City of Hamilton Street Improvement Plan

May 2019

GRE
GREAT RIVER ENGINEERING

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City of Hamilton

Street Improvement Plan

Introduction

The City of Hamilton (City) secured the services of Great River Engineering (GRE) to evaluate the City's roadway system. The overall goal was to provide the City with and overview of current street conditions and recommendation of improvements for their 24 miles of roadway.

This goal was accomplished by gathering data during onsite inspections of the existing roadways. The data was used to evaluate the condition of the current system and outline recommended improvements. The recommendation includes a prioritization and probable cost of the roadways.

Field Visits

In March of 2019, GRE inspected 19 miles of roadway. This inspection process was broken down from intersection to intersection to ensure a more detailed and thorough inspection of the City's roadway system. No state routes were inspected.

Due to the large volume of geographically referenced data involved in this project, GRE developed a Geographical Information System (GIS) database. This database allows GRE users to simply click on an item and instantly receive information about it. The inspection process was used to collect information regarding the condition of each roadway by evaluating different components. These components include:

1. **Roadway Name & Width**

2. **Traffic Volume -** High traffic routes were provided by the City. While collecting data, GRE monitored levels as well and ranked the roadways into high, moderate, and low categories.

3. **Surface Type -** Asphalt, chip & seal, and gravel roads were inspected.

4. **Stormwater Collection Condition -** Included approximate size and condition of curb & gutter, ditches, and culverts as applicable.

5. **Roadway Condition -** The assessment of each roadway condition was rated on a one to five scale as follows: 1 – Very Poor, 2 – Poor, 3 – Moderate, 4 – Good, 5 – New or nearly new (No notable deficiencies)

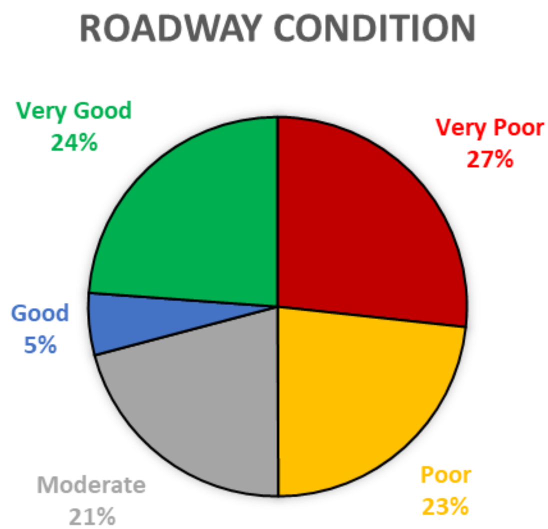
6. **Failure Types –** Types included Alligator Cracking, Block Cracking, Longitudinal Cracking, Transverse Cracking, Edge Cracks, Joint Reflection Cracks, Slippage Cracks, Pot Holes, Depressions, Rutting, Shoving, Upheaval, Raveling

7. **Proposed Improvement –** Categorizes included Full Depth Reclamation (FDR), Mill and Overlay, Surface Sealing, or No work needed at this time

8. **Pictures –** Included overall roadway photo and close ups of failures.

Findings

Of the 19 miles of roadway that GRE inspected, approximately 17.5 miles were asphalt or chip and seal. Less than 1.5 miles were gravel. Of the 17.5 miles of asphalt or chip and seal, about half were considered very poor or poor. The graphic below shows the breakdown of roadway condition in the City. Additionally, Exhibit 1 shows the existing condition of each roadway.



Typical failures that were encountered on roads rated very poor include alligator cracking, pot holes spread throughout, and rutting. These failure types are typically associated with a weak base or sub grade. Below are a few sample pictures from the City's roads showing these failures.

Alligator Cracking

Pot Holes

Rutting

Typical failures that were encountered on roads rated poor include edge cracking and depressions. Edge cracking is typically caused by poor drainage or vegetation along the pavement edge. Depressions are caused by a weak or thin surface. Below are a few sample pictures from the City's roads showing these failures.

Edge Cracking

Depressions

Typical failures that were encountered on roads rated moderate include raveling or block cracking. Raveling and block cracking are usually caused by incorrect mix design or application. Without proper sealing moisture will penetrate the cracks and create worse conditions.


Raveling


Block Cracking

Roads rated good or very good are roadways that did not contain any notable deficiencies. Some did exhibit longitudinal or transverse cracking. These cracks should be sealed to keep moisture out to extend the service life of the roadways.


Transverse Cracking


Longitudinal Cracking

Subsurface Conditions

Three boring locations were tested for subsurface conditions. The full geotechnical engineering report can be found in Appendix B. In general, the findings were as follows:

SOIL STRATA TYPE	Approximate Layer Thicknesses
Asphaltic Concrete	2 inches
Deteriorated Asphalt/Chip-And-Seal Pavement	9 – 9 ½ inches
Undocumented Fill	9 inches – 1 foot
Low Plasticity Clay	1¾ – 2 feet

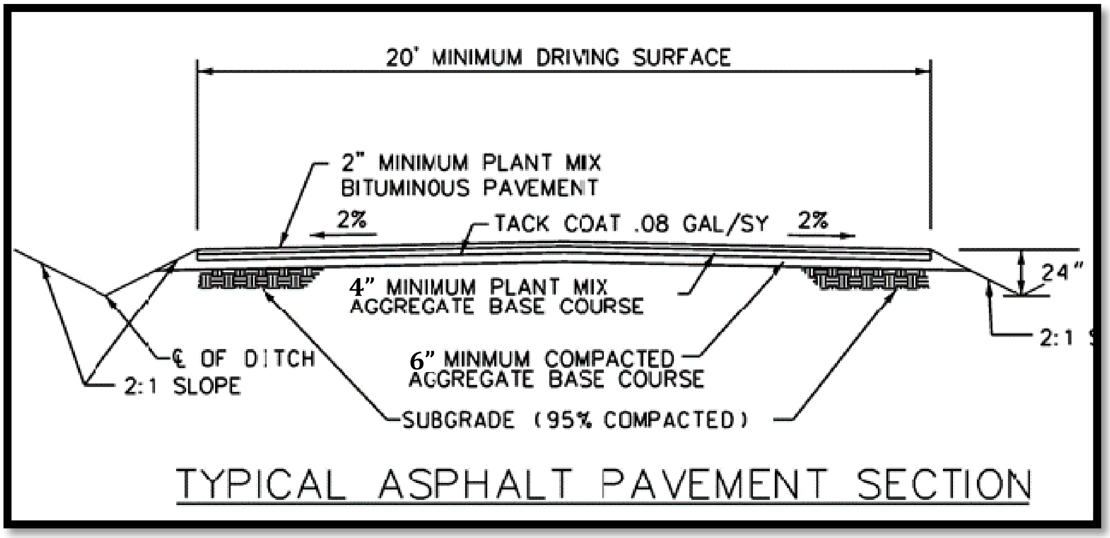
Improvements

After the existing conditions were analyzed, GRE began evaluating options for improvements.

The first option considered was Full Depth Reclamation (FDR). Full Depth Pavement Reclamation can be accomplished with either asphalt or concrete. Asphalt has an approximate service life of 10 - 25 years. The work consists of the following:

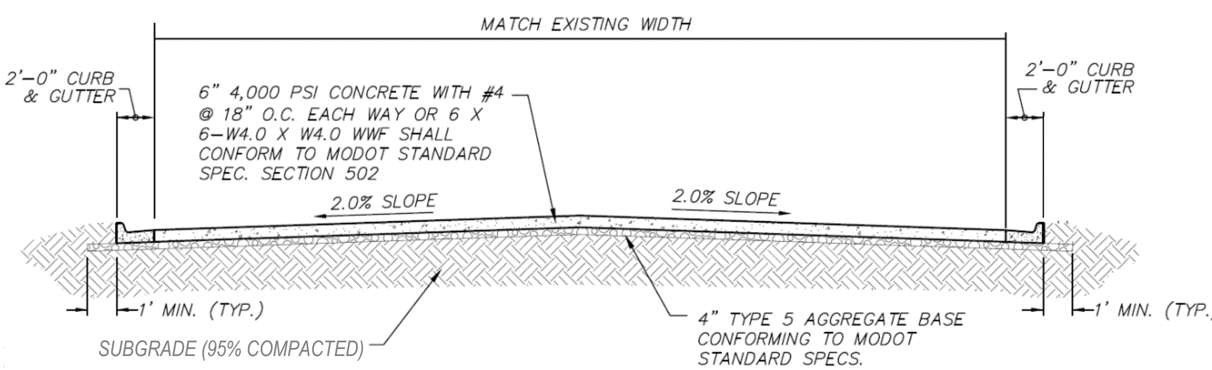
- Linear Grading, Class 1, consists of removing 12 inches of existing pavement and subgrade. It also includes any grading work necessary to bring the roadway to the required grade and cross section within reasonable tolerance. The work shall also include the following:
    1. Construction of all inlet and outlet ditches and ditch blocks within the linear grading limits unless otherwise provided for in the contract.
    2. Construction of entrances and approaches.
    3. Breaking up and satisfactory removal or incorporation into the roadway of all gravel, macadam or bituminous surfaces.
    4. Compaction of the roadway subgrade within linear grading limits
- Subgrade Stabilization consists of the repair of any soft spots found in the subgrade during construction.
- Type 1 Aggregate for Base consists of furnishing and placing 6 inches of one or more courses of aggregate on a prepared subgrade as shown on the plans or as directed by the engineer.
- Bituminous Base consists of a 4 inches bituminous mixture base placed, spread and compacted as shown on the plans or as directed by the engineer.
- Bituminous Pavement consists of a 2 inches bituminous pavement surface placed, spread and compacted as shown on the plans or as directed by the engineer.
- Tack Coat consists of spraying tack coat across the full width of the existing surface before the bituminous pavement mixture is applied. This will ensure both surfaces seamlessly come together.
- Modified Cold Milling (Depth Transition) consists of a 10-foot depth transitions at the beginning and end of a project and side roads, bridge ends or other locations shown on the plans. All

entrances and driveways shall consist of a 2-foot depth transition. This will ensure a smooth transition from new to existing pavement.



Concrete has an approximate service life of 20 - 40 years.   The work consists of the following:

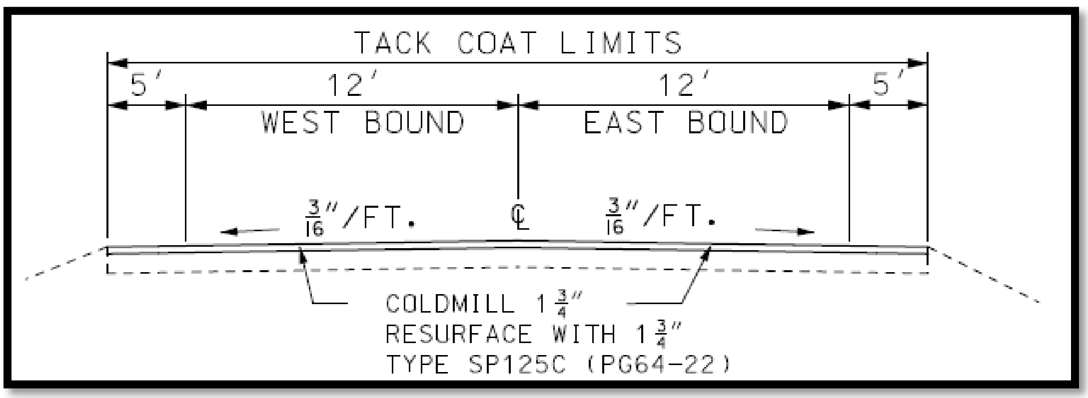
- Linear Grading, Class 1 and subgrade stabilization would be the same
- Type 1 Aggregate for Base consists of furnishing and placing 4 inches of one or more courses of aggregate on a prepared subgrade as shown on the plans or as directed by the engineer.
- Full Depth Pavement Saw cuts consists creating a transitions at the beginning and end of a project and side roads.
- 6" Portland Cement Concrete Pavement consists of constructing a Portland cement concrete base or pavement, minimally reinforcement as specified, shown on the plans or directed by the engineer.



<u>Typical Concrete Pavement with Curb and Gutter Section</u>

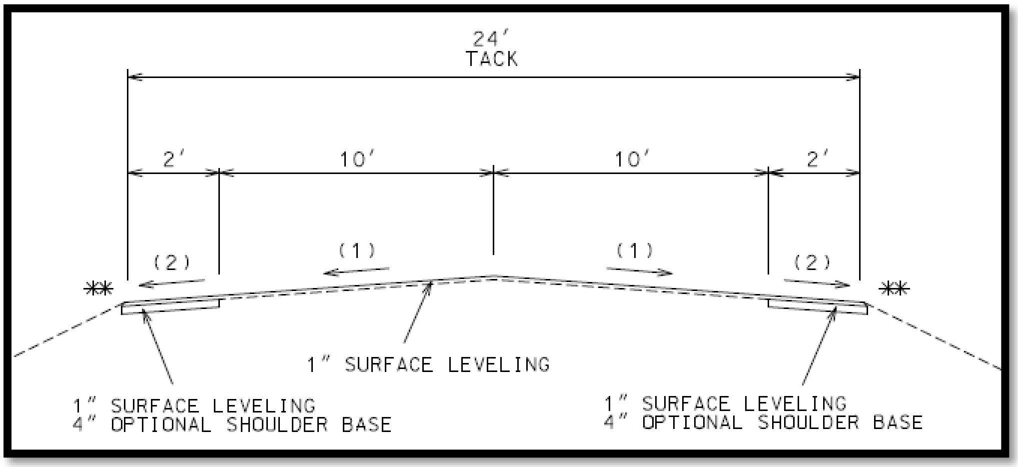
The second improvement option considered was Mill/Overlay. A Mill/Overlay has an approximate service life of 7-10 years and consists of the following work:

- Coldmilling Bituminous Pavement for Removal consists of coldmilling the existing pavement surface 1.75 inches to the depth, profile and cross slope shown on the plans and removing and disposing of the milled material.
- Tack Coat consists of spraying tack coat across the full width of the existing surface before bituminous pavement mixture is applied. This will ensure both surfaces seamlessly come together.
- Bituminous Pavement consists of a 1.75 inches bituminous pavement surface placed, spread and compacted as shown on the plans or as directed by the engineer.
- Modified Cold Milling (Depth Transition) consists of a 10-foot depth transitions at the beginning and end of a project and side roads, bridge ends or other locations shown on the plans. All entrances and driveways shall consist of a 2-foot depth transition. This will ensure a smooth transition from new to existing pavement.



The third improvement option was Surface Sealing. Surface Sealing has an approximate service life of 5 – 7 years and consists of the following work:

- Tack Coat consists of spraying tack coat across the full width of the existing surface before bituminous pavement mixture is applied. This will ensure both surfaces seamlessly come together.
- Bituminous Pavement consists of a 1-inch bituminous pavement surface placed, spread and compacted as shown on the plans or as directed by the engineer.
- Modified Cold Milling (Depth Transition) consists of a 10-foot depth transitions at the beginning and end of a project and side roads, bridge ends or other locations shown on the plans. All entrances and driveways shall consist of a 2-foot depth transition. This will ensure a smooth transition from new to existing pavement.



In general, GRE recommends roads rated very poor are improved using FDR. This is due to the weak subgrade that needs to be fixed prior to repairing the surface. It is recommended roads rated poor are improved using Mill/Overlay. This will allow proper removal of deficient pavement and application of a smooth surface. For roads rated moderate, GRE recommends Surface Sealing. This will extend the life of existing pavements. Roads rated good or very good are considered to not need work at this time. Gravel roads were not considered for improvement as they can be maintained by the City at a relatively low cost. Developing and implementing an Operation and Maintenance Plan would keep the gravel roads and newly improved roads from becoming future issues.

Preliminary Opinion of Probable Costs

A preliminary opinion of probable costs was developed for each of the proposed improvements. The preliminary opinion of probable costs includes estimated construction costs, contingencies, and engineering. Construction unit costs are based on industry averages and anticipated costs based on experience with similar projects. Costs associated with engineering and contingencies are based on a percentage of construction costs. An example estimated cost for each improvement type is included in Appendix A.

Based on these preliminary opinions of probable cost, it is estimated that to repair all the roads rated moderate, poor, or very poor would cost $6.1 million today.

Prioritization

The purpose of prioritizing the projects is to provide the City with an understanding of which projects have the greatest immediate need. The City will use the prioritized project list in conjunction with the preliminary opinion of probable cost estimates and an understanding of the funding and resources available to determine an implementation schedule for the projects.

The prioritization process involved evaluations of each of the proposed projects against a significant set of criteria. The evaluation criteria were developed to best meet the City's needs based on the scope of services for this study and input from the City.

For the analyzed roadways, the main criteria was traffic volume. Higher volume roads were prioritized first.

The next criteria was distribution of the improvements. By distributing the improvements, travelers will be able to commute more efficiently throughout the community rather than in just one area. GRE took into account recent improvement projects by the City when prioritizing future projects.

The third criteria was cost. The City identified approximately $150,000 a year to be used for street improvements. With that in mind, GRE grouped roadways in proximately to each other and with similar improvement type to reach the funding level.

GRE identified the top ten projects to be considered by the City for future improvements. They are listed below and shown in Exhibit 2. Exhibit 3 shows the proposed improvements with the recent improvements.

Recommended Improvement Projects

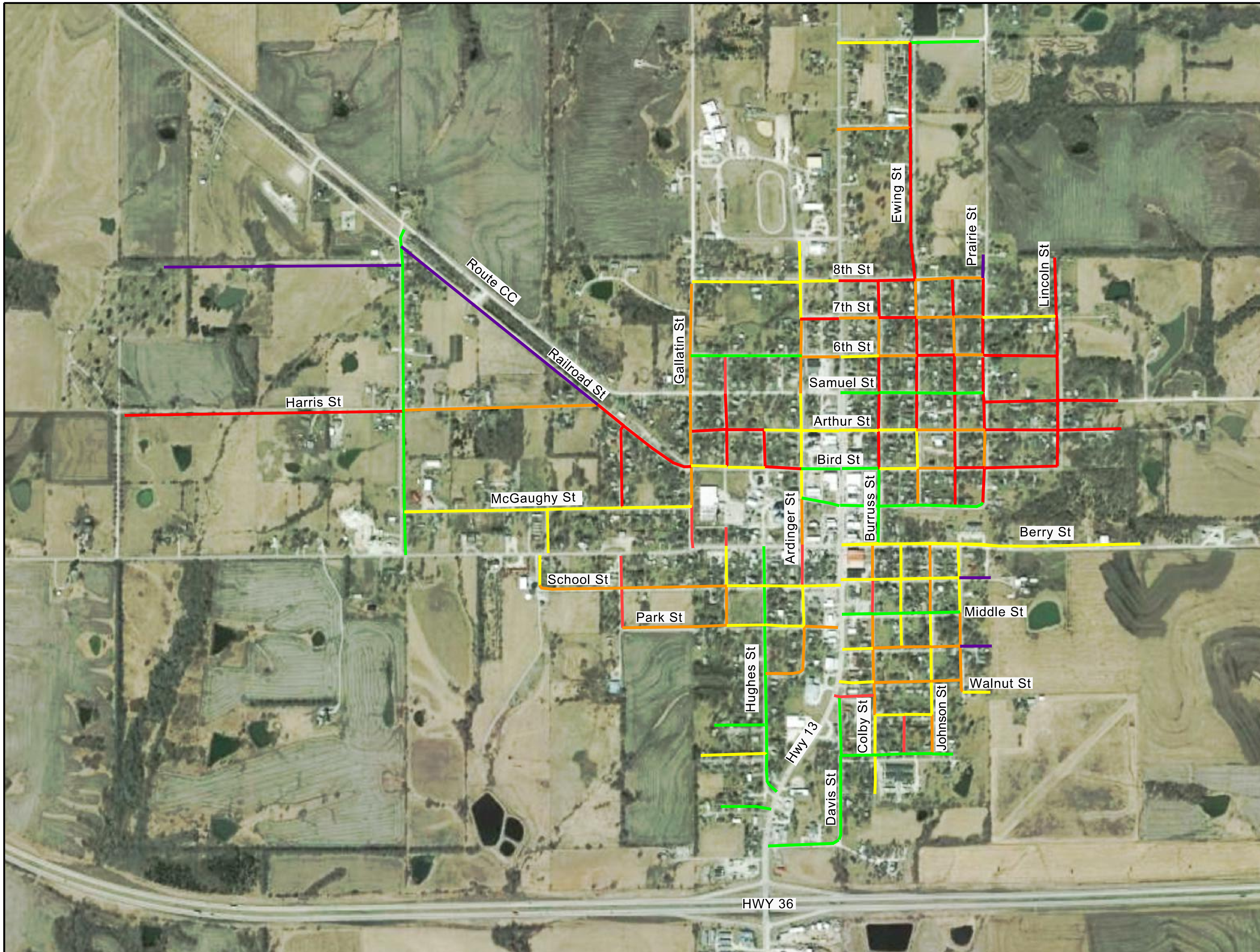
Project	Street Name	Intersection 1	Intersection 2	Length (ft)	Width (ft)	Condition Rating	Traffic Volume	Proposed Improvement	Probable Cost
1	Gallatin Road	W Berry St	W 8th St	2396	21	2	High	Mill/Overlay	$123,000
2	N Ardinger St	W Bird St	W Samuel St	684	22	2	High	FDR	$153,277
3	N Ardinger St	W Samuel St	W 7th St	700	22	2	High	FDR	$156,793
4	N Ardinger St	W 7th St	Memorial Ln	695	22	2	High	FDR	$155,694
5	N Ardinger St	W Bird St	W Berry St	700	22	2	High	FDR	$156,793
6	N Ardinger St	W Berry St	Park St	728	22	2	High	FDR	$163,203
7	E Berry St	City Limits	Hwy 13	2730	34	3	Moderate	Surface Seal	$153,159
	E School St	City Limits	Hwy 13	1083	22	3	Moderate		
8	N Ewing St	E. 8th St	E Samuel St	900	20	1	Low	FDR	$154,939
9	N Ewing St	E Samuel St	E Arthur	467	20	1	Low	FDR	$154,939
	Burruss St	E Samuel St	E Arthur	433	20	1	Low		
10	N Ewing St	E Arthur	E McGaughy	653	20	1	Low	Mill/Overlay	$141,838
	7th St	Lincoln St	Ardinger	2332	18	1	Moderate		

Summary

A total of 19 miles of roadway were inspected. Each roadway was categorized by existing condition and pavement failure types were identified. This information was used to determine improvements needed throughout the City's roadway system. GRE identified the top ten improvements that would benefit the City. Additionally, GRE provided an approximate cost for each project so that the City can plan for the future.

Exhibits

Exhibit 1: Existing Conditions



N
W E
S

Key

Red line	Very Poor
Orange line	Poor
Yellow line	Moderate
Green line	Good or New
Purple line	Gravel

0 1,000 FEET

Exhibit Date: 5/10/2019

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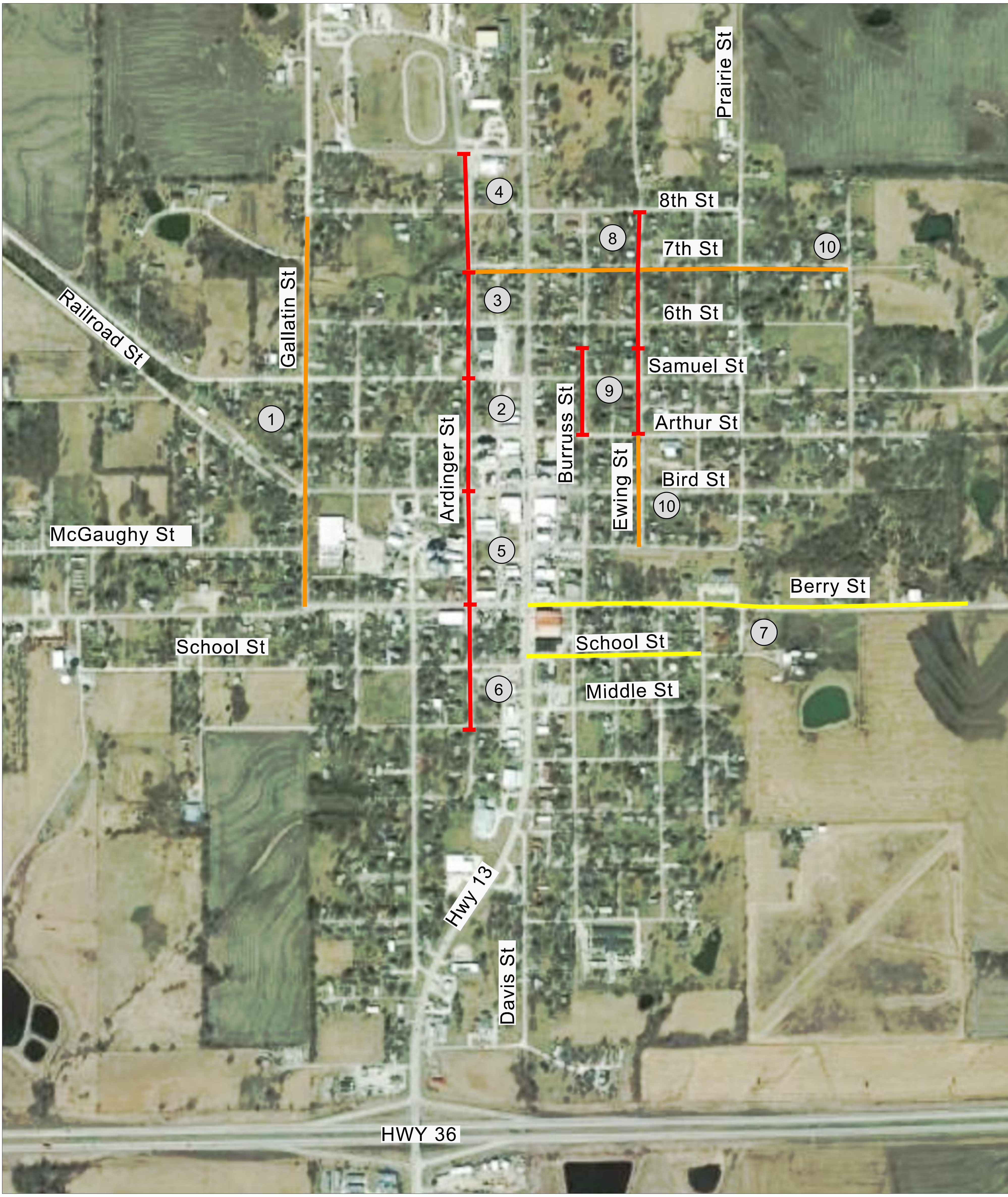

Exhibit 2: Proposed Improvements

Key

- FDR
- Mill Overlay
- Surface Seal

0 500 1,000 FEET

N W E S

Exhibit Date: 5/10/2019

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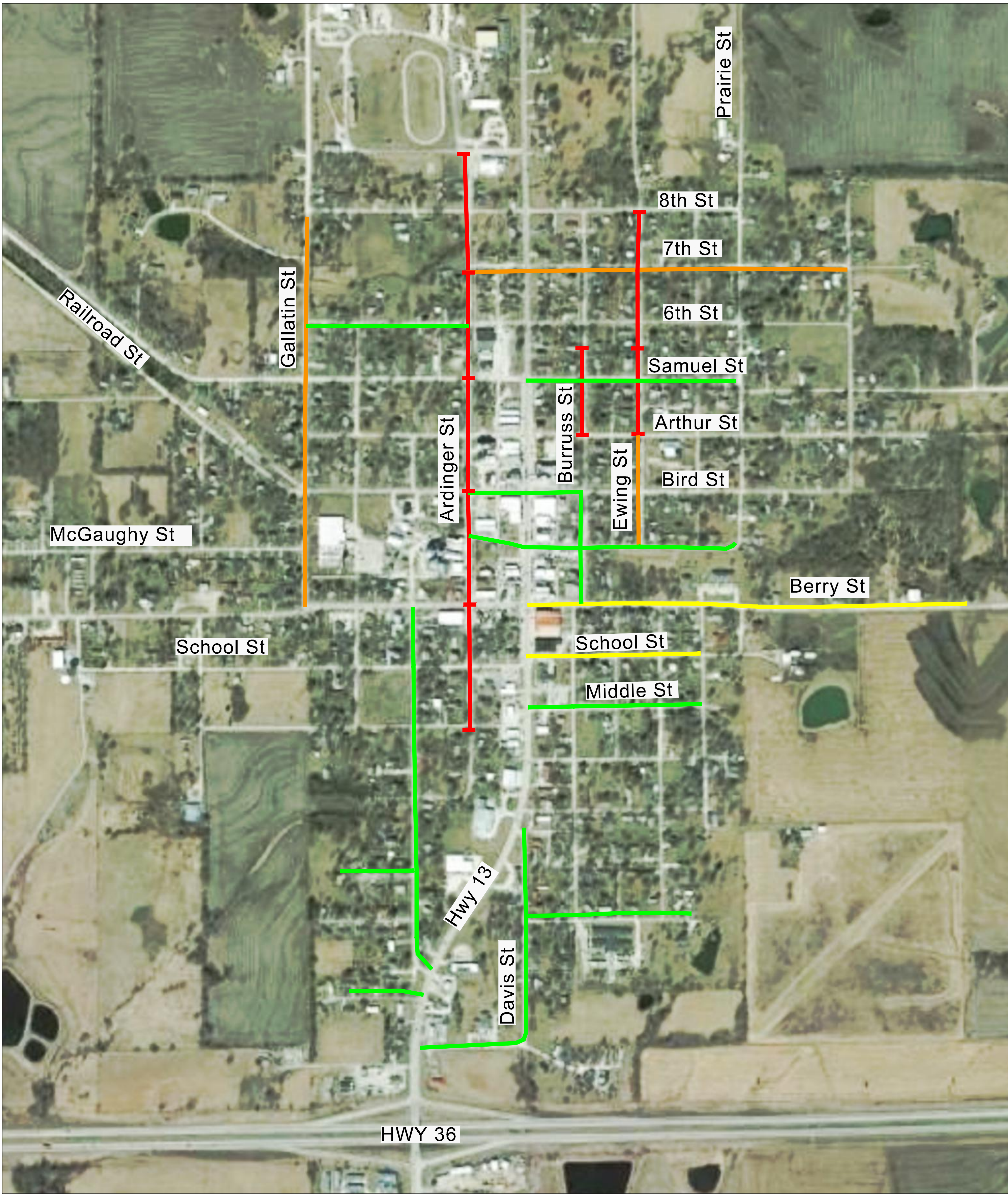

Exhibit 3:
Proposed Conditions

Key

- FDR
- Mill Overlay
- Surface Seal
- No Work Needed

0 500 1,000 FEET

Exhibit Date: 5/10/2019

N W E S

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Appendix A

LOCATION	
INTERSECTION	&
IMPROVEMENT TYPE	FDR with Concrete Replacement
ROADWAY LENGTH (FT)	725
ROADWAY WIDTH (FT)	20

OPINION OF PROBABLE CONSTRUCTION COST

LINE	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	AMOUNT
ROADWAY ITEMS					
1	MOBILIZATION	LS	1	$ 5,098.79	$ 5,098.79
2	LINEAR GRADING CLASS 1	STA.	7	$ 751.00	$ 5,444.75
3	TYPE 1 AGGREGATE FOR BASE (4 IN. THICK)	S.Y.	1,611	$ 5.00	$ 8,055.56
4	FULL DEPTH PAVEMENT SAWCUTS	L.F.	240	$ 3.00	$ 720.00
5	6" PORTLAND CEMENT CONCRETE PAVEMENT	S.Y.	1,611	$ 50.00	$ 80,555.56
6	SILT FENCE	L.F.	1,450	$ 4.00	$ 5,800.00
7	SUBGRADE COMPACTION (6-INCH DEPTH)	STA.	8	$ 175.00	$ 1,400.00
8	TRAFFIC CONTROL	LS	1	$ 3,059.28	$ 3,059.28
				ROADWAY ITEMS SUBTOTAL	**$110,133.93**
PROFESSIONAL SERVICES					
9	ENGINEERING DESIGN	PERCENT	12%		$ 13,216.07
10	ENGINEERING CONSTRUCTION ADMINISTRATION	PERCENT	6%		$ 6,608.04
				PROFESSIONAL SERVICES SUBTOTAL	**$ 19,824.11**
				SUBTOTAL	**$129,958.04**
				CONTINGENCY (15%)	**$ 19,493.71**
				TOTAL OPINION OF PROBABLE COST	**$ 149,451.74**

LOCATION	
INTERSECTION	&
IMPROVEMENT TYPE	FDR with Asphalt Replacement
ROADWAY LENGTH (FT)	850
ROADWAY WIDTH (FT)	20

OPINION OF PROBABLE CONSTRUCTION COST

LINE	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	AMOUNT
ROADWAY ITEMS					
1	MOBILIZATION	LS	1	$ 5,133.77	$ 5,133.77
2	LINEAR GRADING CLASS 1	STA.	9	$ 751.00	$ 6,383.50
3	TYPE 1 AGGREGATE FOR BASE (6 IN. THICK)	S.Y.	1,889	$ 9.00	$ 17,000.00
4	BITUMINOUS PAVEMENT MIXTURE PG64-22, (BP-1)	TON	218.8	$ 100.00	$ 21,884.94
5	BITUMINOUS PAVEMENT MIXTURE PG64-22 (BASE)	TON	407.8	$ 115.00	$ 46,895.86
6	TACK COAT	GAL	108	$ 2.50	$ 269.44
7	MODIFIED COLD MILLING (DEPTH TRANSITIONS)	S.Y.	267	$ 7.00	$ 1,866.67
8	SILT FENCE	L.F.	1,700	$ 4.00	$ 6,800.00
9	SUBGRADE COMPACTION (6-INCH DEPTH)	STA.	9	$ 175.00	$ 1,575.00
10	TRAFFIC CONTROL	LS	1	$ 3,080.26	$ 3,080.26
				ROADWAY ITEMS SUBTOTAL	**$110,889.45**
PROFESSIONAL SERVICES					
11	ENGINEERING DESIGN	PERCENT	12%		$ 13,306.73
12	ENGINEERING CONSTRUCTION ADMINISTRATION	PERCENT	6%		$ 6,653.37
				PROFESSIONAL SERVICES SUBTOTAL	**$ 19,960.10**
				SUBTOTAL	**$130,849.55**
				CONTINGENCY (15%)	**$ 19,627.43**
				TOTAL OPINION OF PROBABLE COST	**$ 150,476.98**

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LOCATION	
INTERSECTION	&
IMPROVEMENT TYPE	Mill/Overlay
ROADWAY LENGTH (FT)	2850
ROADWAY WIDTH (FT)	22

OPINION OF PROBABLE CONSTRUCTION COST

LINE	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	AMOUNT
ROADWAY ITEMS					
1	MOBILIZATION	LS	1	$ 5,373.00	$ 5,373.00
2	BITUMINOUS PAVEMENT MIXTURE PG64-22, (BP-1)	TON	674.1	$ 100.00	$ 67,413.43
3	TACK COAT	GAL	579	$ 2.50	$ 1,446.67
4	COLDMILLING BITUMINOUS PAVEMENT FOR REMOVAL OF SURFACE (3 IN. THICK OR LESS)	S.Y.	6,967	$ 2.00	$ 13,933.33
5	MODIFIED COLD MILLING (DEPTH TRANSITIONS)	S.Y.	267	$ 7.00	$ 1,866.67
6	SILT FENCE	L.F.	5,700	$ 4.00	$ 22,800.00
7	TRAFFIC CONTROL	LS	1	$ 3,223.80	$ 3,223.80
				ROADWAY ITEMS SUBTOTAL	**$ 116,056.90**
PROFESSIONAL SERVICES					
8	ENGINEERING DESIGN	PERCENT	8%		$ 9,284.55
9	ENGINEERING CONSTRUCTION ADMINISTRATION	PERCENT	4%		$ 4,642.28
				PROFESSIONAL SERVICES SUBTOTAL	**$ 13,926.83**
				SUBTOTAL	**$ 129,983.73**
				CONTINGENCY (15%)	**$ 19,497.56**
				TOTAL OPINION OF PROBABLE COST	**$ 149,481.29**

LOCATION	
INTERSECTION	&
IMPROVEMENT TYPE	Surface Sealing
ROADWAY LENGTH (FT)	4800
ROADWAY WIDTH (FT)	22

OPINION OF PROBABLE CONSTRUCTION COST

LINE	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	AMOUNT
ROADWAY ITEMS					
1	MOBILIZATION	LS	1	$ 5,386.67	$ 5,386.67
2	BITUMINOUS PAVEMENT MIXTURE PG64-22, (BP-2)	TON	644.7	$ 100.00	$ 64,466.67
3	TACK COAT	GAL	1200	$ 2.50	$ 3,000.00
4	MODIFIED COLD MILLING (DEPTH TRANSITIONS)	S.Y.	267	$ 7.00	$ 1,866.67
5	SILT FENCE	L.F.	9,600	$ 4.00	$ 38,400.00
6	TRAFFIC CONTROL	LS	1	$ 3,232.00	$ 3,232.00
				ROADWAY ITEMS SUBTOTAL	**$116,352.00**
PROFESSIONAL SERVICES					
7	ENGINEERING DESIGN	PERCENT	8%		$ 9,308.16
8	ENGINEERING CONSTRUCTION ADMINISTRATION	PERCENT	4%		$ 4,654.08
				PROFESSIONAL SERVICES SUBTOTAL	**$ 13,962.24**
				SUBTOTAL	**$130,314.24**
				CONTINGENCY (15%)	**$ 19,547.14**
				TOTAL OPINION OF PROBABLE COST	**$ 149,861.38**

Appendix B

intertek psi

REPORT OF GEOTECHNICAL EXPLORATION

City of Hamilton Street Pavement
7th Street, North Ardinger Street, and East Walnut Street
Hamilton, Missouri

Prepared for

Great River Engineering
1100 Main Street, Suite 2890
Kansas City, Missouri

Prepared by

Professional Service Industries, Inc.
8669 Olive Boulevard
Saint Louis, Missouri 63132

May 3, 2019

PSI Project Number 0040-289

Katherine Heidinger
Project Manager

STATE OF MISSOURI
JACOB T. BILELLO
5/3/19
NUMBER
PE-2004017134
PROFESSIONAL ENGINEER

Jacob T. Bilello, P.E.
Department Manager
MO PE-2004017134
EXP. December 31, 2020

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TABLE OF CONTENTS

1. PROJECT INFORMATION

1.1 PROJECT AUTHORIZATION

The following table summarizes, in chronological order, the project authorization history for the services performed and represented in this report by Professional Service Industries, Inc. (PSI).

PROJECT TITLE: PROPOSED CITY OF HAMILTON STREET PAVEMENT - HAMILTON, MISSOURI		
Document and Reference Number	**Date**	**Requested/Provided By**
Request for Proposal	March 7, 2019	Ms. Lindsey Chaffin of Great River Engineering
PSI Proposal Number: 0040-271454	March 8, 2019	Mr. Jacob Bilello of PSI
Notice to Proceed	April 16, 2019	Ms. Lindsey Chaffin of Great River Engineering

1.2 PROJECT DESCRIPTION

PSI understands that the City of Hamilton, Missouri is planning to rehabilitate its city streets. The existing streets consist of asphalt and/or chip-and-seal pavement. It is PSI's understanding that there is no significant grading proposed for the project. It is PSI's understanding that the client intends to utilize asphalt pavement for the remediation, and that remediation efforts may range from a mill and overlay to full-depth replacement. The following table lists the material and information provided for this project:

DESCRIPTION OF MATERIAL	PROVIDER/SOURCE	DATE
Geotech Locations (JPG file of proposed boring locations)	Great River Engineering	March 27, 2019

Design traffic loading information was not provided. Therefore, PSI has based this report on the pavement section being constructed with a life expectancy of 20 years with an equivalent traffic loading condition of 30,000 equivalent 18-kip single axle loads (ESALs) for standard-duty pavements and 60,000 ESALs for heavy-duty pavements.

The geotechnical recommendations presented in this report are based on the available project information and the subsurface materials described in this report. If the noted information is incorrect, please inform PSI in writing so that we may amend the recommendations presented in this report if appropriate and if desired by the client. PSI will not be responsible for the implementation of its recommendations when it is not notified of changes in the project.

1.3 PURPOSE AND SCOPE OF SERVICES

The purpose of this study was to explore the subsurface conditions at the site to prepare recommendations for subgrade and pavement sections for the proposed construction. PSI's scope of services included drilling three (3) soil test borings at the site to depths of about 3½ feet below the ground surface, select laboratory testing, and preparation of this geotechnical report. This report briefly outlines the project description, presents available project information, testing procedures, describes the site and subsurface conditions, and presents recommendations regarding the following:

- A discussion of subsurface conditions encountered including recommended soil properties, a site location plan, a boring location plan, boring logs, and laboratory data;
- An evaluation of the data as it pertains to pavements for the project;
- Recommendations for site preparation, including placement and compaction of fill soils;
- Pavement section design and pavement subgrade preparation; and
- Comments regarding factors that will impact construction and performance of the proposed construction.

The scope of services did not include an environmental assessment for determining the presence or absence of wetlands, or hazardous or toxic materials in the soil, bedrock, surface water, groundwater, or air, on, or below, or around this site. Any statement in this report or on the boring logs regarding odors, colors, and unusual or suspicious items or conditions are strictly for informational purposes.

2. SITE HISTORY AND CONDITIONS

2.1 SITE LOCATION AND DESCRIPTION

The boring locations for the proposed City of Hamilton street pavement rehabilitation were located along 7th Street, North Ardinger Street, and East Walnut Street in Hamilton, Missouri. The site latitude and longitude of the boring locations are listed in the table below:

Boring No.	Approximate Location	Latitude	Longitude
B-1	7th Street	39.748049°	-90.996234°
B-2	North Ardinger Street	39.742854°	-93.999363°
B-3	East Walnut Street	39.738914°	-93.996105°

The boring locations along 7th Street and East Walnut Street are generally within residential areas, while the boring location along North Ardinger Street is in an industrial area.

2.2 SITE HISTORY (TIMELINE)

Based on historical aerial images obtained from GoogleEarth^{TM}, the areas of the borings have remained relatively unchanged since 1996. Based on the results of our exploration, it appears there have been several layers of asphalt overlay that have been placed over the years.

2.3 GENERAL AREA GEOLOGY

A review of the United States Geological Survey geologic units of Missouri indicates that the bedrock in this region is part of the Kansas City Group consisting of cyclic deposits of limestone and shale with minor sandstone and coal deposits. Additionally, the Missouri Department of Natural Resources GEOSTRAT map layers shows that the surficial geology in this area is glacial drift composed of silty clay and clay mixed with pebbles of limestone, chert and quartzite.

3. EXPLORATION PROCEDURES AND SUBSURFACE CONDITIONS

The soil borings were performed with an electric core machine and a hand auger. Representative grab samples were obtained from the auger bucket and sealed in plastic bags for transport to PSI's soils laboratory. The laboratory testing program was conducted in general accordance with applicable ASTM specifications. The results of these tests are to be found on the accompanying boring logs located in the Appendix.

3.1 SUBSURFACE CONDITIONS

The site subsurface conditions were explored with three (3) soil test borings within the street pavement areas. The borings were drilled to a depth of about 3½ feet. The boring locations were selected by Ms. Lindsey Chaffin of Great River Engineering. PSI personnel staked the borings in the field by measuring distances from available surface features using a 100-foot tape. The locations should be considered accurate only to the degree implied by the means and methods used to define them.

Approximately 11 to 11½ inches of asphaltic pavement was present at the surface of the borings. In Borings B-1 and B-2, the pavement generally consisted of 2½ inches of asphaltic concrete over 9 to 9½ inches of either deteriorated asphalt or chip-and-seal pavement. In Boring B-3 the pavement consisted of 11½ inches of asphaltic concrete. The soils encountered at the borings beneath the pavement primarily included fine-grained soils that extended to the terminal depths of the borings. Based on results of visual classification, these soils were classified as low plasticity (lean) clay (CL) in accordance with the Unified Soil Classification System (USCS). The dynamic cone penetrometer values within these fine-grained soils indicate consistencies of medium stiff to stiff. The moisture contents of the fine-grained soils ranged from 21 to 35 percent with an average value of 28 percent.

The following table briefly summarizes the range of results from the field and laboratory testing programs. Please refer to the attached boring logs and laboratory data sheets for more specific information:

SOIL STRATA TYPE	Approximate Layer Thicknesses	RANGE OF PROPERTY VALUES	
		Dynamic Cone Penetration (blows)	Moisture Content, %
Asphaltic Concrete	2 inches	---	---
Deteriorated Asphalt/Chip-And-Seal Pavement	9 – 9 ½ inches	---	---
Undocumented Fill	9 inches – 1 foot	6 – 11	21 – 28
Low Plasticity Clay	1¾ – 2 feet	5 – 9	28 – 35

Auger refusal materials were not encountered within the borings. Refusal is a designation applied to materials that cannot be further penetrated by the auger with ordinary effort and is normally indicative of a very hard or very dense material, such as boulders or gravel lenses or the upper surface of bedrock.

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring logs included in the Appendix should be reviewed for specific information at individual boring locations. These records include soil descriptions, stratifications, penetration resistances, and locations of the samples and laboratory test data. The stratifications shown on the boring logs represent the conditions only at the actual boring locations. Variations may occur and should be expected between boring locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual. Water level information obtained during field operations is also shown on these boring logs. The samples that were not altered by laboratory testing will be retained for 60 days from the date of this report and then will be discarded.

3.2 WATER LEVEL MEASUREMENTS

Free groundwater was not observed in the borings upon completion, indicating that groundwater at the site at the time of the exploration was either below the terminated depths of the borings, or that the soils encountered are relatively impermeable. Although free water was not encountered at this time, water can be present within the depths explored during other times of the year depending upon climatic and rainfall conditions. However, it should be noted that saturated soils were identified during laboratory analysis at depths as shallow as 1 foot below the ground surface.

The groundwater level at the site, as well as perched water levels and volumes, will fluctuate based on variations in rainfall, snowmelt, evaporation, surface run-off and other related hydro-geologic factors. The water level measurements presented in this report are the levels that were measured at the time of PSI's field activities.

4. GEOTECHNICAL EVALUATION

The following geotechnical related recommendations have been developed based on the subsurface conditions encountered and PSI's understanding of the proposed development. Should changes in the project criteria occur, a review must be made by PSI to determine if modifications to our recommendations will be required.

There are four (4) primary geotechnical related concerns at this site that have been identified, which will affect the performance of the foundations for this structure. The following summarizes those concerns:

1. The shear strength and compressibility of the upper soils will control the behavior of the pavements.
2. Existing undocumented fill material was encountered within the pavement areas.
3. Relatively wet and sensitive soils were encountered in the upper parts of the borings and equipment mobility difficulty may be anticipated.
4. Drying of some of the on-site soils may be required to achieve proper compaction during grading.

4.1 SHEAR STRENGTH AND COMPRESSIBILITY OF SOIL

The primary geotechnical property controlling the bearing capacity and compressibility of the soils bearing the applied loads is the shear strength of the soil. PSI believes the shear strength of the soils in the upper 3½ feet of the ground surface ranges from 900 pounds per square foot (psf) to 2,000 psf. This shear strength is considered "undrained" or a "total stress" parameter and will be used in conjunction with other physical and geometric parameters to provide a recommended pavement design.

4.2 EXISTING UNDOCUMENTED FILL

Undocumented fill was encountered at the soil boring locations ranging from nine (9) inches to one (1) foot thick. The presence of the undocumented fill introduces a construction risk due to the potential for excessive and/or non-uniform settlement. The amount of risk is based on consistency of the fill and variations in the material property. For purposes of this report, PSI is providing the following definition of fill and the different classifications:

Fill – Man-placed soil is called "fill", and the process of placing it is termed "filling". One of the most common problems of earth construction is the wide variability of the source soil, termed "borrow". An essential part of the geotechnical engineering report is to provide guidance for the placement of fill from a borrow source in a manner that achieves the design parameters for the project being constructed. Fill is further classified by the placement process. The following lists various terms applied to fill placement practices:

a. **Uncontrolled Fill** - Fill material that consists of soil and/or non-soil materials that has been placed in a manner that does not produce consistent density, uniform moisture content at time of placement, and in general materials of durable physical characteristics is termed an uncontrolled fill.
b. **Undocumented Fill** - Fill material composed of soil that has **not** been observed by a geotechnical engineer or qualified technician under the direction of a geotechnical engineer during the actual fill placement process with physical measurements of lift thickness, dry density, moisture content at time of placement, location of tests and fill soils placed, and the methodology of placement with types of placement equipment is termed undocumented fill.
c. **Engineered Fill** - Fill material that is placed to have specific shear strength, permeability, consolidation, or other physical parameter(s) specific to the end use of the man placed soil material. Applications include, but are not limited to, retaining wall backfill, pond and landfill liners, embankments, dams, and bridge abutments.

The risk of settlement of the fill can be reduced if the existing fill is removed and replaced with a controlled compacted fill, but this option could be costly. If it is desirable to reduce the amount of risk associated with excessive/non-uniform settlement at the site in pavement areas, it would be necessary, at a minimum, to proof roll in the pavement areas and perform proof compaction for the soil subgrade as outlined in the “Site Preparation” and “Foundation Recommendation” sections of this report. Although soft fill soils were not encountered at the boring locations, this does not eliminate the possibility that soft or loose pockets or layers are present between the borings.

4.3 EQUIPMENT MOBILITY

The upper fine-grained soils can potentially be sensitive to increases in moisture content during construction activities. PSI has been involved with several projects in this region where these otherwise competent soils can undergo a significant loss of stability while construction activities take place during wetter portions of the year. Soils that become disturbed would need to be excavated and replaced; however, remedial excavation may expose progressively wetter soils with depth and compound the problem condition.

Depending on weather and soil conditions at the time of construction, methods for accomplishing grading may include the use of wide-track, low-contact-pressure type equipment to perform the recommended site grading. The determination of the proper equipment for use in excavation would be dependent on the condition of the soils at the time of construction and the prevailing weather conditions. Narrow track equipment and rubber-tired vehicles may experience difficulty moving about the site and may deteriorate otherwise suitable soils.

4.4 SITE COMPACTION

Since this site predominantly consists of silts and clays, it may become difficult to properly compact the soils because of high moisture contents. The soils may need to be scarified and dried to a moisture content that will facilitate compaction in accordance with the structural fill requirements of this report.

5. GEOTECHNICAL RECOMMENDATIONS

5.1 SITE PREPARATION

PSI recommends that vegetation, roots, unwanted pavement, soft, organic, frozen, and unsuitable soils in the construction areas be stripped from the site and either wasted or stockpiled for later use in non-load bearing areas. A representative of the geotechnical engineer should determine the depth of removal at the time of construction.

In this region, these otherwise competent silts and lean clays can undergo a significant loss of stability when construction activities take place during wetter portions of the year. PSI anticipates that the soils in the project area can become easily disturbed if subjected to conventional rubber tire or narrow track-type equipment. Soils that become disturbed would need to be excavated and replaced; however, this remedial excavation may expose progressively wetter soils with depth, thus compounding the problem condition. Appropriate wide-track equipment selection should aid in minimizing potential disturbance.

To assist in documenting the existing undocumented fill materials during construction, it is recommended that a representative of the geotechnical engineer be on-site to perform in-place moisture/density testing of the undocumented fill. These tests would be performed in multiple locations as determined by PSI personnel. In general, PSI recommends that the locations for the tests be at the top of the soil subgrade elevation. If any of the field tests do not meet PSI compaction requirements as defined in this report, based on the Modified Proctor test of the particular material, that area will need to be further defined with additional tests and will likely need to be excavated and replaced with structural fill. The soil in this defined area must be reconditioned according to the “Site Preparation” section of this report. If all field tests are in compliance with the report recommendations or the soil is reconditioned to meet PSI’s report recommendations, then the tested fill can be considered to be documented.

After stripping and excavating to the proposed subgrade level, as required, the pavement areas should be proof-rolled with a loaded tandem axle dump truck or similar piece of heavy rubber-tired vehicle (typically with an axle load greater than 9 tons). Soils that are observed to rut or deflect excessively (typically greater than 1-inch) under the moving load should be undercut and replaced with properly compacted fill. The proof-rolling and undercutting activities should be observed and documented by a representative of the geotechnical engineer and should be performed during a period of dry weather. The subgrade soils should be scarified and compacted to at least 90% of the materials' Modified Proctor maximum dry density, in general accordance with ASTM procedures, to a depth of at least 6 inches below the surface.

After subgrade preparation and observation have been completed, fill placement required to establish grade may begin. Fill materials should be free of organic or other deleterious materials, have a maximum particle size less than 3 inches, and have a liquid limit less than 45 and plasticity index less than 25. Fill materials should have a Proctor maximum dry density greater than 100 pcf. Soils classified as CL, ML, CL-ML, SM, SC-SM, SW, and GW will generally be suitable for use as structural fill. Soils classified as MH, CH, GP and SP could be made suitable for use as structural fill with caution. The application of these materials should be reviewed by the geotechnical engineer prior to implementation. Soils classified as OL, OH, and PT should be considered unsuitable. The on-site low plasticity clay soils are suitable for use as structural fill, but some moisture conditioning, such as scarifying and drying, may be needed to achieve compaction. If the fill is too dry, water should be uniformly applied and thoroughly mixed into the soil by disking or scarifying. Close moisture content control will be required to achieve the recommended degree of compaction.

Structural fill to establish construction grades should be placed in maximum loose lifts of 8 inches and compacted as defined in the fill placement portion of this report. Each lift of compacted-engineered fill should be observed, tested and documented by a representative of the geotechnical engineer prior to placement of subsequent lifts. The edges of compacted fill should extend 5 feet beyond the edges of pavements prior to sloping. In addition to structural fills, utility trenches within the pavement areas should be compacted as outlined above.

Clean or screened rock could be used as select fill, but a fabric separator would be needed where it is placed adjacent to fine grained soils. This type of fill and backfill should be tracked or tamped to achieve densification.

5.1.1 SOIL AND AGGREGATE FILL PLACEMENT CRITERIA

The fill placed shall be tested and documented by a geotechnical technician and directed by a geotechnical engineer to evaluate the placement of fill material. It should be noted that the geotechnical engineer of record can only certify the testing that is performed, and the work observed and documented by that engineer or staff in direct reporting to that engineer. The following table summarizes the recommended compaction effort for various types of engineered fills.

MATERIAL TESTED	PROCTOR TYPE	MIN % DRY DENSITY	MOISTURE CONTENT RANGE	FREQUENCY OF TESTING*
Structural Fill (Cohesive)	Modified	90%	-2 to +2 %	1 per 1,000 cy of fill placed
Structural Fill (Granular)	Modified	90%	-2 to +2 %	1 per 1,000 cy of fill placed
Random Fill (non-load bearing)	Modified	88%	-3 to +3 %	1 per 3,000 cy of fill placed
Utility Trench Backfill / Wall Backfill	Modified	90%	-2 to +2 %	1 per 200 cy of fill placed

*Minimum of 1 test per lift

The test frequency for the laboratory reference should be one laboratory Proctor test for each material used on the site. If the borrow or source of fill material changes, a new reference moisture/density test should be performed. Tested fill materials that do not achieve either the required dry density or moisture content range shall be recorded, the location noted, and reported to the Contractor and Owner. A re-test of that area should be performed after the Contractor performs remedial measures.

5.2 UTILITIES TRENCHING

Excavation for utility trenches shall be performed in accordance with OSHA regulations as stated in 29 CFR Part 1926. It should be noted that utility trench excavations have the potential to degrade the properties of the adjacent fill materials. Utility trench walls that are allowed to move laterally can lead to reduced bearing capacity and increased settlement of adjacent structural elements and overlying slabs.

Backfill for utility trenches is as important as the original subgrade preparation or structural fill placed to support either a foundation or slab. Therefore, it is imperative that the backfill for utility trenches be placed to meet the project specifications for the structural fill of this project. If on-site soils are placed as trench backfill, the backfill for the utility trenches should be placed in 4- to 6-inch loose lifts and compacted to a minimum of 90% of the maximum dry density achieved by the Modified Proctor test. The backfill soil should be moisture conditioned to be within 2% of the optimum moisture content as determined by the Modified Proctor test. Up to 4 inches of bedding material placed directly under the pipes or conduits placed in the utility trench can be compacted to the 90% compaction criteria with respect to the Modified Proctor. Compaction testing should be performed for every 200 cubic yards of backfill place or each lift within 200 linear feet of trench, whichever is less. Backfill of utility trenches should not be performed with water standing in the trench. If granular material is used for the backfill of the utility trench, the granular material should have a gradation that will filter protect the backfill material from the adjacent soils. If this gradation is not available, a geosynthetic non-woven filter fabric should be used to reduce the potential for the migration of fines into the backfill material. Granular backfill material shall be compacted to meet the above compaction criteria. The clean granular backfill material should be compacted to achieve a relative density greater than 75% or as specified by the geotechnical engineer for the specific material used.

5.3 PAVEMENT SECTION RECOMMENDATIONS

Based on the request of Great River Engineering, PSI evaluated the options of providing either a mill and overlay of the existing pavement section, or replacement of the pavement section. The thickness of the existing asphaltic concrete on the surface is about two (2) inches as encountered in the borings. Therefore, PSI has based the mill and overlay option on leaving one (1) inch of existing asphaltic concrete pavement in place.

PSI's scope of services did not include CBR testing of existing subgrade or potential sources of imported fill for the specific purpose of detailed pavement section analysis. Instead, PSI has based this report on pavement-related design parameters based on field strength testing and laboratory index testing of the soil subgrade.

In large areas of pavement, or where pavements are subject to significant traffic, a more detailed analysis of the subgrade and traffic conditions should be made. The results of such a study will provide information necessary to design an economical and serviceable pavement.

The recommended thicknesses presented below are considered typical and minimum for the parameters used in this report. The pavement subgrade should be prepared as discussed in the "Site Preparation" section of this report. PSI has estimated the subgrade soils will be prepared to achieve a CBR of at least 5. Based on this value, it is possible to use a locally typical "standard" pavement section consisting of the following:

Recommended Pavement Sections*				
Pavement Materials **	Thickness (inches)			
	Mill and Overlay		Full Depth Replacement	
	30,000 ESALs	60,000 ESALs	30,000 ESALs	60,000 ESALs
Depth of Mill	1	1	N/A	N/A
Asphaltic Surface Course	1½	2	1	1 ½
Asphaltic Binder Course	2½	2½	2	2 ½
Base Rock	N/A	N/A	6	6

* Pavement sections were evaluated based on the 1986 AASHTO Design equations; a reliability of 80%; and a 20-year 18-kip single axle load (ESAL) of 30,000 for standard duty and 60,000 for heavy duty areas. Flexible Pavements were evaluated based on an initial serviceability of 4.2 and a terminal service of 2.0.
** Pavement materials should conform to local and state guidelines, if applicable.

Prior to paving, the prepared subgrade should be proof-rolled using a loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of 9 tons per single axle. Localized soft areas identified should be repaired prior to paving. Moisture content of the subgrade be maintained between -2% and +3% of the optimum at the time of paving. It may require rework when the subgrade is either desiccated or wet.

PSI recommends that a MODOT Type 5 aggregate base rock (MODOT Specifications Handbook, Sec. 1007.3.2) be used under the asphalt pavements. The material should be placed and compacted as discussed in the "Soil and Aggregate Fill" section of this report. The following recommended gradations are based on the specifications of MODOT for a Type 5 aggregate base rock.

Sieve Size	**Percent Passing by Weight (Mass)**
1-inch (25.0 mm)	100
1/2-inch (12.5 mm)	60-90
No. 4 (4.75 mm)	35-60
No. 30 (600 µm)	10-35
No. 200 (75 µm)	0-15

Pavement may be placed after the subgrade has been properly compacted, fine graded and proof-rolled. The work should be done in accordance with State Department of Transportation guidelines. The granular base course should be built at least 2 feet wider than the pavement on each side to support the tracks of the slipform paver. This extra width is structurally beneficial for wheel loads applied at pavement edges. The asphalt base course should be compacted to a minimum of 95% Marshall density according to ASTM D1559.

Asphaltic surface mixture should have a minimum stability of 1,800 pounds and the surface course should be compacted to a minimum of 97% Marshall density according to ASTM D1559. To reduce the potential thermal cracking in this region, asphalt binder grade of PG 64-28 is recommended. However, for base mixes to be placed 4 inches below the surface, PG 64-22 is sufficient.

Asphaltic concrete mix designs and Marshall characteristics should be reviewed by PSI to determine if they are consistent with the recommendations given in this report.

Construction traffic should be minimized to prevent unnecessary disturbance of the pavement subgrade. Disturbed areas, as verified by PSI, should be removed and replaced with properly compacted material.

PSI recommends pavements be sloped to provide rapid surface drainage. Water allowed to pond on or adjacent to the pavement could saturate the subgrade and cause premature deterioration of pavements, and removal and replacement may be required. Consideration should be given to the use of an interceptor drain to collect and remove water collecting in the granular base. The interceptor drains could be incorporated with the storm drains of other utilities located in the pavement areas.

Periodic maintenance of the pavement should be anticipated. This should include sealing of cracks and joints and by maintaining proper surface drainage to avoid ponding of water on or near the pavement area.

6. CONSTRUCTION CONSIDERATIONS

PSI should be retained to provide observation and testing of construction activities involved in the foundation, earthwork, and related activities of this project. PSI cannot accept responsibility for conditions that deviate from those described in this report, nor for the performance of the foundation system if not engaged to also provide construction observation and testing for this project.

6.1 MOISTURE SENSITIVE SOILS/WEATHER RELATED CONCERNS

The upper fine-grained soils encountered at this site may be sensitive to disturbances caused by construction traffic and to changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. In addition, soils that become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will therefore be advantageous to perform earthwork and foundation construction activities during dry weather.

6.2 DRAINAGE AND GROUNDWATER CONSIDERATIONS

PSI recommends that the Contractor determine the actual groundwater levels at the site at the time of the construction activities to assess the impact groundwater may have on construction. Water should not be allowed to collect on prepared subgrades of the construction area either during or after construction. Undercut or excavated areas should be sloped toward one corner to facilitate removal of collected rainwater, groundwater, or surface runoff. Positive site drainage should be provided to reduce infiltration of surface water beneath pavements.

While groundwater was not encountered at the time the field exploration was conducted, it is possible that seasonal variations will cause fluctuations or a water table to be present in the upper soils. Additionally, perched water may be encountered in discontinuous zones within the overburden or near the contact with bedrock. Water should be removed from excavations by pumping. The Geotechnical engineer should be consulted if excessive and uncontrolled amounts of seepage occur.

6.3 RECOMMENDED CONSTRUCTION SERVICES

The information provided in this report may be based on interpretation of client supplied information, publicly available data bases, exploration data, and PSI's experience and knowledge. The client must recognize that some geological variations are expected occur between boring locations and physical characteristics are expected to vary with time; therefore, it is important to retain the geotechnical engineer throughout the construction period. Though the geotechnical engineer may be needed during other phases of the project, PSI recommends the geotechnical engineer, or their representative, be present during the following at a minimum to confirm the materials are consistent with our design recommendations:

- Stripping of the subgrade
- Proof-rolling of the subgrade prior to fill and pavement placement
- Fill placement to establish grade
- Compaction testing of granular base and asphalt pavement during placement

If conditions are observed that vary from those stated in this report, PSI can provide updated recommendations based on the site conditions at the time of construction.

6.4 EXCAVATIONS

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document was issued to better enhance the safety of workers entering trenches or excavations. It is mandated by this federal regulation that excavations, whether they be utility trenches, basement excavation or footing excavations, be constructed in accordance with the new OSHA guidelines. It is PSI's understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

PSI is providing this information solely as a service to our client. PSI does not assume responsibility for construction site safety or the contractor's or other party's compliance with local, state, and federal safety or other regulations.

7. GEOTECHNICAL RISK

The concept of risk is an important aspect of the geotechnical evaluation. The primary reason for this is that the analytical methods used to develop geotechnical recommendations do not comprise an exact science. The analytical tools which geotechnical engineers use are generally empirical and must be used in conjunction with engineering judgment and experience. Therefore, the solutions and recommendations presented in the geotechnical evaluation should not be considered risk-free and, more importantly, are not a guarantee that the interaction between the soils and the proposed structure will perform as planned. The engineering recommendations presented in the preceding section constitutes PSI's professional estimate of those measures that are necessary for the proposed structure to perform according to the proposed design based on the information generated and reference during this evaluation, and PSI's experience in working with these conditions.

8. REPORT LIMITATIONS

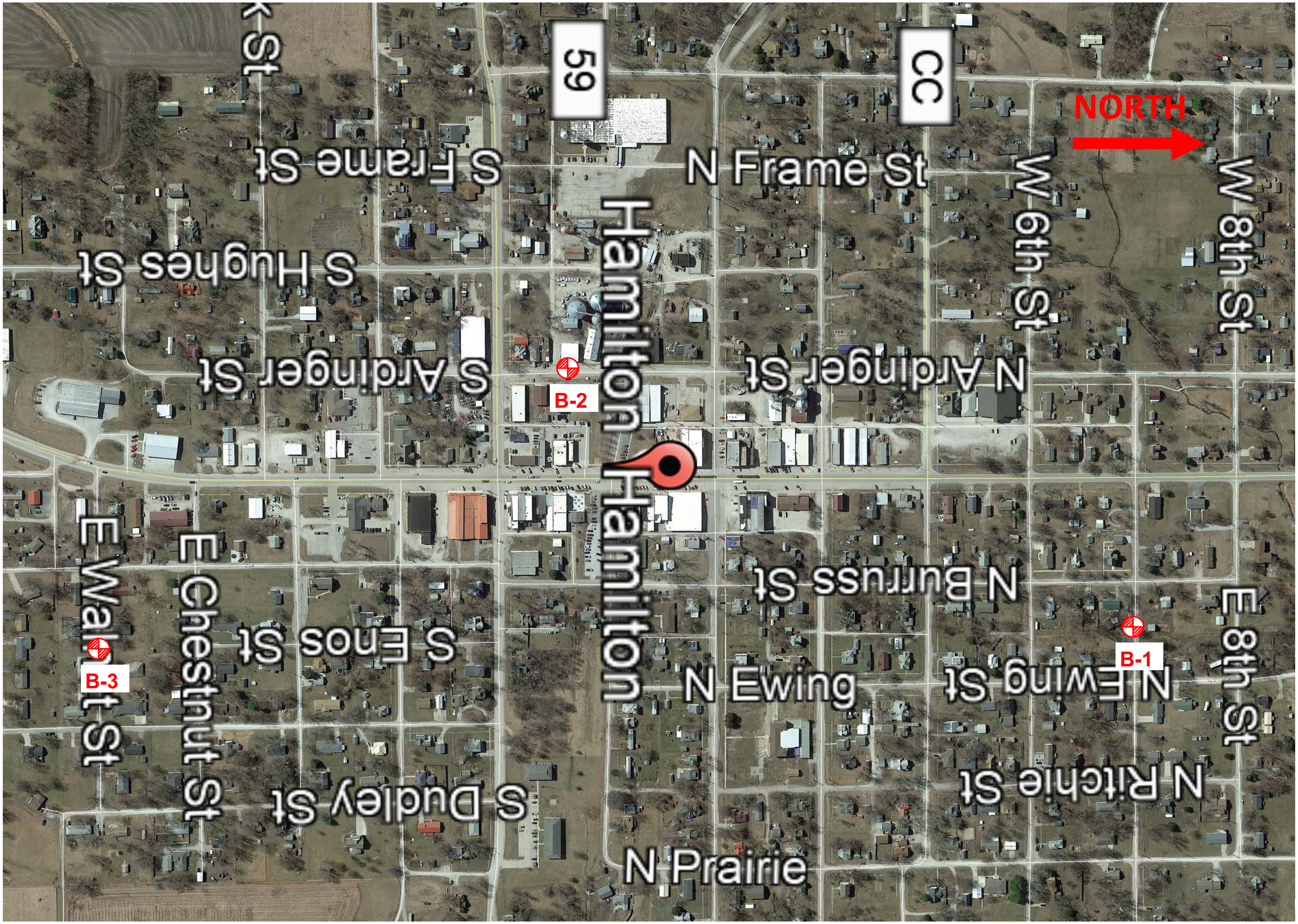
The recommendations submitted are based on the available subsurface information obtained by PSI and design details furnished by Great River Engineering. If there are revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the foundation recommendations are required. If PSI is not retained to perform these functions, PSI will not be responsible for the impact of those conditions on the project.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

After the plans and specifications are more complete, the geotechnical engineer should be retained and provided the opportunity to review the final design plans and specifications to check that our engineering recommendations have been properly incorporated into the design documents. At that time, it may be necessary to submit supplementary recommendations. This report has been prepared for the exclusive use of Great River Engineering for the specific application to the City of Hamilton Street Pavement in Hamilton, Missouri.

APPENDIX A – AERIAL PHOTOGRAPH & BORING LOCATION PLAN

Professional Service Industries, Inc.



Boring Location Sketch	Hamilton Pavememnt Cores Hamilton, MO	PSI Project Number 0040-289	Drawn By: JTB Date: 5/3/2019

APPENDIX B – BORING LOGS

Professional Service Industries, Inc.
8669 Olive Boulevard
Saint Louis, MO 63132
Telephone: (314) 432-8073
Fax: (314) 432-5119

LOG OF B-1

PSI Job No.: 0040289-1
Project: Hamilton Pavement Cores
Location: Hamilton, Missouri

Excavation Method: Core and Hand Auger
Sampling Method: Grab
DCP Type: 1 3/4" DCP
Boring Location: 7th Street

WATER LEVELS	
While Drilling	None
Upon Completion	None
Delay	N/A

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	Dynamic Cone (DCP) Blows per 1¾-inch	Moisture, %	Additional Remarks
	0					**2" Asphalt**				
						9½" Deteriorated Asphalt				
	1		Grab	1	6	**Undocumented FILL** Dark Brown Lean CLAY; trace of fine sand (fill)		9	21	
						Low Plasticity CLAY				
	2		Grab	2	6	Dark Brown Lean CLAY		5	28	
	3		Grab	3	6	Dark Brown Lean CLAY		5	28	
						Hand Auger Terminated at 3½ Feet				

DYNAMIC CONE PENETRATION TEST DATA
Blows per 1¾-inch ◎ (0, 15, 30)
× Moisture; PL; LL (0, 25, 50)
STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)

Completion Depth: 3.0 ft
Date Boring Started: 4/25/19
Date Boring Completed: 4/25/19
Logged By: M. Kaufman
Excavation Contractor: PSI, Inc.

Sample Types:
Shelby Tube
Dynamic Cone (DCP)
Grab Sample

Latitude: 39.748049°
Longitude: -93.996234°
Excavation Equipment: Hand Auger
Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

intertek psi
Professional Service Industries, Inc.
8669 Olive Boulevard
Saint Louis, MO 63132
Telephone: (314) 432-8073
Fax: (314) 432-5119

LOG OF B-2

PSI Job No.: 0040289-1
Project: Hamilton Pavement Cores
Location: Hamilton, Missouri

Excavation Method: Core and Hand Auger
Sampling Method: Grab
DCP Type: 1 3/4" DCP
Boring Location: North Ardinger Street

WATER LEVELS

While Drilling	None
Upon Completion	None
Delay	N/A

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	Dynamic Cone (DCP) Blows per 1¾-inch	Moisture, %	Additional Remarks
	0					**2" Asphalt**				
						9" Deteriorated Asphalt				
						Undocumented FILL				
	1		Grab	1	6	Dark Gray Lean CLAY; trace fine gravel (fill)		11	26	
						Low Plasticity CLAY				
	2		Grab	2	6	Gray and Orange-Brown Lean CLAY		9	29	
	3		Grab	3	6	Orange-Brown and Gray Lean CLAY		7	29	
						Hand Auger Terminated at 3½ Feet				

DYNAMIC CONE PENETRATION TEST DATA
Blows per 1¾-inch ◎ (0, 15, 30)
× Moisture ◪ PL ✚ LL (0, 25, 50)
STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)

Completion Depth: 3.0 ft
Date Boring Started: 4/25/19
Date Boring Completed: 4/25/19
Logged By: M. Kaufman
Excavation Contractor: PSI, Inc.

Sample Types:
Shelby Tube
Dynamic Cone (DCP)
Grab Sample

Latitude: 39.742854°
Longitude: -93.999363°
Excavation Equipment: Hand Auger
Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

Professional Service Industries, Inc.
8669 Olive Boulevard
Saint Louis, MO 63132
Telephone: (314) 432-8073
Fax: (314) 432-5119

LOG OF B-3

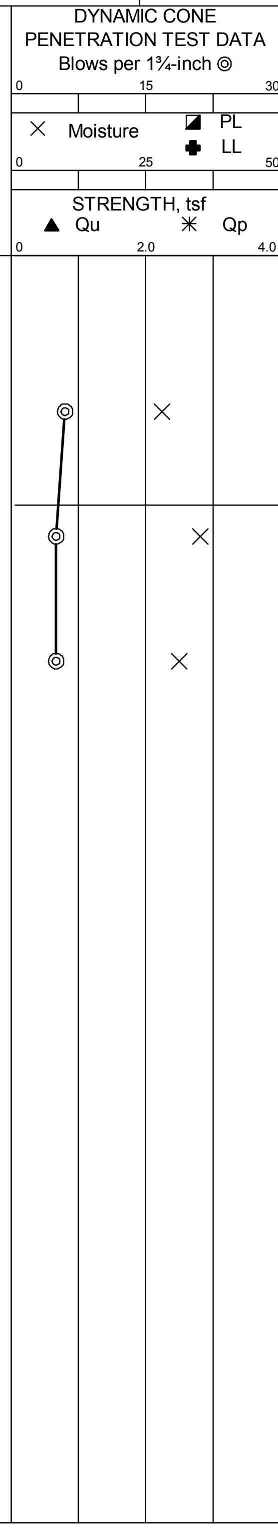
Sheet 1 of 1

PSI Job No.:	0040289-1
Project:	Hamilton Pavement Cores
Location:	Hamilton, Missouri
Excavation Method:	Core and Hand Auger
Sampling Method:	Grab
DCP Type:	1 3/4" DCP
Boring Location:	East Walnut Street

WATER LEVELS

While Drilling	None
Upon Completion	None
Delay	N/A

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	Dynamic Cone (DCP) Blows per 1¾-inch	Moisture, %	Additional Remarks
	0					**2" Asphalt**				
						9½" Deteriorated Asphalt				
						Undocumented FILL				
	1		Grab	1	6	Dark Gray Lean CLAY (fill)		6	28	
						Low Plasticity CLAY				
	2		Grab	2	6	Dark Gray Lean CLAY		5	35	
	3		Grab	3	6	Blue-Gray Lean CLAY		5	31	
						Hand Auger Terminated at 3½ Feet				



Completion Depth:	3.0 ft	Sample Types:	Latitude: 39.738914°
Date Boring Started:	4/25/19	Shelby Tube	Longitude: -93.996105°
Date Boring Completed:	4/25/19	Dynamic Cone (DCP)	Excavation Equipment: Hand Auger
Logged By:	M. Kaufman	Grab Sample	Remarks:
Excavation Contractor:	PSI, Inc.		

The stratification lines represent approximate boundaries. The transition may be gradual.

APPENDIX C – GENERAL NOTES & SOIL CLASSIFICATION CHART

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

- SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
- HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
- M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
- R.C.: Diamond Bit Core Sampler
- H.A.: Hand Auger
- P.A.: Power Auger - Handheld motorized auger

- SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
- ST: Shelby Tube - 3" O.D., except where noted.
- RC: Rock Core
- TC: Texas Cone
- BS: Bulk Sample
- PM: Pressuremeter
- CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

- N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
- N_{60}: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
- Q_u: Unconfined compressive strength, TSF
- Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
- w%: Moisture/water content, %
- LL: Liquid Limit, %
- PL: Plastic Limit, %
- PI: Plasticity Index = (LL-PL),%
- DD: Dry unit weight, pcf
- ▼,▽,▼ Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N - Blows/foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50 - 80
Extremely Dense	80+

ANGULARITY OF COARSE-GRAINED PARTICLES

Description	Criteria
Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular:	Particles are similar to angular description, but have rounded edges
Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges

GRAIN-SIZE TERMINOLOGY

Component	Size Range
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.005 mm to 0.075 mm
Clay:	<0.005 mm

PARTICLE SHAPE

Description	Criteria
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% Dry Weight
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

Q_U - TSF	N - Blows/foot	Consistency
0 - 0.25	0 - 2	Very Soft
0.25 - 0.50	2 - 4	Soft
0.50 - 1.00	4 - 8	Firm (Medium Stiff)
1.00 - 2.00	8 - 15	Stiff
2.00 - 4.00	15 - 30	Very Stiff
4.00 - 8.00	30 - 50	Hard
8.00+	50+	Very Hard

MOISTURE CONDITION DESCRIPTION

Description	Criteria
Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term	% Dry Weight
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

Description	Criteria
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided:	Fracture planes appear polished or glossy, sometimes striated

Description	Criteria
Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed:	Inclusion of small pockets of different soils
Layer:	Inclusion greater than 3 inches thick (75 mm)
Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

Q_U - TSF	Consistency
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

Description	Criteria
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

Voids	Void Diameter
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

Component	Size Range
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered:	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES		SM	SILTY SANDS, SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

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Graphic Symbols for Materials and Rock Deposits

CONCRETE
Portland Cement Concrete

BITUMINOUS CONCRETE

CLAYSTONE

COAL
Coal, Anthracite Coal

CONGLOMERATE/BRECCIA
Conglomerate, Breccia

IGNEOUS ROCK
Anorthsite, Basalt, Metabasalt, Diabase (Gabbro), Gabbro, Granite/Granodionite, Homfels, Pegmatite, Rhyolite/Metarhyolite

LIMESTONE
Limestone, Dolomite

METAMORPHIC ROCK
Amphibolite, Gneiss, Marble, Phyllite, Quartzite, Schist, Serpentinite, Slate

CHERT

SANDSTONE
Sandstone, Orthoquarzite (Sandstone)

SHALE

SILTSTONE

NO RECOVERY

VOID

APPENDIX D – DRILLING, FIELD, AND LAB TESTING PROCEDURES

FIELD TESTS AND MEASUREMENTS

Penetration Tests and Split-Barrel Sampling of Soils

During the sampling procedures, Dynamic Cone Penetrometers (DCP) were performed at regular intervals to obtain penetration values of the soil. The results of the penetration tests indicate the relative density and comparative consistency of the soils, and thereby provide a basis for estimating the relative strength and compressibility of the soil profile components.

LABORATORY TESTING PROGRAM

In addition to the field investigation, a supplemental laboratory-testing program was conducted to determine additional engineering characteristics of the foundation materials necessary in analyzing the behavior of the soils as it relates to the pavement rehabilitation. Laboratory results may be found on the boring logs and individual test results are included in the Appendix. The laboratory testing program is as follows:

Laboratory Determination of Water (Moisture) Content of Soil by Mass

The water content is a significant index property used in establishing a correlation between soil behavior and its index properties. The water content is used in expressing the phase relationship of air, water, and solids in a given volume of material. In fine grained cohesive soils, the behavior of a given soil type often depends on its water content. The water content of a soil, along with its liquid and plastic limits as determined by Atterberg Limit testing, is used to express its relative consistency or liquidity index.