PAVEMENT DESIGN REPORT, SEVENTH STREET, TOWN OF RENFREW

Project No.: RFSO 2024-03-DEE

Prepared for:

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APPENDICES

1.0 INTRODUCTION

Egis Canada Ltd. (Egis) has been retained by the Town of Renfrew to carry out geotechnical services under RFSO – 2024-03-DEE "Proposal for Engineering Services Proposal Rehabilitation of Seventh Street".

The project included the following roadway in the Town of Renfrew, the project limits and characteristics of which are described in Section 4.0:

- Seventh Street, from O'Brien Road to Barnet Boulevard (approximately 300 m).

It is understood that the Town of Renfrew intends to complete pavement improvements on Seventh Street.

The intent of the work was to summarize geotechnical data for the subject roadway within the project limits and establish potential future rehabilitation options.

The scope of work first involved background review of information, as summarized in Sections 1.1 through 1.3, followed by a geotechnical investigation through the advancement of pavement boreholes, material sampling and testing, and the synthesis of the pavement design report outlining factual geotechnical data and recommendations for the rehabilitation of the subject roadway. Site investigation and design methodologies are presented in Section 2.0 through 5.0. Design Options and Recommendations are respectively presented in Sections 6.0, 7.0, and 8.0.

1.1 Traffic Data

The Seventh Street Annual Average Daily Traffic (AADT), annual growth rate and percent of commercial vehicles has not been provided, however, assumed values for a Local Urban road can conservatively be estimated to be AADT of 1,000 vehicles. The annual growth rate can also be conservatively estimated to be 1 % and the commercial/truck traffic can be estimated to be 2 %.

The AADT, commercial percentage, and growth for Seventh Street are summarized in Table 1, below.

Table 1: Average Annual Daily Traffic (AADT) volumes for Seventh Street

From	To	Growth Rate %	Commercial %	AADT 2024 (Assumed)
O'Brien Road	Barnet Boulevard	1	2	1,000

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1.2 Physiography and Geology

Seventh Street is within the Ottawa Valley Clay Plains physiographic region of southern Ontario, whereas surficial mapping indicates that Seventh Street consists of Fine-textured glaciomarine deposits of silt and clay, minor sand and gravel, massive to well laminated.

The bedrock underlying Seventh Street consists of Precambrian bedrock, described as crystalline basement. However, the bedrock was not encountered during the geotechnical investigation and is greater than 2.1 m in depth from the surface grade.

1.3 Frost Depth

Based on OPSD 3090.101, derived from the Ministry of Transportation and Communications Research Publication RR225 "Aspects of Prolonged Exposure of Pavements to Sub-Zero Temperatures:" dated 1981[5], the Frost Penetration Depth (f) for the project area in Renfrew, Ontario is 1.8 m.

2.0 GEOTECHNICAL INVESTIGATION DETAILS

The site investigation was carried out in order to gain an understanding of the existing pavement and subsurface structure, to provide a summary, and further establish potential rehabilitation recommendation options for Seventh Street within the project limits of O'Brien Road to Barnet Boulevard. After confirming the drilling program to be implemented, performing an initial site reconnaissance visit and borehole layout, Egis coordinated locates with Ontario OneCall prior to proceeding with the geotechnical investigation. The boreholes were placed at intervals of 60 to 90 metres along Seventh Street in midlane and shoulder locations.

Asphalt core holes were advanced at the intersections of Seventh Street and O'Brien Road and Barnet Boulevard, the locations of which were strategically placed to identify asphalt depth characteristics critical to transitions of new asphalt to old asphalt.

Reference may be made to the Location Plan provided in Appendix A for individual borehole and core hole locations.

2.1 Geotechnical Drilling

The investigation consisted of making site observations, geotechnical drilling, collection of representative granular and soil samples for index testing and characterization and logging of field data. Members of the investigation team took part in daily tailgate safety meetings conducted by Egis prior to commencing the field investigation to ensure each member was aware of their role, and the site-specific hazards and conditions to be expected for that specific day. Traffic control during the site investigation was conducted as per OTM Book 7.

Referencing the Location Plan, Appendix A, the borehole locations were generally offset from the existing underground service locations. Borehole locations were dictated by allowable offsets from existing underground services.

The geotechnical drilling was completed by Limitless Drilling, of Renfrew, Ontario under the direct supervision of Egis staff over the course of the investigation on April 29th, 2024. Boreholes were advanced using a 6" solid stem auger to a depth of 2.1 m or practical refusal. The pavement structure was documented, outlining the asphalt, base and subbase depths including the underlying subsoil stratigraphy, as discussed in Section 3.0. During drilling, auger samples of the road base, subbase and subgrade soils were taken, as necessary, and used in conjunction with the measured pavement thicknesses to model the existing pavement structure. All boreholes were backfilled with auger cuttings, compacted and sealed with premium asphaltic concrete cold patch upon completion. The borehole records for Seventh Street are provided in full in Appendix C.

The drilling program and sampling particularly focused on the total depth and layer thicknesses of the pavement structures (e.g., asphalt or surface treatment depth, granular base and subbase depths, and the type and gradation of subgrade material). In addition to the overall asphalt depths obtained during the borehole drilling program, asphalt cores were obtained at the cross street locations (O'Brien Road and Barnet Boulevard) to provide data to develop asphalt transition details. Appendix D presents the asphalt core photos.

2.2 Logging, Sampling and Laboratory Testing

Soil logging was undertaken in accordance with the MTC Soil Classification and the Canadian Foundation Engineering Manuals (2006). Pavement structure samples from the boreholes were logged and placed in plastic bags, sealed and labelled. Following completion of the site investigation program, all granular and soil samples were further examined by tactile and visual means at our facility. Select granular and soil samples were delivered to Egis's Ottawa laboratory (CCIL and RAQs certified) for testing in accordance with MTO's laboratory testing manual and were integrated into the borehole records. The corresponding laboratory index granular and soil testing that was conducted included:

- LS-602/702 Grain Size Analysis of Aggregates;
- LS-702 Grain Size Analysis of Soils;
- LS-701 Determination of Moisture Content of Soils; and
- LS-703/704 Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

3.0 SITE INVESTIGATION RESULTS AND RECOMMENDATIONS

The following sections outline the site investigation results and corresponding rehabilitation recommendations for Seventh Street. The interpretation of the borehole logs may be assisted by a list of geotechnical abbreviations that have been included in Appendix B

3.1 Location and Section Description

The Seventh Street project limits, from O'Brien Road to Barnet Boulevard is approximately 300 m in length. Within the project limits the reported Average Annual Daily Traffic volume (AADT) is less than 1,000 with an assumed commercial percentage of 2 % and an annual growth rate of 1%.

Figure 1: Seventh Street, north of Barnet Boulevard, looking north (near BH-8)

3.2 Borehole and Core hole Location Plan

The Seventh Street borehole and core hole locations are depicted on the Location Plan, Appendix A.

3.3 Borehole and Core Hole Logs and Laboratory Results

The borehole logs and core hole photos completed for Seventh Street have been respectively appended in Appendix C and D, and further summarized in Table 2. In addition to the borehole stratigraphy, the borehole and core hole logs describe the borehole locations by providing the road station (chainage), centreline offset, coordinates and lane descriptions. For this assignment, the project start of Station 10+000 was defined by the intersection of O'Brien Road and Seventh Street.

Select granular and soil samples were submitted to Egis's certified Ottawa laboratory for testing of grain size analyses, Atterberg Limits, and moisture content. The geotechnical laboratory testing results have been provided in Appendix E, and incorporated into the borehole logs, Appendix C.

3.4 Typical Pavement Structure and Observations

Table 2, below, provides a summary of the pavement structure thicknesses for Seventh Street within the project limits. Groundwater infiltration or standing water was not encountered in any of the boreholes.

Table 2: Typical Pavement Structure for Seventh Street

BH	Station	Offset	Asphalt	Base	Subbase
CH-10	10+012	3.5 m Lt of CL	145	Core Hole Only	
BH-9	10+039	2.8 m Rt of CL	50	-	370
BH-8	10+039	2.6 m Lt of CL	50	130	210
BH-7	10+133	1.8 m Lt of CL	50	-	270
BH-6	10+133	3.8 m Lt of CL	55	100	450
BH-5	10+183	3.9 m Lt of CL	55	100	450
BH-4	10+188	2.4 m Lt of CL	50	-	630
BH-3	10+273	1.9 m Lt of CL	25	190	160
BH-2	10+276	3.5 m Lt of CL	30	60	200
CH-1	10+300	2.8 m Lt of CL	100	Core Hole Only	
Average (Range) (mm)			45 (25 – 55)***	120 (60-190)**	300 (160-630)

*Excluding outlier from BH-4, which had a subbase depth of 630 mm
**Five of eight boreholes exhibited granular base (BH-2, 3, 5, 6, 8)
***Excluding CH-1 and CH-10

Asphalt

The asphalt for Seventh Street consists of a single lift of hot laid asphalt, ranging in thickness from 25 mm to 55 mm, averaging 45 mm.

For the purposes of tie-in information, two pavement core holes were advanced on Seventh Street at the paving limits with O'Brien Road and Barnet Boulevard. The cores were advanced on the newer pavement associated with recent resurfacing of O'Brien Road and Barnet Boulevard. The pavement core photos are provided in Appendix D. The asphalt cores were in good condition with no delamination between pavement lifts. The thickness of the asphalt cores at O'Brien Road and Barnet Boulevard are as follows:

- CH-10, Station 10+012, 3.5 m Lt of CL, HMA thickness = 145 mm
- CH-1, Station 10+300, 2.8 m Lt of CL, HMA thickness = 100 mm

Base

Five of the eight boreholes exhibited a granular base. Where encountered, the base generally consisted of Gravely Sand to Sand with Gravel, minor constituent consisting of Trace Silt to Some Silt.

One grain size analysis was performed on the granular base. The grain size analysis performed on the granular base at BH-3, indicated the material met the OPSS 1010 Table 3 Production Requirements. The performance of this roadway does not appear to be related to granular base material strength issues. The performance of Seventh Street, distresses, and potential causes of distresses are further discussed in Section 3.6.

Moisture content analysis indicated the granular base had a moisture content of 3.1 %.

Subbase

All of the boreholes exhibited a granular subbase that generally consisted of Sand Trace to Some Gravel, with minor constituents of Trace to Some Silt. One borehole BH-9, had a subbase material that consisted of Sand With Gravel Some Silt Some Cobbles.

Three grain size analyses were performed on granular subbase material. The grain size conducted on the granular subbase from BH-3 failed to meet the OPSS 1010 Table 3 Production Requirements for Granular B Type III due to being too fine on multiple sieve designations and failed to meet the Granular B Type I criteria, due to being too fine on the 75 µm sieve designation.

Borehole BH-4 exhibited a granular subbase material directly under the surface asphalt layer (depth of 50 to 150 mm), followed by another distinct subbase layer (depth of 150 mm to 689 mm. Both samples failed to meet the OPSS 1010 criteria for Granular B Type I and Type III due to being too fine on various sieve designations.

Moisture content analysis indicated the granular subbase had a moisture content of 3.9 to 3.6 %.

Subgrade

The subgrade soils encountered below the existing pavement structures generally consisted of soil that ranged from Silt With Clay to Clayey Silt, occasionally with minor constituents of sand. In BH-7, the soil underlying the pavement structure consisted of Clayey Silt Some Cobbles and transitioned to Silt With Clay.

Moisture content analysis indicated the granular subbase had a moisture content of 27.1 % to 29.2 %.

An Atterberg limits analysis indicated the material was CL (clay low plasticity).

As per grain size analysis testing, the material is considered to have moderate susceptibility to frost heaving (MSFH) to high susceptibility to frost heaving (HSFH).

3.5 Core Construction

For the purposes of discerning if Seventh Street has core construction, midlane and adjacent shoulder boreholes were advanced. The results of the borehole investigation indicated that the shoulder and midlane boreholes did not exhibit core construction.

3.6 Current Pavement Condition

A pavement condition of Seventh Street was conducted by Egis on April 29th, 2024. The pavement condition evaluation is summarized in Table 3.

The existing pavement distresses include wheel track rutting, distortions, longitudinal wheel path alligator cracking, longitudinal alligator cracking, pavement edge alligator cracking. These types of distresses are typically related to insufficient bearing support, poor base drainage and stiff or brittle asphalt mixes at cold temperatures. However, considering the pavement surface appears to have an oxidized appearance, the likely cause of the asphalt deficiencies is likely brittle asphalt due to age.

Table 3 shows a summary of significant existing distresses that were observed by Egis within the project limits, along with the potential generic causes of these distresses (which may or may not be applicable in this case) and **bolded probable causes** of the distresses. Site photographs are provided in Appendix F.

Table 3: Significant Distresses Observed on Seventh Street

<table>
<tr><th>Type of Distress</th><th>Severity of Distress</th><th>Density of Distress</th><th>Potential Generic Causes (may or may not be applicable)</th></tr>
<tr><td>Coarse Aggregate Loss (Ravelling)</td><td>Severe</td><td>Throughout</td><td>• Stripping due to water
• Fracture of aggregate due to load
• Poor adhesion of binder
• Poor compaction
• Hardening due to ageing</td></tr>
<tr><td>Distortion</td><td>Moderate</td><td>Throughout</td><td>• Differential Frost heave
• Differential settlement of subgrade or base material
• Loss of granular into rock
• Culvert failures
• Lack of subgrade support
• Embankment slope failures
This is the result of potholes caused by alligator cracking</td></tr>
<tr><td>Longitudinal Wheel Track Alligator Cracking</td><td>Severe</td><td>Throughout</td><td rowspan="4">• Insufficient bearing support
• Poor base drainage and stiff or brittle asphalt mixes</td></tr>
<tr><td>Centreline Alligator Cracking</td><td>Severe</td><td>Throughout</td></tr>
<tr><td>Pavement Edge Alligator Cracking</td><td>Severe</td><td>Throughout</td></tr>
<tr><td>Transverse Alligator Cracking</td><td>Severe</td><td>Throughout</td></tr>
</table>

4.0 TRAFFIC LOADING ANALYSIS

For pavement design purposes, a comprehensive traffic loading analysis is conducted based on the traffic data presented in Table 1. For the traffic loading analysis, the following traffic parameters are considered to calculate the Cumulative Equivalent Single Axle Loads (ESALs);

- AADT at the time of construction (base) year;
- Construction year;
- Percentage of annual average traffic growth;
- Percentage of Commercial Vehicles;
- Combination of Commercial Vehicles based on their axles and spacing of axles;
- Directional Distribution;
- Lane Distribution, and
- Initial Design Life of pavement.

As some of the data were not available from the Town of Renfrew, Egis used the following MTO published guidelines to make reasonable assumptions to carry out the analysis:

- MI-183 "Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions (2008), and
- Procedure for Estimating Traffic Loads for Pavement Design, 1995.

4.1 Equivalent Single Axle Loads (ESALs)

The equivalent single axle loads (ESALs) for the design lanes of Seventh Street, within the project limits, were calculated using the traffic data presented in Table 1. The input parameters for the design lane ESALs calculation were derived from MTO publication MI-183 "Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions" and "Procedures for Estimating Traffic Loads for Pavement Design, 1995". Table 3.1 presents the input parameters used to calculate the cumulative ESALs.

Table 4: ESAL Calculations

Location	Base Year AADT[1] (2024)	Comm (%)	Truck Factor	Annual Traffic Growth (%)	DD[2]	LD[3]	Days / Year	Design Life	Cumulative Design Life ESALs	Traffic Category
Seventh Street	1,000	2.0	0.741	1.0	0.5	1.0	365	15 Yrs.	43,500	A (B)[4]
								17 Yrs.	49,900	
								20 Yrs.	59,600	

Notes:
1. Base AADT for construction year 2024 (Assumed)
2. Directional Distribution (DD) – AADT provided is total for both directions
3. Lane Distribution Factor (LD) – two lanes, one in each direction
4. Calculated Traffic Category A; Recommended minimum Traffic Category B (experience based)

5.0 PAVEMENT DESIGN

The main design tools used to determine if design options meet requirements are the Routine (GBE) Method combined with the AASHTO 93 Method. Both methods are viable and, in the case of the Town's roads, complement each other as described below.

5.1 Routine Method

The Routine Method was used extensively for pavement design analysis prior to the introduction of the AASHTO 93 method. It is typically no longer used for high volume freeways and highways where traffic volumes have far exceeded those used in the original analysis. It is based on GBE (Granular Base Equivalencies), subgrade, and AADTs under Ontario conditions. There are two pertinent tables from the Pavement Design and Rehabilitation Manual that recommend pavement structure thicknesses and GBE values:

- Table 3.3.2, Structural Design Guidelines for Flexible Pavements-King's Highways and Freeways; and
- Table 3.3.3, Structural Design Guidelines for Flexible Pavements-Secondary Highways.

These tables assume a maximum commercial vehicle percent of 10%. Table 3.3.3 for secondary highways is suitable for AADT volumes up to 3000, which is typical of lower volume roads, where half load seasons may apply. However, for higher volume roads (AADT > 4000) or roads that are anticipated to maintain loading year-round, Table 3.3.2 for King's Highways and Freeway is referred to. Given the subject road section's assumed AADT of 1,000, for the purposes of this assignment, Table 3.3.3 will be used for analysis.

For the purposes of design, the Table 3.3.3 granular base and subbase thickness recommendations are not strictly followed, as long as the GBE value is achieved.

Routine Method Design

For the purposes of design analysis, the following Table 5 provides design values based on entering the Routine Method table (Table 3.3.3, Structural Design Guidelines for Flexible Pavements-Secondary Highways) with the 2025 AADT of 1,000 vehicles per day and a Lacustrine Clay subgrade. The Lacustrine clay subgrade would be a practical worst-case scenario for the road subgrade.

Table 3.3.3 provides only a minimum recommendation of a Surface Treatment wearing surface. In this regard, Table 3.3.2 is referenced, whereas for traffic volumes of 200 to 1000 AADT the minimum asphalt depth is 50 mm.

Table 5: ***Required Routine Method Table Values***	
AADT (2019)	1,000
Subgrade Material	Lacustrine Clay
Table 3.3.3 for AADT 500 to 1000 Lacustrine Clay[4]	
Hot Mix (mm)	50 (Table 3.3.2, 200 to 1000 AADT)
Base (mm)	150
Subbase (mm)	250
GBE	315

In summary, the routine method for low volume roads specifies a required GBE value of 315 mm with a minimum 150 mm base thickness over a 250 mm thick subbase. A minimum 50 mm asphalt wearing surface has also been added given the urban environment.

5.2 AASHTO 93

AASHTO 93 (American Association of State Highway and Transportation Officials) is a pavement design tool based on empirical formulas developed beginning with the AASHO Road Test. The Road Test was the first in a series of experiments carried out by AASHTO to determine how traffic contributed to the deterioration of highway pavements. This design tool incorporates structural analysis using equivalent single axle loads (ESAL), and rather than granular base equivalencies it uses structural and drainage coefficients assigned to the various pavement material types. In addition, it requires a Roadbed Soil Resilient Modulus (M_r) value assigned to the subgrade material. The output of the AASHTO 93 method is a Structural Number (SN) to determine the requirements of the characteristics and thickness of the pavement layers. The parameters have been adjusted to reflect Ontario traffic conditions (Hajek Report[2]) and the tables were utilized with respect to the "Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions, 2008" and the addendum report entitled "Recommended Initial and Terminal Serviceability Levels" dated 2001[2].

5.2.1 AASHTO 93 Design Parameters

The design criteria and parameters selected for all of the input values with respect to the pavement and soil model are shown in Table 6. The parameters selected refer to urban roads and are based on the traffic data shown in Section 4.1. The M_r and the Structural Layer Coefficient variables described in Table 6 are determined from the borehole investigation.

Table 6: *Parameters Selected for Design Analysis*	
Design Criteria	**Value Used**
Initial Serviceability (Po)	4.0 (Resurfacing), or 4.2 (Reconstruction
Terminal Serviceability (Pt)	2.0
Overall Standard Deviation	0.49
Reliability Level, %	85
M_r (MPa)	30 (Suitable for clay/silt subgrade)
Structural/Drainage Layer Coefficients	New = 0.42/1.0 Existing = 0.22/1.0 New Base = 0.14/1.0 Existing Base = 0.10/0.9 New Subbase = 0.09/1.0 Existing Subbase = 0.07/0.9

5.3 AASHTO 93 and Routine Method Design Options

The pavements have been designed using the AASHTO 93 Design Methodology along with MTO's MI-183 report. These pavement design analyses, provided in Tables 7 and 8 were supplemented with engineering judgement including consideration of typical service life experience for rehabilitated pavements in Ontario. The parameters used for the design of the pavements are summarized in Tables 5 and 6.

The following Table 7 presents three options for the resurfacing of Seventh Street, and Table 8 provides a pavement reconstruction option. For abbreviation reference: Full Depth Removal (FDR), Partial Depth Removal (PDR), Hot Mix Asphalt (HMA), Granular (Gran).

Table 7: Resurfacing Options			
DESIGN OPTION	**Option 1** **FDR HMA (50mm), Pave 50mm**	**Option 2** **FDR HMA and PDR Gran to Total 90mm, Pave 90mm**	**Option 3** **FDR HMA and PDR Gran to Total 250 mm, Place 150 Base, Pave 100mm**
Design Input Parameters	● Initial Serviceability Index = 4.0; ● Terminal Serviceability Index = 2.0; ● Desired Reliability = 85%; ● Estimated Elastic Modulus of Subgrade Soil = 30 MPa; ● Standard Deviation = 0.49		
Construction Details	● Full depth removal of HMA □ to a depth of 50 mm ● Repave with □ 50 mm Surface Course	● Partial removal of HMA and partial depth removal of granular □ to a depth of 90 mm ● Augment, level and compact existing granulars ● Repave with □ 40 mm Surface Course over □ 50 mm Binder Course	**● Full depth removal of HMA and partial depth removal of granular** **□ to average depth of 250 mm** **● Augment, level and compact existing granulars** **● Place 150 mm Granular A Base** **● Repave with** **□ 40 mm Surface Course over** **□ 60 mm Binder Course**
Existing SN/GBE	40 / 301		
Target SN / GBE	62 mm (15 Years) / 315		**64 mm (17 Years) / 315**
SN / GBE Provided	51 mm / 336	64 mm / 386	**77 mm / 457**
Service Life Estimate: - AASHTO 93 - PDRM Table 3.3.1* - Experience Based/ Limiting factors	11 yrs. 7 – 11 yrs. 10 yrs. / Low SN, drainage issues	18 yrs. 10 -14 yrs. 12 yrs. / Drainage issues	**20 yrs.** **14 – 18 yrs.** **18 yrs.** /** **Drainage issues, starts a new rehabilitation cycle**

* Based on Pavement Design and Rehabilitation Manual – Second Edition, Table 3.3.1, Service Life Experience in Ontario, for King's Highways.

** Service Life may be extended by proof rolling existing road granulars/subgrade and provide base work that may include augmentation with granular base and compaction.

Table 8: Reconstruction Option	
DESIGN OPTION	Option 4 FDR HMA and Gran to Total 550mm, Place 300mm Subbase, 150 Base, and Pave 100 HMA
Design Input Parameters	● Initial Serviceability Index = 4.2; ● Terminal Serviceability Index = 2.0; ● Desired Reliability = 85%; ● Estimated Elastic Modulus of Subgrade Soil = 30 MPa; ● Standard Deviation = 0.49
Construction Details	● Full depth removal of HMA, Granulars and Subgrade □ to a combined depth of 550 mm ● Level and compact existing subgrade ● Place 300 mm Gran B Type I Subbase ● Place 150 mm Gran A Base ● Pave with □ 40 mm Surface Course over □ 60 mm Binder Course
Existing SN	40 / 301
Target SN / GBE	65 mm (20 Years) / 315
SN / GBE Provided	90 mm / 548
Service Life Estimate: - AASHTO 93 - PDRM Table 3.3.1* - Other factors	 20 yrs. 14 – 18 yrs. Starts a new rehabilitation cycle

The four rehabilitation options provided in Tables 7 and 8 include Option 1, FDR HMA (50mm), Pave 50mm; Option 2, FDR HMA and PDR Gran to Total 90mm, Pave 90mm; Option 3, FDR HMA and PDR Gran to Total 250 mm, Place 150 Base, Pave 100mm; and Option 4, Option 4 FDR HMA and Gran to Total 550mm, Place 300mm Subbase, 150 Base, and Pave 100 HMA. The rehabilitation methodologies are further described as:

- Option 1, FDR HMA (50mm), Pave 50mm;
  - Full Depth Removal (FDR) of asphalt to a depth of 50 mm,
  - Level and compact existing granulars. Prior to placing new pavement material, proof roll the existing road granulars and provide base work that may include augmentation with new granular base and compaction,
  - Rehabilitate the pavement by paving 50 mm HMA,
  - New subdrain installations should be installed to partially address drainage issues.
    - This rehabilitation option has a calculated SN of 51 mm and does not meet the required 15-year SN of 62 mm, and correlates to an AASHTO 93 service life of 11 years.

        - Based on the PDRM Table 3.3.1, a service life of 7 to 11 years is estimated.
        - Practically, a 10-year service life is anticipated, which is due to the existing salient conditions, i.e., low calculated SN, and drainage issues.

- Option 2, FDR HMA and PDR Granular to Total 90mm, Pave 90mm
    - Full Depth Removal (FDR) of asphalt and partial depth removal of granular to a total depth of 90 mm,
    - Level and compact existing granulars. Prior to placing new pavement material, proof roll the existing road granulars and provide base work that may include augmentation with new granular base and compaction,
    - Rehabilitate the pavement by paving 50 mm HMA,
    - New subdrain installations should be installed to partially address drainage issues.
        - This rehabilitation option has a calculated SN of 64 mm and meets the required 15-year SN of 62 mm, correlating to an AASHTO 93 service life of 18 years.
        - Based on the PDRM Table 3.3.1, a service life of 10 to 14 years is estimated.
        - Practically, a 12-year service life is anticipated, which is due to the existing salient conditions, i.e., drainage issues.

- **Option 3, FDR HMA and PDR Granular to Total 250 mm, Place 150 Base, Pave 100mm**
    - **FDR of asphalt and granular to a total depth of 250 mm,**
    - **Level and compact existing granulars. Prior to placing new pavement material, proof roll the existing road granular material and provide base work that may include augmentation with new granular base and compaction,**
    - **Rehabilitate by placing 150 mm Granular A, and paving 100 mm HMA,**
    - **New subdrain installations should be installed to partially address drainage issues.**
        - **This rehabilitation option addresses drainage issues,**
        - **This rehabilitation option has a calculated SN of 77 mm exceeding the required 17 year and 20-year SN of 64 mm and 65 mm (respectively), which correlates to an AASHTO 93 service life greater than 20 years,**
        - **Based on the PDRM Table 3.3.1, a service life of 14 to 18 years is estimated,**
        - **Practically, an 18-year service life is anticipated.**

- Option 4, Option 4 FDR HMA and Granular to Total 550mm, Place 300mm Subbase, 150 Base, and Pave 100 HMA
    - FDR of asphalt and granular to a total depth of 250 mm,
    - Level and compact existing subgrade. Prior to placing new pavement material, proof roll the existing road subgrade material and provide subgrade work that may include augmentation with new fill material and compaction,
    - Rehabilitate by placing 300 mm Granular B Type I, 150 mm Granular A, and paving 100 mm HMA,
    - New subdrain installations should be installed to address drainage issues.
        - This rehabilitation option addresses drainage issues,

- This rehabilitation option has a calculated SN of 77 mm, exceeding the 20-year SN of 65 mm, which correlates to an AASHTO 93 service life greater than 20 years,
- Based on the PDRM Table 3.3.1, a service life of 14 to 18 years is estimated,
- Practically, an 18-year service life is anticipated.

6.0 PAVING OPTION SELECTION

To provide a rationale for the selected paving Option, the following provides a comparison of the pros and cons of each Option resulting in one of the four Options being selected for Seventh Street.

6.1 Paving Option Comparison and Pros and Cons

For comparison purposes, the rehabilitation alternatives presented in Sections 5 are tabulated in Tables Table 9.

Table 9: Summary of Design Analysis Seventh Street

Pavement Structure	Option 1	Option 2	**Option 3**	Option 4
	FDR HMA (50mm), Pave 50mm	FDR HMA and PDR Gran to Total 90mm, Pave 90mm	**FDR HMA and PDR Gran to Total 250 mm, Place 150 Base, Pave 100mm**	FDR HMA and Gran to Total 550mm, Place 300mm Subbase, 150 Base, and Pave 100 HMA
New Asphalt Mix, mm	50	90	**100**	100
Grade Raise, mm	0	0	**0**	0
Existing Asphalt Remaining, mm	0	0	**0**	0
Add Granular Base, mm	0	0	**150**	150
Add Granular Subbase, mm	0	0	**0**	300
Use of Existing Base, mm	115	75	**0**	0
Use of Existing Subbase, mm	300	300	**215**	0
Required Structural Number (SN), mm	62 (15-Year for Resurfacing)	62 (15-Year for Resurfacing)	**64 (17 Year for Major Rehabilitation)**	65 (20-Year for Reconstruction)
Required GBE, mm	315	315	**315**	315
Calculated Structural Number (SN)	51	64	**77**	90
Calculated GBE, mm	336	386	**457**	548
Service Life Estimate: - Experience - AASHTO 93	10 exp 11 AASHTO	12 exp 18 AASHTO	**18 exp 20 AASHTO**	18 exp >20 AASHTO

The pros and cons of each option were analyzed taking into consideration the constructability and work zone safety. Based on Table 7, 8 and 9 data, a summary of each option is provided in Table 10 below.

Table 10: Pros and Cons Analysis		
Treatment Type	**Pros**	**Cons**
Option 1 FDR HMA (50mm), Pave 50mm	• Allows crossfall correction • Provides new wearing surface • Lowest initial cost option	• Generates RAP • Does not meet strength requirements for AASHTO 93 (15-year) • Granular base bearing support deficiencies are not addressed which may result in premature deterioration of asphalt surface • Gravel surface during construction
Option 2 FDR HMA and PDR Gran to Total 90mm, Pave 90mm	• Allows crossfall correction • Provides new wearing surface • Second lowest initial cost option • Meets strength requirements for AASHTO 93 (17 years)	• Generates RAP • Granular base bearing support deficiencies are not addressed potentially resulting in premature deterioration of asphalt surface • Gravel surface during construction
Option 3 **FDR HMA and PDR Gran to Total 250 mm, Place 150 Base, Pave 100mm**	• **Allows crossfall correction** • **Meets AASHTO 93 (20-year)** • **Second longest anticipated service life** • **Allows for complete crossfall correction of pavement materials** • **More uniform pavement structure** • **Increases granular base bearing support that addresses poor quality and inconsistent occurrence of base material** • **Future rehabilitation may include partial depth removal of asphalt surface**	• **Generates RAP** • **Temporary ramping during construction** • **Gravel surface during construction** • **Second highest initial cost option**
Option 4 FDR HMA and Gran to Total 550mm, Place 300mm Subbase, 150 Base, and Pave 100 HMA	• Highest strength alternative • Highest anticipated service life • Ability to Increase overall pavement strength to meet required SN and GBE • Allows for complete crossfall correction • More uniform pavement structure • Increases granular base bearing support that addresses poor quality of base and subbase material • Future rehabilitation may include partial depth removal of asphalt surface	• Generates RAP • Temporary ramping during construction • Gravel surface during construction • Highest initial cost option

6.2 Other Paving Option Criteria

Rehabilitation recommendations are based on a field review of the subject road, a thorough review of the borehole investigation results and subsequent laboratory testing, GBE analysis and AASHTO 93. The road section is in an urban area with many driveway entrances and intersecting streets at the project limits. Primary concerns on this section of roadway include:

- The current significant pavement distresses, e.g., severe alligator cracking throughout, indicate that the asphalt surface has become brittle due to age.
- Granular subbase material is out of specification, typically being too fine on multiple sieve designations or having a high silt content.
- The presence of granular base is not consistent in all borehole locations.
- Grade raises are considered unacceptable due to:
    - The subject pavement rehabilitation will tie into the adjacent asphalt pavement surfaces that are not excavated or removed during construction,
    - The pavement rehabilitation will tie into the existing entrances and side streets,
    - Existing appurtenances (manholes and catch basins) will require adjustment for grade raises;
- Cold/Hot In Place Recycling methods requiring large trains of equipment are typically not applicable for the short urban section of pavement.
- Full Depth Reclamation of the existing asphalt surface is not desirable due to the inconsistent presence of granular material, and undesirable grade raises.
- The Town of Renfrew may desire a Marshall mix design with performance graded asphalt cement for local streets.

An analysis of Tables 9 and 10 provides the following summary:

- Options 1 and 2 do not replace the underlying granular base. Due to the inconsistent occurrence of the granular base, bearing support deficiencies may result in premature deterioration of asphalt surface.
- Paving Option 1 fails to meet the required SN for a 15-year service life for resurfacing.
- Options 2 requires removal of the asphalt and partial depth of the existing granular materials, which further weakens the base material's strength,
- Options 3 and 4 address the structural requirements of the base materials.
- Option 4, based on the provided calculated GBE (548) and SN (90 mm) values as compared to the required GBE of 315 and SN of 65, is significantly overdesigned.

6.3 Recommended Alternative

In summary, based on a detailed consideration of the pros and cons for Options 1 through 4, **Option 3, FDR HMA Granular to Total 250 mm, Place 150 Base, Pave 100mm (2x50 mm lifts) of HMA** is the preferred option for Seventh Street. This option will remove all of the existing poorly performing asphalt, provide a consistent thickness of granular base material, improve drainage issues, and provide a zero-grade raise that meets the structural requirements for a standard 20 year AASHTO 93 service life.

7.0 MATERIALS

7.1 Reclaimed Materials

The existing hot mix asphalt is suitable for recycling as Reclaimed Asphalt Product (RAP).

In accordance with OPSS.MUNI 1010, the RAP can be used for generic purposes (not necessarily for this project) such as recycled aggregate for granular subbase (Granular B Type III) or as recycled aggregate for granular base. RAP can also be used for backfill material, engineered fill, stabilization for subgrades, pavement shoulders, and rural driveways.

7.2 Granular Materials

Imported Granular A will be required for construction activities related to the rehabilitation of the pavement profile within the project limits.

7.3 Asphalt Cement Grade

As per Figure 1 and Table 2 of the MTO Superpave and SMA Guide, March 2008 the Town of Renfrew exists within the Performance Graded Asphalt Cement (PGAC) Zone 2, which has a base PGAC grade of 58-34, as per amendments to OPSS 310, dated November 2012.

For the traffic load of 59,600 ESALs, the LTTP Binder V3.1 software program calculates a PGAC of 58-34 for Slow-speed traffic and 52-34 for Fast-speed traffic. The LTTP Binder V3.1 software takes into consideration historical data from five relevant weather stations, traffic speed and traffic volume.

The MTO Superpave and SMA Guide recommends that if there is a disagreement between Tables 2/3 and the LTTP Binder program, the higher requirement should govern. Thus, considering the relatively low traffic load, with an assumed speed of 40 to 50 km/h, a PGAC grade of 58-34 is recommended.

7.4 Tack Coat

A tack coat, consisting of SS-1 emulsified asphalt, is recommended to be applied, as per OPSS PROV 308, latest edition, to all existing or milled surfaces and between all new lifts of hot mix asphalt.

7.5 Asphalt

Two option for asphalt are provided here, one for the use of Superpave (SP) asphalt and one for the use of Marshall asphalt:

For Marshall asphalt

- The surface course should be a 50 mm lift of HL-3 Marshall mix PGAC 58-34.
- The binder course should be a 50 mm lift of HL-8 Marshall mix PGAC 58-34.

For Superpave asphalt

- The surface course should be a 50 mm, SP 12.5, Category B, PGAC 58-34.
- The binder courses should be a 50 mm, SP 19.0, Category B, PGAC 58-34

7.6 Asphalt Placement and Compaction

The construction operations associated with placement and compaction of asphalt should be in accordance with the construction specification for hot mix asphalt, OPSS.MUNI 310. Similarly, the material specifications should be in accordance with OPSS.MUNI 1151 for Superpave mixes.

In accordance with Table 10 of OPSS.MUNI 310, the HL-3 surface course and HL-8 binder course should be compacted to at least 92% of the Maximum Relative Density (MRD).

8.0 DISCUSSION AND RECOMMENDATIONS

The following outlines general recommendations to be considered for the subject rehabilitation of Seventh Street.

8.1 Rehabilitation of Seventh Street

Outlined below, **Option 3,** from Table 7, is the preferred strategy for the Seventh Street main lanes. For reference, the paving strategy provided below includes an option for Marshall asphalt and for Superpave asphalt.

Saw cut the existing HMA at the project limits and remove full depth asphalt (average asphalt 45 mm), and remove partial depth granular material to a total combined depth of 250 mm, and reinstate as follows:

Proof Roll existing granular base material and conduct base repairs as required.
Augment existing granular base with new Granular A, grade and compact as required

For Marshall asphalt:	
Place and compact Granular A	150 mm
Pave HL-8 Marshall mix PGAC 58-34 Binder Course	50 mm
Pave HL-3 Marshall mix PGAC 58-34Surface Course	50 mm
Total Thickness (New Asphalt)	100 mm
Total Thickness (New Pavement)	250 mm
Structural Number Provided	77 mm

For Superpave asphalt:	
Place and compact Granular A	150 mm
Pave Superpave 19.0 B, PGAC 58-34 Binder Course	50 mm
Pave Superpave 12.5 B, PGAC 58-34 Surface Course	50 mm
Total Thickness (New Asphalt)	100 mm
Total Thickness (New Pavement)	250 mm
Structural Number Provided	77 mm

It is anticipated that the rehabilitation will provide up to 18 years of service life when augmented with regular maintenance (crack filling) treatments.

Provide a tack coat as described in Section 7.

8.2 Drainage

Water has a damaging effect on most of the materials used in road construction. Groundwater can weaken and degrade the pavement structure, which can develop into deformations, cracking and potholes. Likewise, saturation of the pavement sub-layers will reduce the moduli of elasticity of the sub-layers giving rise to early rutting and cracking and requiring early maintenance. In General, sub-soil drainage systems should be provided to prevent the water table from rising and affecting the pavement materials.

Optional Subdrain

As an option to provide improved road section long term performance, the designer should investigate the feasibility of providing subdrains for Seventh Street. However, the location and spacing of the existing storm sewer appurtenances may make subdrain installation impractical.

For Seventh Street, should subdrain installation be deemed feasible/specified:

- A continuous subdrain system designed to freely drain into catch basins is recommended to be installed in accordance with OPSS.MUNI 405. It is recommended that the subdrains be placed along both sides of Seventh Street.
- The subdrain trench bottom should be installed at a depth of 800 mm from the proposed surface grade. The subdrain is to include all construction details described in OPSD 216.021, including 19 mm clear stone, non-woven filter cloth, and 150 mm diameter perforated polyethylene subdrain with knitted filter sock.
- Following the removal of the HMA and granular to a total combined depth of 250 mm, the existing granular material should be graded to provide the required continuous slope towards subdrains (if installed).
- The new Granular A Base should include grading the material to provide the required continuous slope towards the subdrains (if installed).

8.3 Existing Granular and New Base Preparation and Compaction

For the Seventh Street rehabilitation, from O'Brien Road to Barnett Boulevard, remove existing asphalt to an average depth of 45 mm and partial depth removal of granular to a total combined depth of 250 mm. The exposed existing granular should be compacted and then proof rolled with a heavy rubber-tired vehicle (such as a loaded gravel truck) in conjunction with inspection by a geotechnical engineer. The granular should be inspected for signs of rutting or displacement. Areas displaying signs of rutting or displacement should be re-compacted and re-proof rolled, or the material should be sub-excavated and replaced with compacted engineered fill materials. Granular fill material should be Granular A. Where required, augment the granular base as necessary and grade the granular base to provide the required grade.

Upon completion of the existing granular material preparation, place, grade, and compact 150 mm of new Granular A base. For new granular road base, the fill materials shall consist of Granular A. The new base should be placed in lift thicknesses not exceeding 200 mm before compaction and should be uniformly compacted to at least 100 % of the SPMDD.

All compaction should be completed in accordance with OPSS 501 before the subsequent layer is placed. Generally, the intent for a pavement reconstruction project is to have the granular material meet the physical property and production requirements of OPSS 1010 Tables 2 and 3, respectively.

8.4 Excavations

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). Within the depth of the investigation boreholes, the subgrade soils generally consisted of Silt With Clay to Clayey Silt. For the purposes of the OHSA, subgrade soils within the project limits are classified as Type 3 soils.

Although there may have been insufficient time for groundwater to stabilize inside the boreholes, no groundwater was observed in any of the open boreholes during the drilling program. Ground water levels should be expected to vary and fluctuate seasonally in response to precipitation and other weather-related conditions.

8.5 Transitions

Pavement transitions are required at the project limits with O'Brien Road and Barnet Boulevard. The following provides a description of the pavement transitions:

- Saw cut the asphalt at the project limits with O'Brien Road and Barnet Boulevard
- Grade and compact the existing granular and provide a new 150 mm granular base as described in Section 8.3
- The new binder course shall be butt jointed against the existing asphalt.
- For the new surface course, the existing asphalt pavement surface shall be milled an additional 0.3 m (minimum) wide to a depth equal to the surface course thickness (50 mm). The surface course will lap onto the existing asphalt.
- Provide a tack coat as described in Section 7.

9.0 CLOSURE AND STATEMENT OF LIABILITY

The geotechnical investigations included a limited sampling of the roadway and the information presented herein is representative of the findings at the specific borehole locations. Conditions other than those noted in this report may exist within the site and cannot be extrapolated extensively away from the sample locations. If differing site conditions are encountered or if the Town of Renfrew becomes aware of any additional information that differs from or is relevant to the Egis Canada Ltd. (Egis) findings, the Town of Renfrew agrees to immediately advise Egis so that the information presented in this report may be re-evaluated.

Under no circumstances shall the liability of Egis for any claim in contract or in tort, related to the services provided and/or the content and recommendations in this report, exceed the extent that such liability is covered by such professional liability insurance from time to time in effect including the deductible therein and which is available to indemnify Egis. Such errors and omissions policies are available for inspection by the Town of Renfrew at all times upon request and if the Town of Renfrew desires to obtain further insurance to protect it against any risks beyond the coverage provided by such policies, Egis will co-operate with the Town of Renfrew to obtain such insurance.

Egis Canada Ltd. (Egis) prepared this report for the exclusive use of the Town of Renfrew for RFSO – 2024-03-DEE "Proposal for Engineering Services Proposal Rehabilitation of Seventh Street. Any use which a third party makes of this report or any reliance on or decision to be made based on it, are the responsibility of such third parties. Egis accepts no responsibility and will not be liable for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

This Pavement Design Report was prepared by James Hutson, C.E.T., and was reviewed by Philip Almond, P.Eng.

Egis Canada Ltd.

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Manager, Pavements, North America

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PAVEMENT DESIGN REPORT, SEVENTH STREET, TOWN OF RENFREW

APPENDIX A: LOCATION PLAN

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Figure 1, Seventh Street, Renfrew, Overall Borehole Plan

Figure 2, Seventh Street, Renfrew, Borehole Plan from O'Brien Street

Figure 3, Seventh Street Renfrew, Borehole Plan from Barnet Boulevard

PAVEMENT DESIGN REPORT, SEVENTH STREET, TOWN OF RENFREW

APPENDIX B: OPSD 100.06 ABBREVIATIONS (GEOTECHNICAL)

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ABBREVIATIONS FOR BORING AND TEST DATA

Accep	Acceptable	Gry	Grey	Psty	Polystyrene
Agg	Aggregate	H	Heavy	Poss	Possible
Amor	Amorphous	Hi	Highly	PST	Prime and Surface Treated
Asph	Asphalt	HP	High Plasticity	Quant	Quantity
BR	Bedrock	HM	Hot Mix	Reinf	Reinforced
Blk	Black	Lt	Light	RSS	Remoulded Shear Strength
Bl	Blue	Liq	Liquid	RF	Rock Fill
BH	Borehole	W_L	Liquid Limit	Sa	Sand
Bld (y)	Boulder (y)	Lo	Loam	Sat	Saturated
Blds	Boulders	L	Loose	SH	Shale
BU	Break Up	Mrl	Marl	St	Sensitivity
Br	Brown	Matl	Material	SSM	Select Subgrade Material
CF	Channel Face	Max	Maximum	Sh Rk	Shot Rock
Cl	Clay	MDD	Maximum Dry Density	Si (y)	Silt (y)
Co	Coarse	MWD	Maximum Wet Density	Sl (y)	Slight (ly)
Cob	Cobbles	Med	Medium	SP	Slight Plasticity
Comp	Compact	MP	Medium Plasticity	Stn (y)	Stoney
Conc	Concrete	Mod	Moderate	D_R	Relative Density
Contam	Contaminated	Mott	Mottled	Stks	Streaks
Cord	Corduroy	Mul	Mulch	Surf	Surface
Cr	Crushed	NFP	No Further Progress	Temp	Temperature
Dk	Dark	NFP (Blds)	No Further Progress (Boulders)	TH	Test Hole
Decomp	Decomposed	Num	Numerous	TP	Test Pit
D	Dense	OCC	Occasional	Tps	Topsoil
E	Earth	Wopt	Optimum Moisture Content	Tr	Trace
Fib	Fibrous	Ora	Orange	USS	Undisturbed Shear Strength
w	Field Moisture Content	Org	Organic	Unreinf	Unreinforced
F	Fine	Org M	Organic Matter	Varv	Varved
Fr Wat	Free Water	Ob	Overburden	VF	Very Fine
FB	Frost Boil	Pavt	Pavement	WT	Water Table
FH	Frost Heave	Pedo	Pedological	Weath	Weathered
Gran	Granular	Pen Mac	Penetration Macadam	W	With
Gr	Gravel (ly)	Wp	Plastic Limit	Wd (y)	Wood (y)
Grn	Green	Ip	Plasticity Index	Yel	Yellow

SUSCEPTIBILITY TO FROST HEAVING

HSFH — High
MSFH — Medium
LSFH — Low

ONTARIO PROVINCIAL STANDARD DRAWING | Date 1986 07 18 | Rev

ABBREVIATIONS

GEOTECHNICAL

Date _ _ _ _ _ _

OPSD — 100.06

PAVEMENT DESIGN REPORT, SEVENTH STREET, TOWN OF RENFREW

APPENDIX C: BOREHOLE LOGS

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CH No.: 10
Sta.: 10+012, 3.5 m Lt of CL, Seventh Street

0 - 145 Asph

BH No.: 9
Sta.: 10+10+039, 2.8 m Rt of CL, Seventh Street

0 - 50 Asph
50 - 420 Br Co Sa W Gr Some Si Some Cob (AS10)
420 - 2.13 Br Cl W Si (AS-11)

BH No.: 8
Sta.: 10+039, 2.6 m Lt of CL, Seventh Street

0 - 50 Asph
50 - 180 Br Sa W Gr Some Si
180 - 390 Br Sa Tr Gr Tr Si (AS-7)
390 - 1.30 Br Cl W Si (AS-8)
1.3 - 2.13 Br Si W Cl Tr Sa (AS-9)

BH No.: 7
Sta.: 10+10+133, 1.8 m Lt of CL, Seventh Street

0 - 50 Asph
50 - 140 Br Sa Tr Gr Tr Si (AS-12)
140 - 320 Br Sa Tr Si Some Cob
320 - 1.20 Br Cl(Y) Si Some Cob (AS-13)
1.20 - 2.13 Br Si W Cl (AS-14)

BH No.: 6
Sta.: 10+133, 3.8 m Lt of CL, Seventh Street

0 - 55 Asph
55 - 150 Br Sa W Gr Tr Si (AS-15)
150 - 600 Br Sa Tr Gr Tr Si
600 - 2.13 Br Si W Cl (AS-16)

BH No.: 5
Sta.: 10+183, 3.9 m Lt of CL, Seventh Street

0 - 55 Asph
55 - 150 Br Sa W Gr Tr Si
150 - 600 Br Sa Tr Gr Tr Si
600 - 2.13 Br Si W Cl

BH No.: 4
Sta.: 10+188, 2.4 m Lt of CL, Seventh Street

0 - 50 Asph
50 - 150 Br Sa Tr Gr Tr Si (AS-17)
19.0mm = 100%
16.0mm = 98.4%
13.2mm = 97.6%*
9.5mm = 87.9%*
4.75mm = 73.2%*
2.36mm = 64.7%
1.18mm = 56.8%*
0.6mm = 46.2%
0.3mm = 30.7%*
0.15mm = 18.8%
0.075mm = **12.2%***
(Not) Accep Gran B Type III
*(Not) Accep Gran A
%M = 3.9%
150 - 680 Br Sa Some Gr Some Si (AS-18)
16.0mm = 100%
13.2mm = 98.4%*
9.5mm = 95.1%*
4.75mm = 88.3%*
2.36mm = 82.8%
1.18mm = 75.8%*
0.6mm = 62.7%
0.3mm = 40.6%*
0.15mm = 23.1%
0.075mm = 13.2%*
(Not) Accep Gran B Type III
*(Not) Accep Gran A
%M = 6.3%
680 - 750 Gry Cl W Si Tr Gr (AS-19)
750 - 1.20 Br Si W Cl (AS-20)
1.20 - 2.13 Br Si W Cl (AS-21)

BH No.: 3
Sta.: 10+273, 1.9 m Lt of CL, Seventh Street

0 - 25 Asph
25 - 220 Br Sa W Gr Tr Si (AS-1)
26.5mm = 100%
19.0mm = 92.7%
16.0mm = 87.1%
13.2mm = 77.8%
9.5mm = 66.3%
4.75mm = 53.6%
2.36mm = 45.1%
1.18mm = 37.2%
0.6mm = 27.6%
0.3mm = 17.3%
0.15mm = 10.9%
0.075mm = 7.5%
Accep Gran A
%M = 3.1%
220 - 380 Br Sa Tr Gr Tr Si (AS-2)
26.5mm = 100%
19.0mm = 97.3%

		16.0mm	=	96.2%
		13.2mm	=	94.7%*
		9.5mm	=	92.1%*
		4.75mm	=	87.2%*
		2.36mm	=	82.6%
		1.18mm	**=**	**76.0%***
		0.6mm	=	63.6%
		0.3mm	**=**	**41.6%***
		0.15mm	=	23.6%
		0.075mm	**=**	**13.6%***
		(Not) Accept Gran B Type III		
		*(Not) Accep Gran A		
		%M	=	15.51%
380	-	1.30 Br Si W Cl Tr Sa Moist (AS-3)		
		9.5mm	=	100%
		4.75mm	=	99.9%
		2.00mm	=	99.9%
		0.0075	=	97.1%
		0.005	=	48.0%
		0.002	=	29.3%
		MSFH		
		LL	=	34.4%
		PL	=	18.9%
		PI	=	15.5%
		CLASS	=	CL
		%M	=	29.2%
1.30	-	2.13 Br Cl (Y) Si Cl Tr Sa (AS-4)		
		9.5mm	=	100%
		4.75mm	=	99.4%
		2.00mm	=	98.7%
		0.0075	=	96.8%
		0.005	=	38.5%
		0.002	=	33.6%
		HSFH		
		%M	=	27.1%

BH No.: 2
Sta.: 10+276, 3.5 m Lt of CL, Seventh Street

0	-	300	Asph
50	-	90	Br Gr(y) Sa Tr Si
90	-	290	Br Sa Some Gr Tr Si
290	-	1.20	Br Cl Some Si Moist
1.20	-	2.13	Gr Silt W Clay (AS-6)

CH No.: 1
Sta.: 10+300, 1.9 m Rt of CL, Seventh Street

0	-	100	Asph

PAVEMENT DESIGN REPORT, SEVENTH STREET, TOWN OF RENFREW

APPENDIX D: CORE PHOTOS

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CH-1 Core, 100 mm total thickness, 2024

CH-10 Core, 140 mm total thickness, 2024

PAVEMENT DESIGN REPORT, SEVENTH STREET, TOWN OF RENFREW

APPENDIX E: LABORATORY TEST RESULTS

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WATER CONTENT DETERMINATION

Test Method Utilized	☑ MTO LS-701	☐ ASTM D 2216	☐ AASHTO T-265
Project No.: CCO-25-1086			Date Received: May 15,2024
Project Name/Location: Geotech Invest. - 7th Street Renfrew, ON			Date Tested: May 16,2024
Material Type: Soils			Lab Sample No.: OL-24009

Borehole No.	Depth Sample Taken (ft ' & m)	Sample Container I.D.	Wet Sample + Tare (A)	Dry Sample + Tare (B)	Tare (C)	Mass of Sample (D) (B-C)	% Moisture (A-B)/Dx100
BH-3 AS-1	0.025-0.22	P.41	876.95	855.84	181.95	673.89	**3.1**
BH-3 AS-2	0.22-0.37	P.73	844.71	794.63	180.64	613.99	**8.2**
BH-3 AS-3	0.38-1.30	P.85	771.06	630.71	149.98	480.73	**29.2**
BH-3 AS-4	1.30-2.13	P.79	806.52	662.20	129.90	532.30	**27.1**
BH-4 AS-17	0.05-0.15	P.54	708.04	688.14	183.26	504.88	**3.9**
BH-4 AS-18	0.15-0.68	P.59	781.92	745.08	160.44	584.64	**6.3**

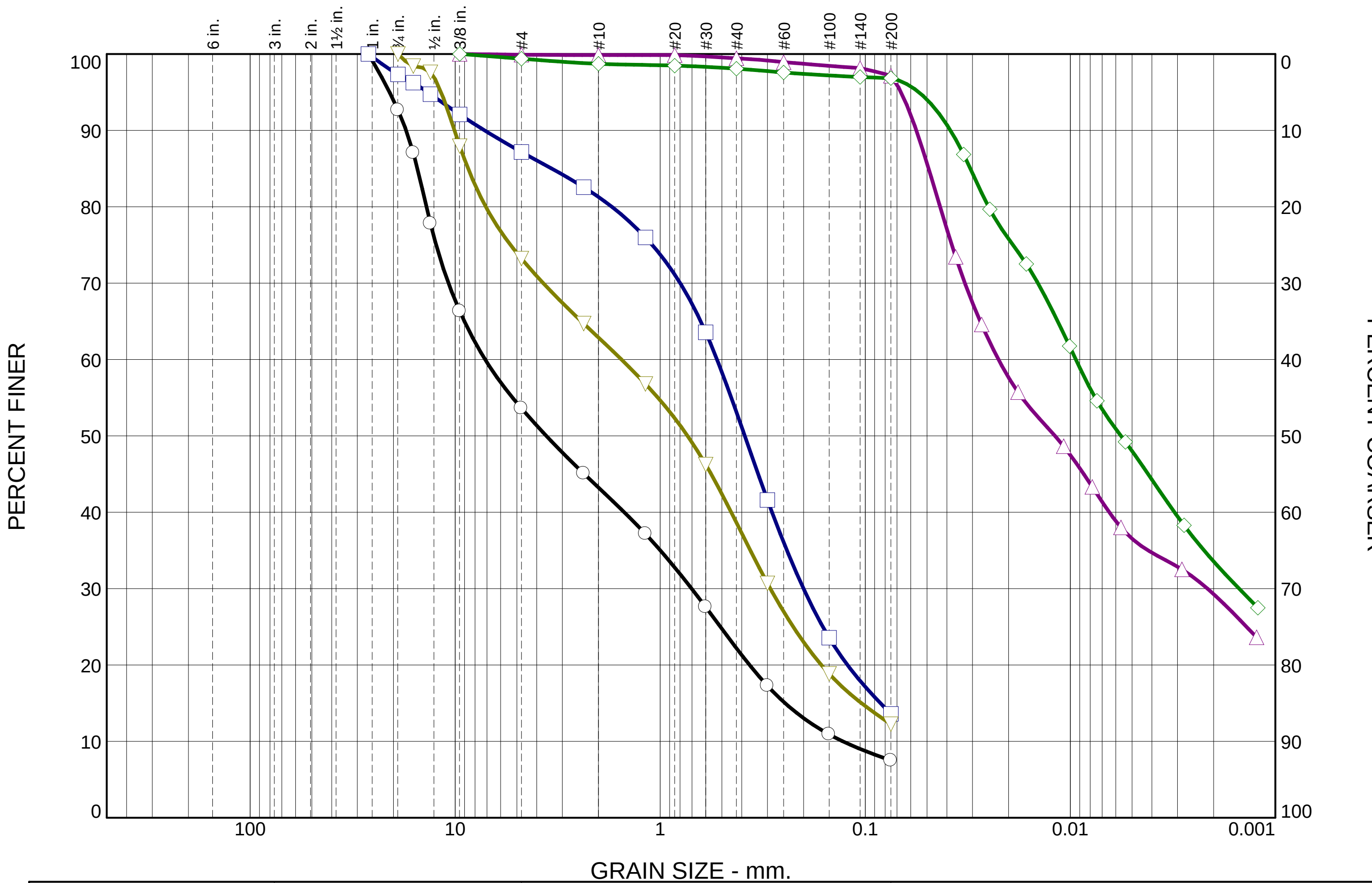
Non-Comformance's from Test Procedure: N/A

Comments:

Checked by: J.H-J

Signature:

Particle Size Distribution Report



	% +75mm	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	7.3	39.1	10.4	21.0	14.7	7.5	
□	0.0	2.7	10.1	5.9	28.2	39.5	13.6	
△	0.0	0.0	0.1	0.0	0.5	2.3	67.8	29.3
◇	0.0	0.0	0.6	0.7	0.6	1.3	63.2	33.6
▽	0.0	0.0	26.8	10.3	24.3	26.4	12.2	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	Seventh Street	AS-1	0.025-0.22m	Sand and Gravel trace Silt/Clay	
□	Seventh Street	AS-2	0.22-0.37m	Sand some Gravel some Silt/Clay	
△	Seventh Street	AS-3	0.38-1.30m	Clayey Silt trace Sand	CL
◇	Seventh Street	AS-4	1.30-2.13m	Clayey Silt trace Silt	
▽	Seventh Street	AS-17	0.05-0.15m	Fine Gravelly Sand some Silt/Clay	

egis

Client: Corporation of the Town of Renfrew
Project: Renfrew-Seventh St Design & Construction
Project No.: CCO-25-1086 **Figure**

Tested By: R.C **Checked By:** J.Hopwood-Jones

GRAIN SIZE DISTRIBUTION TEST DATA

2024-05-24

Client: Corporation of the Town of Renfrew
Project: Renfrew-Seventh St Design & Construction
Project Number: CCO-25-1086
Location: BH-3 AS-1
Depth: 0.025-0.22m
Sample Number: AS-1
Material Description: Sand and Gravel trace Silt/Clay
Tested by: R.C
Checked by: J.Hopwood-Jones

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
673.89	0.00	0.00	26.5mm	0.00	100.0	0.0
			19.0mm	49.53	92.7	7.3
			16.0mm	87.22	87.1	12.9
			13.2mm	149.59	77.8	22.2
			9.5mm	226.90	66.3	33.7
			4.75mm	312.61	53.6	46.4
			2.36mm	370.18	45.1	54.9
			1.18mm	423.50	37.2	62.8
			0.600mm	488.08	27.6	72.4
			0.300mm	557.54	17.3	82.7
			0.150mm	600.38	10.9	89.1
			0.075mm	623.43	7.5	92.5

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	7.3	39.1	46.4	10.4	21.0	14.7	46.1			7.5

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.1287	0.2462	0.3669	0.7036	1.4973	3.5933	7.1501	13.8125	15.2808	17.3333	20.9008

Fineness Modulus	C_u	C_c
4.49	55.54	0.54

GRAIN SIZE DISTRIBUTION TEST DATA

2024-05-24

Client: Corporation of the Town of Renfrew
Project: Renfrew-Seventh St Design & Construction
Project Number: CCO-25-1086
Location: BH-3 AS-2
Depth: 0.22-0.37m
Sample Number: AS-2
Material Description: Sand some Gravel some Silt/Clay
Tested by: R.C
Checked by: J.Hopwood-Jones

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
613.99	0.00	0.00	26.5mm	0.00	100.0	0.0
			19.0mm	16.40	97.3	2.7
			16.0mm	23.11	96.2	3.8
			13.2mm	32.32	94.7	5.3
			9.5mm	48.60	92.1	7.9
			4.75mm	78.81	87.2	12.8
			2.36mm	107.10	82.6	17.4
			1.18mm	147.52	76.0	24.0
			0.600mm	223.78	63.6	36.4
			0.300mm	358.58	41.6	58.4
			0.150mm	469.35	23.6	76.4
			0.075mm	530.55	13.6	86.4

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	2.7	10.1	12.8	5.9	28.2	39.5	73.6			13.6

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
		0.0844	0.1222	0.2001	0.2851	0.3871	0.5288	1.7217	3.3831	7.1927	13.6298

Fineness Modulus
2.36

GRAIN SIZE DISTRIBUTION TEST DATA

2024-05-24

Client: Corporation of the Town of Renfrew
Project: Renfrew-Seventh St Design & Construction
Project Number: CCO-25-1086
Location: BH-3 AS-3
Depth: 0.38-1.30m
Sample Number: AS-3
Material Description: Clayey Silt trace Sand
USCS: CL
Tested by: R.C
Checked by: J.Hopwood-Jones

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
480.73	0.00	0.00	9.5mm	0.00	100.0	0.0
			4.75mm	0.46	99.9	0.1
			2.00mm	0.71	99.9	0.1
54.88	0.00	0.00	0.850mm	0.00	99.9	0.1
			0.425mm	0.23	99.4	0.6
			0.250mm	0.51	98.9	1.1
			0.106mm	0.94	98.1	1.9
			0.075mm	1.49	97.1	2.9

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 99.9
Weight of hydrometer sample =54.88
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -6.0
Meniscus correction only = -1.0
Specific gravity of solids = 2.775
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.6007 **-** 0.187 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	22.2	47.0	41.5	0.0128	46.0	8.0	0.0362	73.4	26.6
2.00	22.2	42.0	36.5	0.0128	41.0	8.9	0.0271	64.6	35.4
5.00	22.2	37.0	31.5	0.0128	36.0	9.9	0.0180	55.7	44.3
15.00	22.2	33.0	27.5	0.0128	32.0	10.6	0.0108	48.6	51.4
30.00	22.2	30.0	24.5	0.0128	29.0	11.2	0.0078	43.3	56.7
60.00	22.2	27.0	21.5	0.0128	26.0	11.7	0.0057	38.0	62.0
250.00	21.8	24.0	18.4	0.0129	23.0	12.3	0.0029	32.5	67.5
1440.00	21.7	19.0	13.3	0.0129	18.0	13.2	0.0012	23.6	76.4

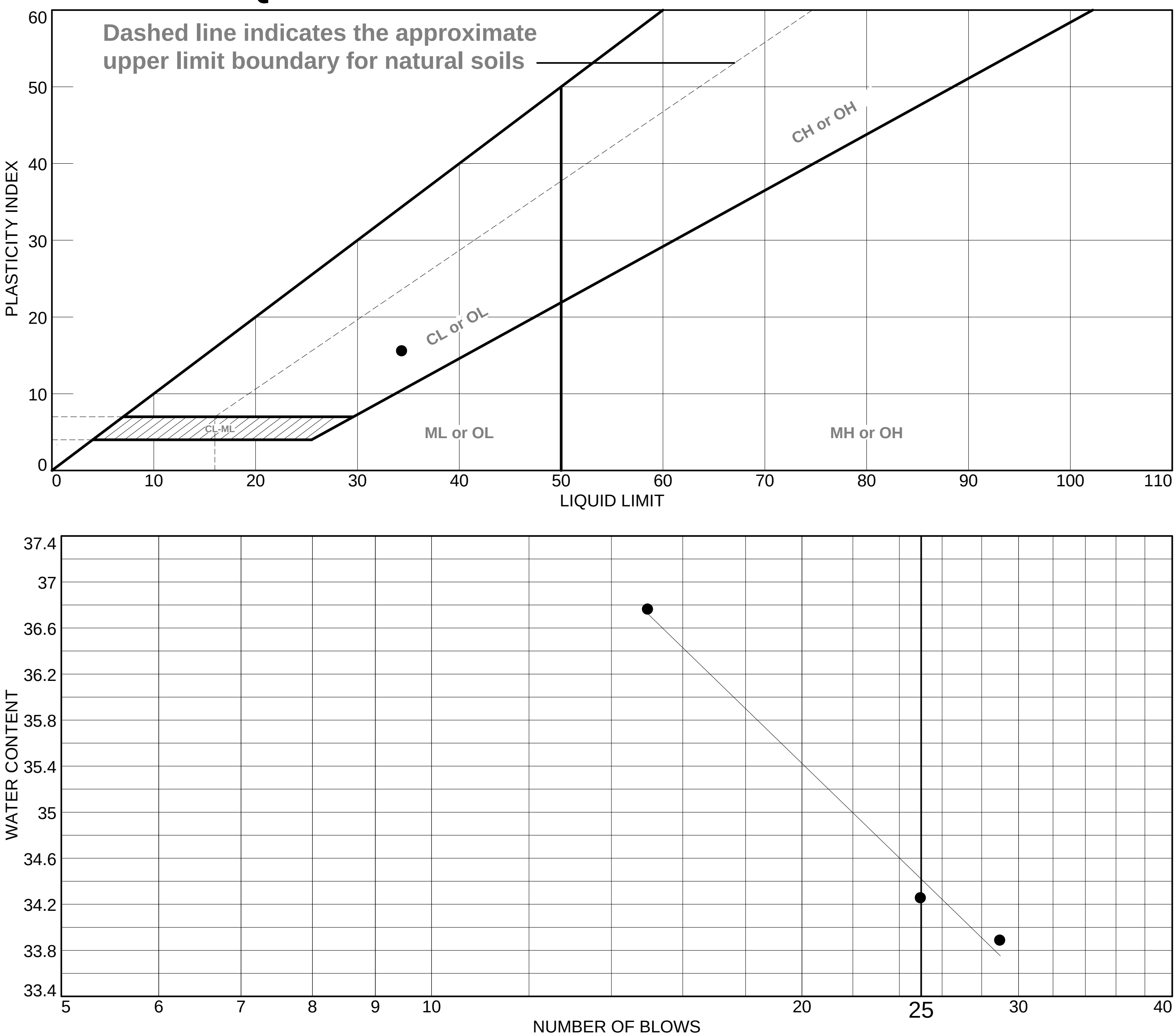
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.1	0.1	0.0	0.5	2.3	2.8	67.8	29.3	97.1

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
				0.0021	0.0065	0.0119	0.0224	0.0431	0.0491	0.0563	0.0669

Fineness Modulus
0.03

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Clayey Silt trace Sand	34.4	18.9	15.5	99.4	97.1	CL

Project No. CCO-25-1086 **Client:** Corporation of the Town of Renfrew

Project: Renfrew-Seventh St Design & Construction

Location: BH-3 AS-3
Sample Number: AS-3 **Depth:** 0.38-1.30m

egis

Remarks:

Figure

Tested By: R.C **Checked By:** J.Hopwood-Jones

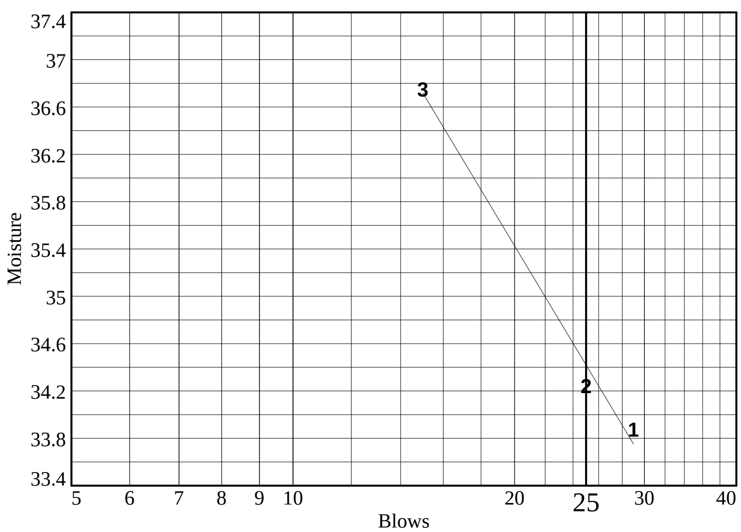
LIQUID AND PLASTIC LIMIT TEST DATA

2024-05-24

Client: Corporation of the Town of Renfrew
Project: Renfrew-Seventh St Design & Construction
Project Number: CCO-25-1086
Location: BH-3 AS-3
Depth: 0.38-1.30m **Sample Number:** AS-3
Material Description: Clayey Silt trace Sand
%<#40: 99.4 **%<#200:** 97.1 **USCS:** CL **AASHTO:** A-6(15)
Tested by: R.C **Checked by:** J.Hopwood-Jones

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	26.04	25.56	26.48			
Dry+Tare	24.60	24.19	24.87			
Tare	20.35	20.19	20.49			
# Blows	29	25	15			
Moisture	33.9	34.2	36.8			



Liquid Limit= 34.4
Plastic Limit= 18.9
Plasticity Index= 15.5
Natural Moisture= 29.2
Liquidity Index= 0.7

Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	22.82	22.77	23.10	
Dry+Tare	22.48	22.36	22.65	
Tare	20.65	20.21	20.30	
Moisture	18.6	19.1	19.1	

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
771.06	630.71	149.98	29.2

GRAIN SIZE DISTRIBUTION TEST DATA

2024-05-24

Client: Corporation of the Town of Renfrew
Project: Renfrew-Seventh St Design & Construction
Project Number: CCO-25-1086
Location: BH-3 AS-4
Depth: 1.30-2.13m
Sample Number: AS-4
Material Description: Clayey Silt trace Silt
Tested by: R.C
Checked by: J.Hopwood-Jones

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
532.30	0.00	0.00	9.5mm	0.00	100.0	0.0
			4.75mm	3.31	99.4	0.6
			2.00mm	6.83	98.7	1.3
53.62	0.00	0.00	0.850mm	0.13	98.5	1.5
			0.425mm	0.35	98.1	1.9
			0.250mm	0.62	97.6	2.4
			0.106mm	0.94	97.0	3.0
			0.075mm	1.02	96.8	3.2

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 98.7
Weight of hydrometer sample =53.62
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -6.0
Meniscus correction only = -1.0
Specific gravity of solids = 2.775
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.6007 **-** 0.187 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	22.2	54.0	48.5	0.0128	53.0	6.7	0.0331	86.8	13.2
2.00	22.2	50.0	44.5	0.0128	49.0	7.4	0.0247	79.7	20.3
5.00	22.2	46.0	40.5	0.0128	45.0	8.2	0.0164	72.5	27.5
15.00	22.2	40.0	34.5	0.0128	39.0	9.3	0.0101	61.8	38.2
30.00	22.2	36.0	30.5	0.0128	35.0	10.1	0.0074	54.6	45.4
60.00	22.2	33.0	27.5	0.0128	32.0	10.6	0.0054	49.2	50.8
250.00	21.8	27.0	21.4	0.0129	26.0	11.7	0.0028	38.3	61.7
1440.00	21.7	21.0	15.3	0.0129	20.0	12.9	0.0012	27.5	72.5

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.6	0.6	0.7	0.6	1.3	2.6	63.2	33.6	96.8

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
				0.0015	0.0031	0.0057	0.0094	0.0251	0.0307	0.0384	0.0548

Fineness Modulus
0.10

GRAIN SIZE DISTRIBUTION TEST DATA

2024-05-24

Client: Corporation of the Town of Renfrew
Project: Renfrew-Seventh St Design & Construction
Project Number: CCO-25-1086
Location: BH-4 AS-17
Depth: 0.05-0.15m
Sample Number: AS-17
Material Description: Fine Gravelly Sand some Silt/Clay
Tested by: R.C
Checked by: J.Hopwood-Jones

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
504.88	0.00	0.00	19.0mm	0.00	100.0	0.0
			16.0mm	8.00	98.4	1.6
			13.2mm	12.06	97.6	2.4
			9.5mm	60.92	87.9	12.1
			4.75mm	135.25	73.2	26.8
			2.36mm	178.22	64.7	35.3
			1.18mm	218.14	56.8	43.2
			0.600mm	271.43	46.2	53.8
			0.300mm	349.96	30.7	69.3
			0.150mm	409.75	18.8	81.2
			0.075mm	443.07	12.2	87.8

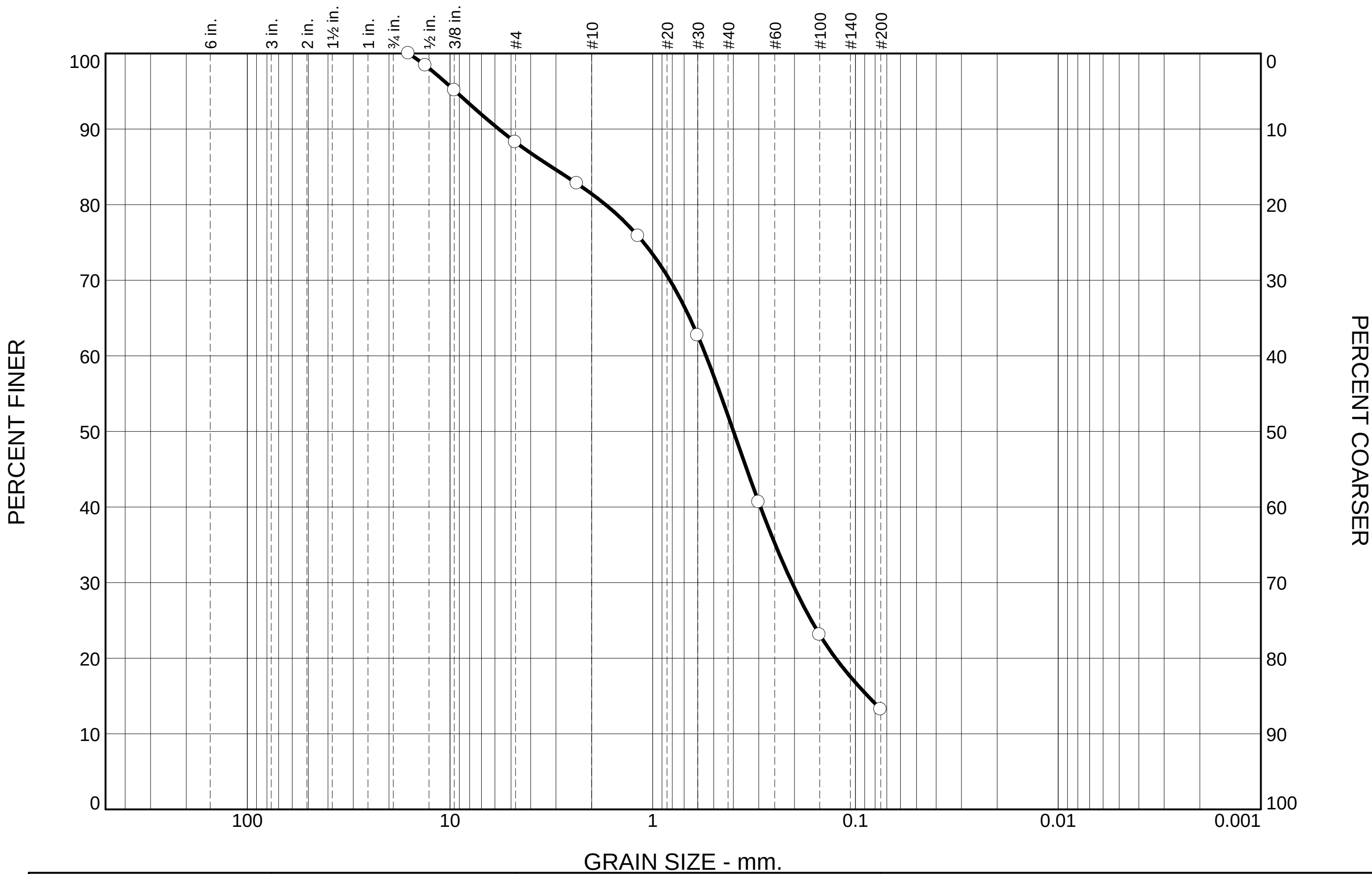
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	26.8	26.8	10.3	24.3	26.4	61.0			12.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
		0.1044	0.1638	0.2905	0.4508	0.7361	1.5452	7.0957	8.6519	10.0825	11.7048

Fineness Modulus
3.22

Particle Size Distribution Report



	% +75mm	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	11.7	6.9	29.3	38.9	13.2	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	Seventh Street	AS-18	0.15-0.68m	Sand some Silt/Clay some fine Gravel	

egis

Client: Corporation of the Town of Renfrew
Project: Renfrew-Seventh St Design & Construction

Project No.: CCO-25-1086 **Figure**

Tested By: R.C **Checked By:** J.Hopwood-Jones

GRAIN SIZE DISTRIBUTION TEST DATA

2024-05-24

Client: Corporation of the Town of Renfrew
Project: Renfrew-Seventh St Design & Construction
Project Number: CCO-25-1086
Location: BH-4 AS-18
Depth: 0.15-0.68m
Sample Number: AS-18
Material Description: Sand some Silt/Clay some fine Gravel
Tested by: R.C
Checked by: J.Hopwood-Jones

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
584.64	0.00	0.00	16.0mm	0.00	100.0	0.0
			13.2mm	9.39	98.4	1.6
			9.5mm	28.64	95.1	4.9
			4.75mm	68.66	88.3	11.7
			2.36mm	100.69	82.8	17.2
			1.18mm	141.26	75.8	24.2
			0.600mm	218.19	62.7	37.3
			0.300mm	347.18	40.6	59.4
			0.150mm	449.65	23.1	76.9
			0.075mm	507.39	13.2	86.8

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	11.7	11.7	6.9	29.3	38.9	75.1			13.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
		0.0870	0.1253	0.2057	0.2941	0.3995	0.5461	1.7070	3.1569	5.7503	9.4089

Fineness Modulus
2.32

PAVEMENT DESIGN REPORT, SEVENTH STREET, TOWN OF RENFREW

APPENDIX F: SITE PHOTOGRAPHS

1-1329 Gardiners Road, Kingston, ON K7P 0L8 | T. 613-542-3788 | F. 613-542-7583
info.north-america@egis-group.com | www.egis-group.com

Seventh Street at Barnet Boulevard, looking north, showing CH-10 location on new asphalt, newer asphalt pavement paved to the Barnet Boulevard back of radii with Seventh Street, 2024

Seventh Street, looking north, showing BH-8 and BH-9 locations, 2024

Seventh Street, looking north, showing BH-6 and BH-7 locations, 2024

Seventh Street, looking north, showing BH-4 and BH-5 locations, 2024

Seventh Street, looking north, showing BH-2 and BH-3 locations, intersection with O'Brien Street in background, 2024

Seventh Street at O'Brien Street intersection. showing CH-1 location on new asphalt, newer asphalt pavement paved to the Barnet Boulevard back of radii with Seventh Street, 2024