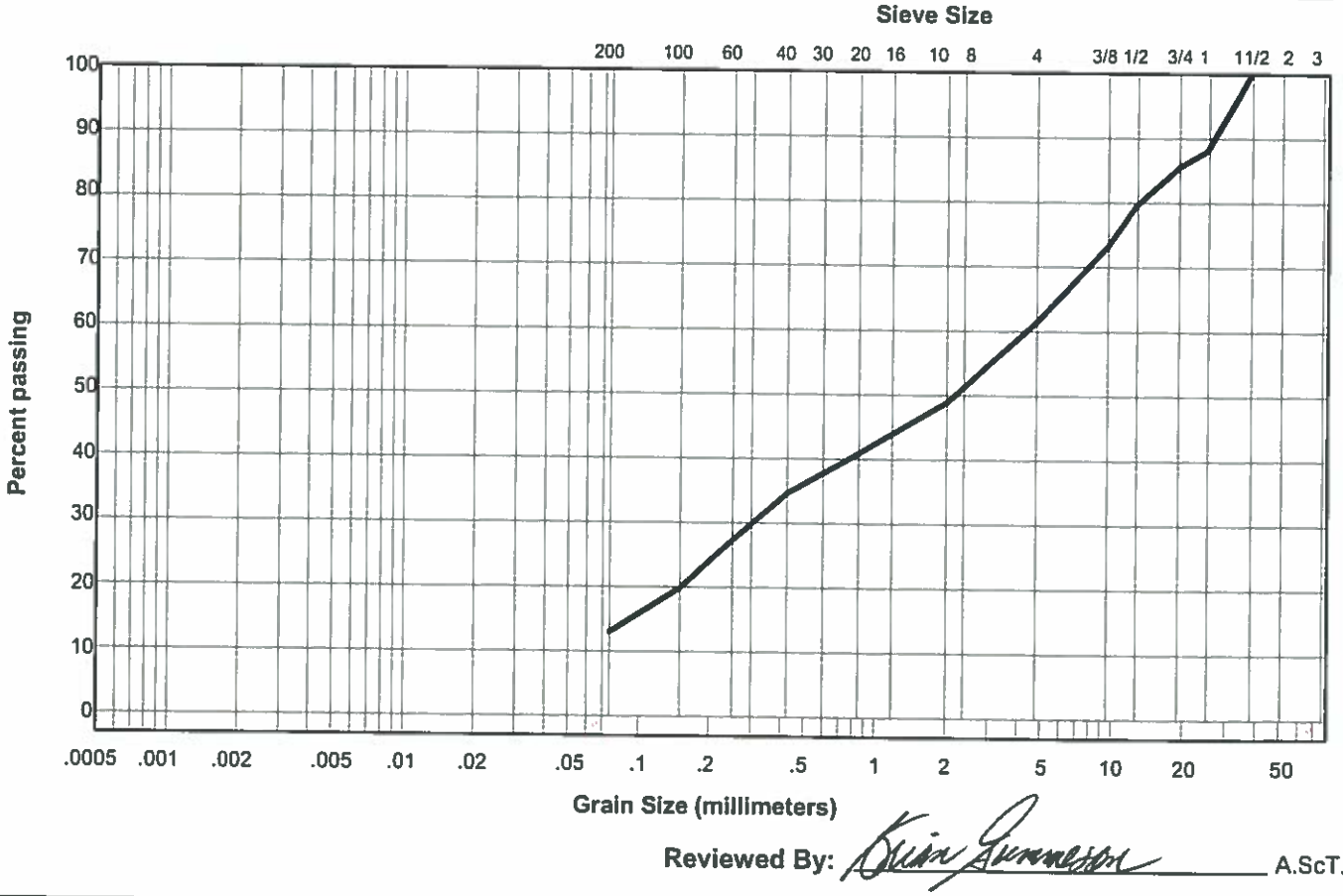
ASTM C136 & C117

Project: Fulford Ganges Road Geotechnical Investigation

Project Number: 704-TRN.PAVE03225-05
Date Tested: July 5, 2021
Borehole Number: 21BH09
Depth: G1 @ 0.3 m
Soil Description: SAND and GRAVEL, some silt, moist, brown
Cu:
Cc:
Natural Moisture Content: 6.7%
Remarks:

Sieve Size (mm)	Percent Passing
37.500	100
25.000	88
19.000	86
12.500	79
9.500	73
4.750	61
2.000	49
0.850	41
0.425	35
0.250	27
0.150	20
0.075	13

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: Kevin Svennesson A.ScT.

TETRA TECH