BEACHWOOD CITY COUNCIL
PUBLIC WORKS COMMITTEE MEETING AGENDA
MONDAY, AUGUST 31, 2020, 6:00 PM

**** Please note, this meeting will be held by video conference via Zoom and livestreamed on the City of Beachwood website at www.beachwoodohio.com and can be viewed on Spectrum Channel 1020 and AT&T U-Verse Channel 99.***

This Public Works Committee Meeting has been duly noticed and is being held in accordance with Ohio Revised Code Section 121.22 specific to recent Amendments made in light of the current COVID-19 declared emergency.

Justin Berns
Alec Isaacson
Barbara Bellin Janovitz

Agenda Items

1. Mayor's Report

2. Discussion and update regarding the Bryden Road Sewer Study

3. Discussion and update regarding the Glenhill Storm Sewer Analysis

4. Discussion regarding backflow preventers and sewer lining on private property

5. Discussion regarding Backyard Drainage Issues

6. Any other matters coming before the Public Works Committee

# # #

June 12, 2020

2020119.07

To: Cities of Beachwood and Shaker Heights

From: GPD Group

Cc: Joe Ciuni, PE, PS

No. of Pages: 10

Prepared By: Taylor Wojciechowski, EIT
Jesse Rufener, PE, CFM

Technical Memorandum: Green Bryden Culvert Study

Project Background & Objective

The intersection of Green Road and Bryden road in Shaker Heights, Ohio has experienced flooding during recent wet weather events. The March 29th- 30th event caused the intersection to be impassable. On May 15th, the intersection flooded and local residents provided videos of the street and downstream channel. There is an 8-ft by 3-ft culvert under the intersection that is suspect to have inadequate capacity. The culvert receives flow from a natural channel and local storm sewer infrastructure. The purpose of this study is to evaluate the hydraulic performance of the culvert and develop alternatives to alleviate or reduce street flooding during the 10 and 25-year design storms. A project location map is shown in **Figure 1**.

Figure 1 Project Location Map

Hydrologic Parameters

The hydrologic analysis for the area was performed using the Storm Water Management Model (SWMM), developed by the U.S Environmental Protection Agency, which was used within the computer program PCSWMM (Version 7.2.2785, 2020), developed by Computational Hydraulics International. The subcatchments contributing to the culvert were delineated using topography obtained from Ohio Geographically Referenced Information Program and data from the NEORSD Local Collection System Infrastructure (LCSI) storm sewers GIS. Two (2) subcatchments were delineated based on loading points to the culvert. The combined size of the subcatchments is 261.5 acres. The size and description of each subcatchment is shown in **Table 1**. Subcatchment locations are shown in **Figure 2**.

Table 1 Subcatchment Sizes

Subcatchment	Area (ac)	Description
1	167.5	Delineated to the natural channel that feeds into the culvert. Local storm sewers are collected by a 60-inch sewer that feeds to the channel.
2	94	Delineated to represent the storm sewers that tie directly into the culvert at the intersection. There is a 48-inch that conveys storm flow from Bryden and a 15-inch that collects storm flow from Green Road and Canterbury Road.

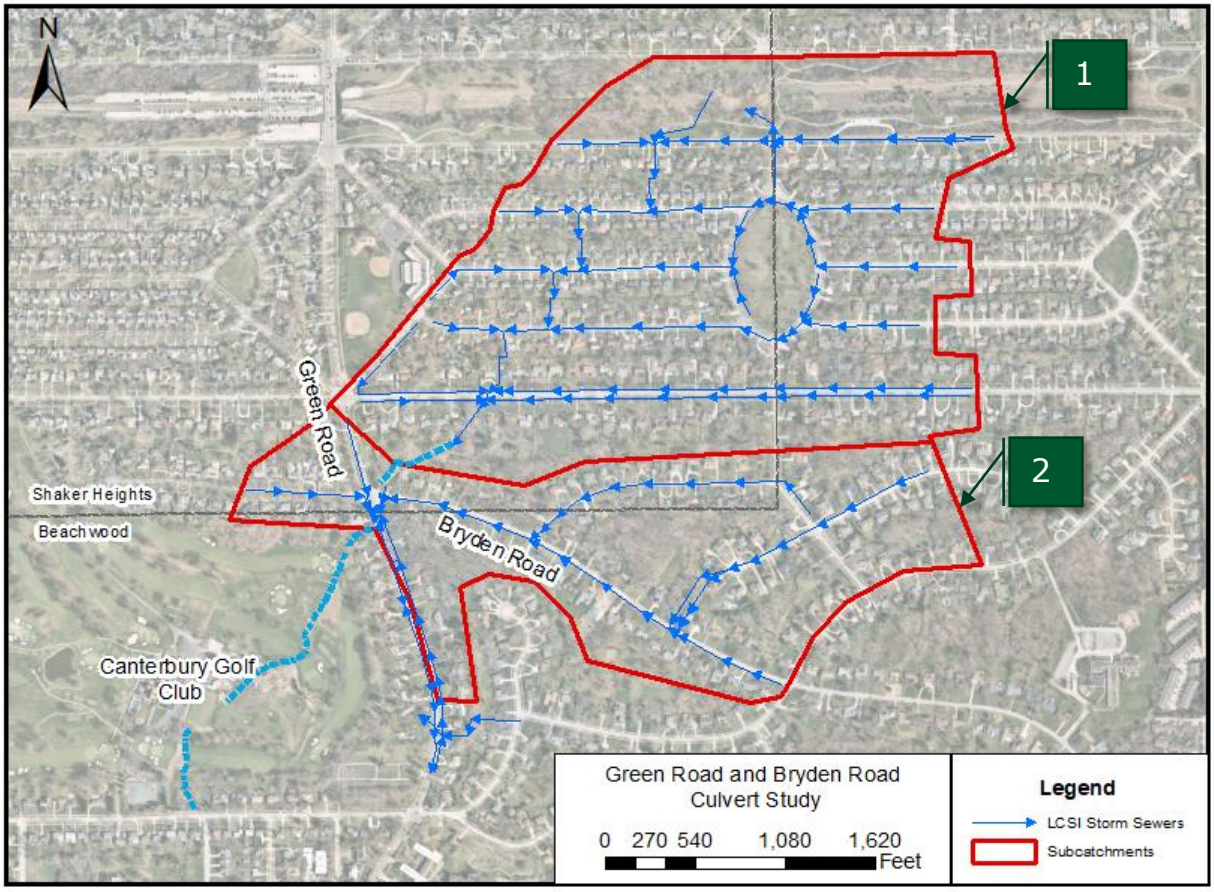

Figure 2 Subcatchment Map

Soil type information was obtained from the USDA Natural Resources Conservation Service Web Soil Survey website to determine the hydrologic soil groups (HSG) within the subcatchment boundaries. The full report can be found in Appendix A. A summary of the HSG is in **Table 2**. All of the soils are classified as group D soils, meaning they have high runoff potential, very slow infiltration rates when thoroughly wetted and consisting of mostly of clay soils with high swelling potential.

Table 2 Soil Characteristics

Soil Characteristics				
MUSYM	Description	*Soil* Group	Area	% Of Subcatchment
ElC	Ellsworth silt loam, 6 to 12 percent slopes	D	1.8	1%
EsC	Ellsworth-Urban land complex, 6 to 18 percent slopes	D	163.7	63%
MgA	Mahoning silt loam, 0 to 2 percent slopes	D	6.7	3%
MgB	Mahoning silt loam, 2 to 6 percent slopes	D	5.4	2%
MmB	Mahoning-Urban land complex, 2 to 6 percent slopes	D	30.1	12%
Ua	Udorthents, loamy		33.4	13%
Ub	Urban land		20	8%

The soil parameters were assigned based on the Horton infiltration methodology. **Table 3** summarizes the parameters used. Tables 4-4 and 4-6 from the EPA Storm Water Management Model (SWMM) Reference Manual Volume 1 were used to identify the maximum and minimum infiltration parameters for group D clay soils. The maximum and minimum infiltration rates were then adjusted to represent soil saturation of the area.

Table 3 Infiltration Parameters

Horton Infiltration Parameters SWMM Manual				Horton Infiltration Parameters Modeled			
Infiltration		Decay Constant (1/hr)	Drying Time (Day)	Infiltration		Decay Constant (1/hr)	Drying Time (Day)
Max (in/hr)	Min (in/hr)			Max (in/hr)	Min (in/hr)		
0.33	0 - 0.05	3.5	7	0.1	0.06	5	7

Land use characteristics were obtained from the 2016 National Land Cover Database (NLCD). The characteristics within the subcatchment boundaries are shown in **Table 4**. These values were used to calculate the impervious area within the subcatchment.

Table 4 Land Use Characteristics

Grid Code	Land Cover	Perc_Imp	Area (ac)	Impervious Area (ac)	% Impervious
22	Developed, Low Intensity	50%	160.7	80.4	31%
21	Developed, Open Space	15%	88.5	13.3	5%
41	Deciduous Forest	0%	2.4	0.0	0%
71	Grassland/Herbaceous	0%	2.2	0.0	0%
23	Developed, Medium Intensity	80%	2.5	2.0	1%
Total					37%

Rainfall from May 14th and 15th was used to compare the model to the flooding videos taken on May 15th around 5:00 P.M. The rainfall data was gathered from a Northeast Ohio Regional Sewer District (NEORSD) rain gauge approximately 1.5-miles away and compared to a personal rain gauge available through wunderground.com approximately 1-mile away. The duration of the wet weather event was about 33 hours. The peak intensity was 1.92 inches/hour on May 14th at 6:00 P.M. There was another high peak of 1.8 inches/hour on May 15th at 4:05 P.M. The total rainfall from the event was 2.09 inches.

Rainfall for the 10-year and 25-year events were used to predict runoff from the project subcatchments. Rainfall was based on data from NOAA's National Weather Service Hydrometerological Design Studies Center Precipitation Frequency Data Service on Altas 14 – Point Precipitation Frequency Estimates ; Ohio. The SCS Type II, 24-hr hydrographs within PCSWMM were utilized to model the 10-year and 25-year events. The rainfall depths can be found in Appendix D.

Hydrologic & Hydraulic Analysis

Hydrology

PCSWMM was utilized to predict runoff from the subcatchments using the methodology within SWMM. The length and width are used to idealize each subcatchment as a rectangle to control the shape of the runoff hydrograph. The values were estimated by developing multiple overland flow paths, representing equal portions of each subcatchment. Each subcatchment had two to three flow paths developed. The subcatchment width was computed by dividing the subcatchment area by the average flow path length. The subcatchment slope was computed by averaging the slope of each flow path. Manning's roughness coefficients for pervious and impervious surface flow were set to 0.15 and 0.013, respectively. Depression storage depths for pervious and impervious surfaces were both set to 0.05-inches. The peak discharge rates for the May 15th, 10-year, and 25-year are listed in **Table 5.**

Table 5 Subcatchment Peak Discharge (cfs)

Subcatchment	May 15th Event	10-yr, 24-hr	25-yr-24-hr
1	108.5	502.9	629.3
2	57.3	270.8	339.5

Subcatchment 1 was routed into a 60-inch pipe that releases into the natural channel that then enters the culvert. The upstream node of the 60-inch pipe had a ponded area of 50,000-sf to represent storage upstream in the streets and sewers that were not accounted for in this model. The channel geometry was

created using LiDAR and had a Manning's coefficient of 0.03. The existing culvert size and length were based off record plans.

Subcatchment 2 was routed into a 48-inch pipe that enters the middle of the culvert. The upstream node of the 48-inch pipe had a ponded area of 100,000 sf to represent upstream storage in the sewers and streets that were not accounted for in this model.

Hydraulic Analysis

Existing Conditions

An overview of the model is shown in **Figure 3**. A weir was added to reflect flow overtopping the road. The May 14th through May 15th event was used to perform an approximate calibration of the existing conditions model using the rainfall described earlier and the provided video evidence. The depth in the culvert outlet channel was estimated to be around 3-ft and the depth on the road was estimated to be around 8-in. Images from the video are shown in **Figure 4**.

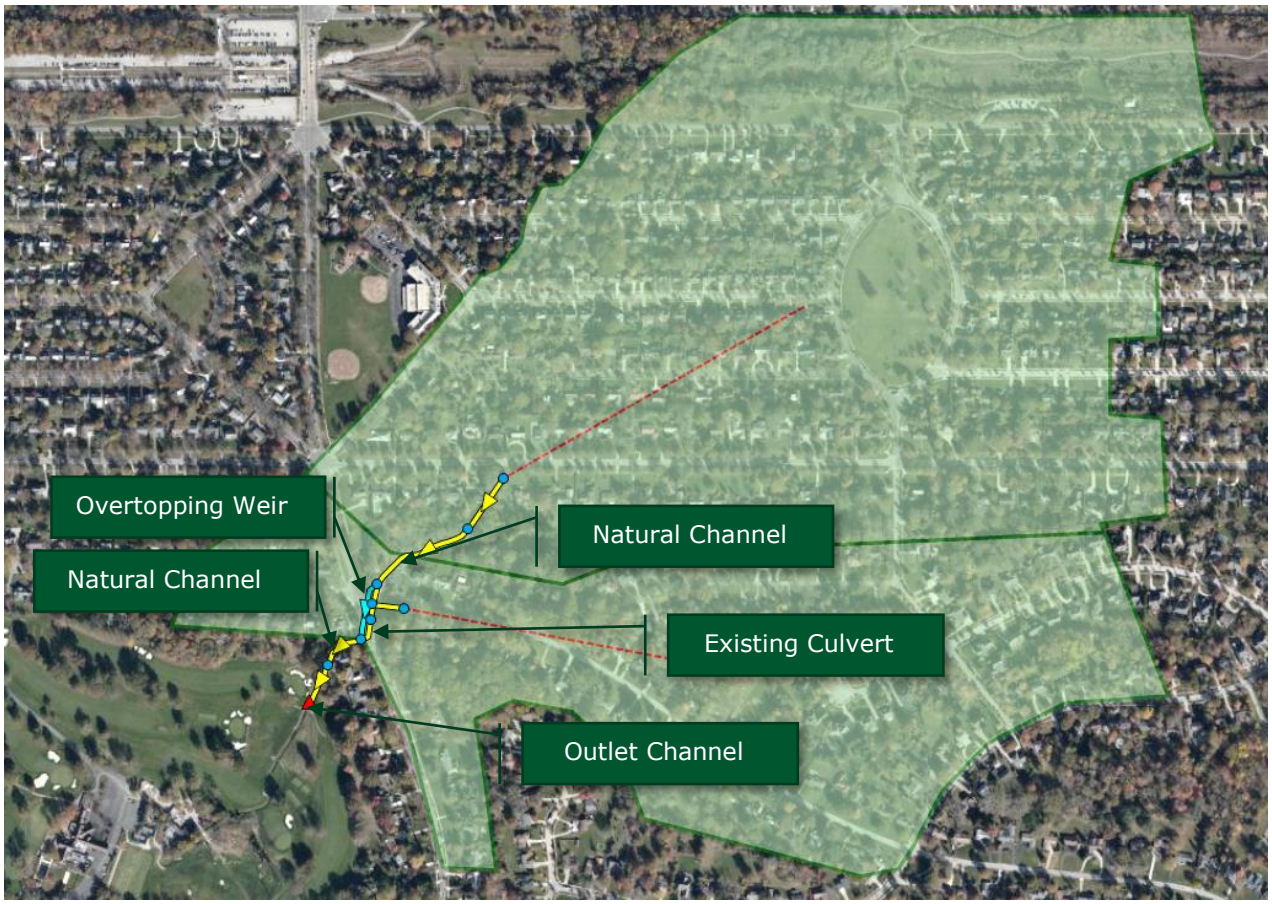

Figure 3 Existing Conditions Model

Figure 4 May 15th Flooding in Culvert Outlet Channel (Left) and on Green Road (Right)

The model results from the May 15th event indicated the overtopping weir did not receive flow and the hydraulic grade line for the culvert was below the street surface. This means the street flooding may have been caused by local storm infrastructure issues such as lack of capacity or blockages. The local storm sewer was not analyzed in this study. The model did not overtop the road and from the video it does not appear the water is flowing from the upstream channel across the road. The culvert outlet channel had a max depth was 2.74-ft, which is consistent with the model results shown in **Figure 4**. The profile of the culvert is shown in **Figure 5**.

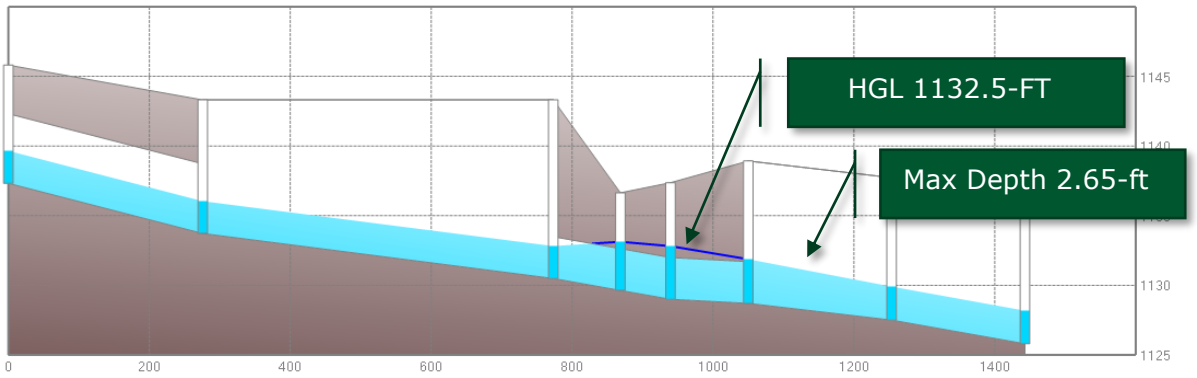

Figure 5 Existing Conditions Results (May 14th - May 15th Event)

The existing conditions model results show the culvert would have inadequate capacity for the 10-year, 24-hour duration design storm. The hydraulic profile is shown in **Figure 6**. The HGL is 1138-ft and the depth in the overtopping weir is 0.8-ft, which indicates flooding.

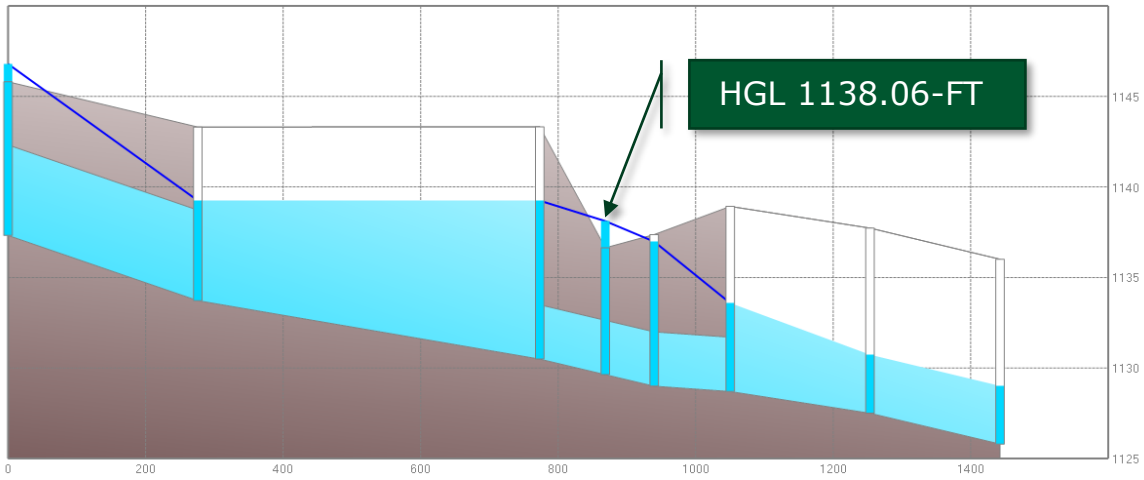

Figure 6 Existing Conditions Results (10-year 24-hour duration)

Alternatives

Typical design criteria, 10-year capacity and 25-year HGL check, was used to develop alternatives for the culvert under the intersection. It is important to note, the existing culvert is in between several utilities. Therefore, increasing the height of the culvert will require numerous water and gas line relocations. Additional alternatives were developed by expanding the culvert horizontally. A plan and general profile of the area can be found in Appendix B. The following four alternatives were analyzed using SWMM:

- Alt. 1: Constructing a new 8-ft x 5-ft culvert and remove the existing.
- Alt. 2: Constructing a new 16-ft x 3-ft culvert and removing the existing.
- Alt. 3: Constructing a new 8-ft x 3-ft culvert to run parallel to the existing 8-ft x 3-ft culvert.
- Alt. 4: Constructing a new 8-ft x 3-ft culvert to run parallel to the existing but tie into the channel further downstream.

All four options alleviate street flooding caused by the culvert in the 10 and 25-year storm. The results are shown in **Table 6**.

Table 6 Max HGL at Manholes on Culvert

Model	10-yr Max HGL (ft)		25-yr Max HGL (ft)	
	ST50EIMA0 Rim: 1136.64	ST50EJMA0 Rim: 1137.37	ST50EIMA0 Rim: 1136.64	ST50EJMA0 Rim: 1137.37
Existing Conditions	1138.06	1136.93	1138.53	1137.34
Alt 1	1136.20	1135.70	1136.90	1136.31
Alt 2	1135.86	1135.40	1136.613	1136.038
Alt 3	1136.12	1135.54	1136.76	1136.078
Alt 4	1135.80	1135.22	1136.32	1135.63

The proposed alternatives due increase the peak flows by up to 18% into the golf course downstream. **Table 7** shows the existing peak flow for the 10 and 25-year events along with the peak for each alternative.

Table 7 Peak Flows into Channel at Golf Course

Model	10-yr Peak Flows (cfs)	25-yr Peak Flows (cfs)
	MC00252	MC00252
Existing Conditions	382.61	430.28
Alt 1	439.90	481.70
Alt 2	448.99	487.82
Alt 3	441.41	480.95
Alt 4	228.95 451.68 (DS at second culvert)	248.70 490.80 (DS at second culvert)

Opinion of Probable Cost

A Class V opinion of probable construction cost (OPCC) based on the Association for the Advancement of Cost Engineering standard was developed for each of the alternatives and is shown in **Table 8**. A detailed breakdown of the OPCC is included in Appendix C.

Table 8 Opinion of Probable Construction Cost

Engineer's Opinion of Probable Construction Cost	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Construction Subtotal	$ 701,743.00	$ 826,636.00	$528,952.00	$537,048.00
Contingency (10%)	$ 70,174.00	$ 82,664.00	$ 52,895.00	$ 53,705.00
Construction Total	$ 771,917.00	$ 909,300.00	$581,847.00	$590,753.00
Engineering and Permitting (10 % of Construction)	$ 77,192.00	$ 90,930.00	$ 58,185.00	$ 59,075.00
Project Total	$ 849,109.00	$ 1,000,230.00	$640,032.00	$649,828.00

The OPCC does not account for any easement and/or property acquisition that may need to be acquired for the construction of the project.

In providing estimates of probable construction cost, the Client understands that the Consultant has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the Consultant's estimates of probable construction cost are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, express or implied, that the bids or the negotiated cost of the Work will not vary from the Consultant's estimate of probable construction cost. Please note that the pricing, contingencies and opinion contained or referenced herein anticipates a standard economic environment, and does not account for any uncertainty related to the COVID-19 pandemic.

Conclusion

The purpose of this study was to analyze the hydraulic performance of the existing 8-ft by 3-ft culvert under the intersection of Green and Bryden Road and to provide alternatives to increase capacity reduce flooding caused by the culvert. Alternative 3 meets the capacity requirement to eliminate culvert caused street flooding and has the lowest estimated cost. An additional benefit is that the existing culvert will remain in place, thus reducing the cost to control water during the project and reducing construction risk.

The results of the May 15th event indicate that the culvert had capacity for the storm, which means the local storm infrastructure may be the cause for some of the street flooding. It is recommended the local storm sewers be further analyzed and inspected and cleaned as necessary.

Risks to the proposed project are primarily unknown utility conflicts that will likely be revealed during construction and increasing the flow downstream due to the added capacity in the culvert. Approximate utility locations are shown on the exhibit plans in the appendix. It should be noted that there is a large 22" diameter gas main that crosses over the existing culvert and will need to be contended with during construction. The increase in flow to the golf course could become a liability if the course is perceived to be damaged by the flow increase.

References

Homer, Collin G., Dewitz, Jon A., Jin, Suming, Xian, George, Costello, C., Danielson, Patrick, Gass, L., Funk, M., Wickham, J., Stehman, S., Auch, Roger F., Riitters, K. H., Conterminous United States land cover change patterns 2001–2016 from the 2016 National Land Cover Database: ISPRS Journal of Photogrammetry and Remote Sensing, v. 162, p. 184–199, at https://doi.org/10.1016/j.isprsjprs.2020.02.019

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Appendix A

NCSS Custom Soil Resource Report

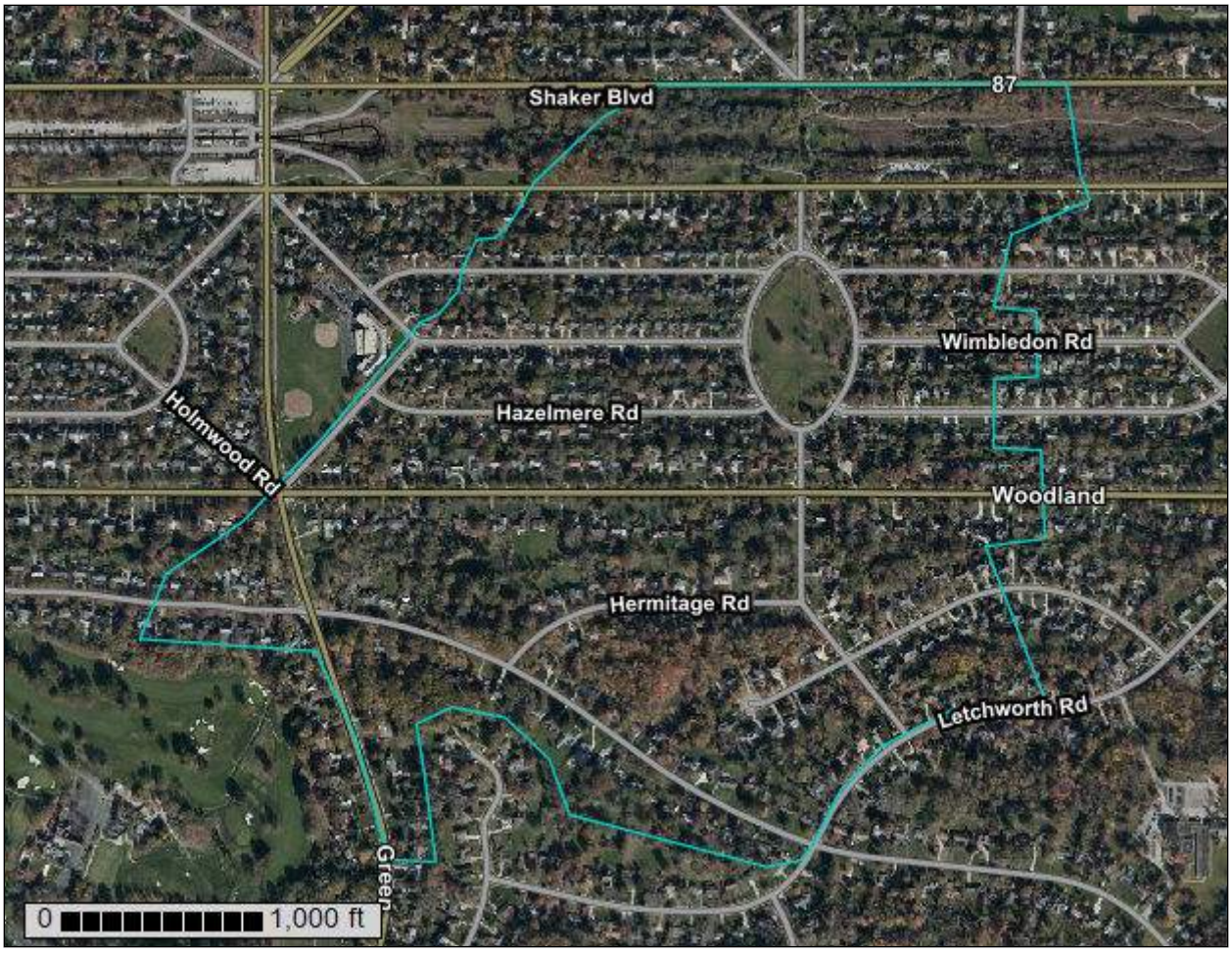
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Cuyahoga County, Ohio



Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

Preface..... 2
How Soil Surveys Are Made.....5
Soil Map..... 8
Soil Map.....9
Legend.....10
Map Unit Legend..... 11
Map Unit Descriptions.....11
Cuyahoga County, Ohio.....13
ElC—Ellsworth silt loam, 6 to 12 percent slopes.....13
EsC—Ellsworth-Urban land complex, 6 to 18 percent slopes.....14
MgA—Mahoning silt loam, 0 to 2 percent slopes.....15
MgB—Mahoning silt loam, 2 to 6 percent slopes.....17
MmB—Mahoning-Urban land complex, 2 to 6 percent slopes.....18
Ua—Udorthents, loamy.....20
UmB—Urban land-Mahoning complex, 2 to 6 percent slopes..... 21
References.....23

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


81° 31' 25" W
81° 29' 51" W
41° 28' 49" N
41° 28' 3" N
456400
456600
456800
457000
457200
457400
457600
457800
458000
458200
458400
4592200
4592000
4591800
4591600
4591400
4591200
4591000
4590800
87
Green
Shaker Blvd
Ua
Duffield Rd
Wimbledon Rd
Rye Rd
UmB
EsC
Woodland
MmB
Hermitage Rd
MgB
EIC
MgA
MmB
MmB
MmB
MgB
MgA
MmB
EIC
Map Scale: 1:10,000 if printed on A landscape (11" x 8.5") sheet.
N
Meters
0
100
200
400
600
Feet
0
450
900
1800
2700
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

9

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cuyahoga County, Ohio
Survey Area Data: Version 18, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 24, 2019—Nov 17, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
ElC	Ellsworth silt loam, 6 to 12 percent slopes	1.8	0.7%
EsC	Ellsworth-Urban land complex, 6 to 18 percent slopes	163.7	62.7%
MgA	Mahoning silt loam, 0 to 2 percent slopes	6.7	2.6%
MgB	Mahoning silt loam, 2 to 6 percent slopes	5.4	2.1%
MmB	Mahoning-Urban land complex, 2 to 6 percent slopes	30.1	11.5%
Ua	Udorthents, loamy	33.4	12.8%
UmB	Urban land-Mahoning complex, 2 to 6 percent slopes	20.0	7.6%
Totals for Area of Interest		**261.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor

components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Cuyahoga County, Ohio

EIC—Ellsworth silt loam, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 2v02d
Elevation: 590 to 1,970 feet
Mean annual precipitation: 33 to 52 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 135 to 215 days
Farmland classification: Not prime farmland

Map Unit Composition

Ellsworth and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ellsworth

Setting

Landform: Till plains
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Till

Typical profile

Ap - 0 to 8 inches: silt loam
BE - 8 to 11 inches: silty clay loam
Bt1 - 11 to 16 inches: silty clay loam
Bt2 - 16 to 25 inches: silty clay loam
Bt3 - 25 to 37 inches: silty clay loam
C - 37 to 60 inches: silty clay loam

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 11 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: Moist Calcareous Till Flats (F139XY002OH)
Hydric soil rating: No

Minor Components

Mahoning

Percent of map unit: 10 percent
Landform: Till plains
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Interfluve, base slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

EsC—Ellsworth-Urban land complex, 6 to 18 percent slopes

Map Unit Setting

National map unit symbol: 2v02f
Elevation: 590 to 1,970 feet
Mean annual precipitation: 33 to 52 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 135 to 215 days
Farmland classification: Not prime farmland

Map Unit Composition

Ellsworth and similar soils: 55 percent
Urban land: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ellsworth

Setting

Landform: Till plains
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Till

Typical profile

Ap - 0 to 8 inches: silt loam
BE - 8 to 11 inches: silty clay loam
Bt1 - 11 to 16 inches: silty clay loam
Bt2 - 16 to 25 inches: silty clay loam
Bt3 - 25 to 37 inches: silty clay loam
C - 37 to 60 inches: silty clay loam

Properties and qualities

Slope: 6 to 18 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 11 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: Moist Calcareous Till Flats (F139XY002OH)
Hydric soil rating: No

Description of Urban Land

Setting
Down-slope shape: Linear
Across-slope shape: Linear

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: Unranked

Minor Components

Udorthents
Percent of map unit: 10 percent
Hydric soil rating: Unranked

Mahoning
Percent of map unit: 5 percent
Landform: Till plains
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Interfluve, base slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

MgA—Mahoning silt loam, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 2v02z
Elevation: 590 to 1,970 feet
Mean annual precipitation: 33 to 52 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 135 to 215 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Mahoning and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mahoning

Setting

Landform: Till plains
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Base slope, interfluve
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Till

Typical profile

Ap - 0 to 7 inches: silt loam
Eg - 7 to 9 inches: silt loam
Btg - 9 to 12 inches: silty clay loam
Bt1 - 12 to 20 inches: silty clay
Bt2 - 20 to 30 inches: silty clay
BCt - 30 to 36 inches: clay loam
C - 36 to 60 inches: clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 6 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: D
Ecological site: Moist Calcareous Till Flats (F139XY002OH)
Hydric soil rating: No

Minor Components

Ellsworth

Percent of map unit: 5 percent
Landform: Till plains
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Miner

Percent of map unit: 5 percent

Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Trumbull

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

MgB—Mahoning silt loam, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2v032
Elevation: 590 to 1,970 feet
Mean annual precipitation: 33 to 52 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 135 to 215 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Mahoning and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mahoning

Setting

Landform: Till plains
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Interfluve, base slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Till

Typical profile

Ap - 0 to 7 inches: silt loam
Eg - 7 to 9 inches: silt loam
Btg - 9 to 12 inches: silty clay loam
Bt1 - 12 to 20 inches: silty clay
Bt2 - 20 to 30 inches: silty clay
BCt - 30 to 36 inches: clay loam
C - 36 to 60 inches: clay loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 6 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: D
Ecological site: Moist Calcareous Till Flats (F139XY002OH)
Hydric soil rating: No

Minor Components

Ellsworth

Percent of map unit: 10 percent
Landform: Till plains
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Trumbull

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

MmB—Mahoning-Urban land complex, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2v037
Elevation: 590 to 1,970 feet
Mean annual precipitation: 33 to 52 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 135 to 215 days
Farmland classification: Not prime farmland

Map Unit Composition

Mahoning and similar soils: 45 percent
Urban land: 30 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mahoning

Setting

Landform: Till plains
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Base slope, interfluve
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Till

Typical profile

Ap - 0 to 7 inches: silt loam
Eg - 7 to 9 inches: silt loam
Btg - 9 to 12 inches: silty clay loam
Bt1 - 12 to 20 inches: silty clay
Bt2 - 20 to 30 inches: silty clay
BCt - 30 to 36 inches: clay loam
C - 36 to 60 inches: clay loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 6 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: D
Ecological site: Moist Calcareous Till Flats (F139XY002OH)
Hydric soil rating: No

Description of Urban Land

Setting

Down-slope shape: Linear
Across-slope shape: Linear

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: Unranked

Minor Components

Ellsworth

Percent of map unit: 10 percent
Landform: Till plains
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Udorthents

Percent of map unit: 10 percent
Hydric soil rating: Unranked

Trumbull

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Ua—Udorthents, loamy

Map Unit Setting

National map unit symbol: 9mxr
Elevation: 800 to 2,000 feet
Mean annual precipitation: 28 to 40 inches
Mean annual air temperature: 46 to 54 degrees F
Frost-free period: 170 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 6s
Hydric soil rating: Unranked

UmB—Urban land-Mahoning complex, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2v038
Elevation: 590 to 1,970 feet
Mean annual precipitation: 33 to 52 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 135 to 215 days
Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 60 percent
Mahoning and similar soils: 20 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting

Down-slope shape: Linear
Across-slope shape: Linear

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: Unranked

Description of Mahoning

Setting

Landform: Till plains
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Interfluve, base slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Till

Typical profile

Ap - 0 to 7 inches: silt loam
Eg - 7 to 9 inches: silt loam
Btg - 9 to 12 inches: silty clay loam
Bt1 - 12 to 20 inches: silty clay
Bt2 - 20 to 30 inches: silty clay
BCt - 30 to 36 inches: clay loam
C - 36 to 60 inches: clay loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 6 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: D
Ecological site: Moist Calcareous Till Flats (F139XY002OH)
Hydric soil rating: No

Minor Components

Udorthents

Percent of map unit: 10 percent
Hydric soil rating: Unranked

Trumbull

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Ellsworth

Percent of map unit: 5 percent
Landform: Till plains
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

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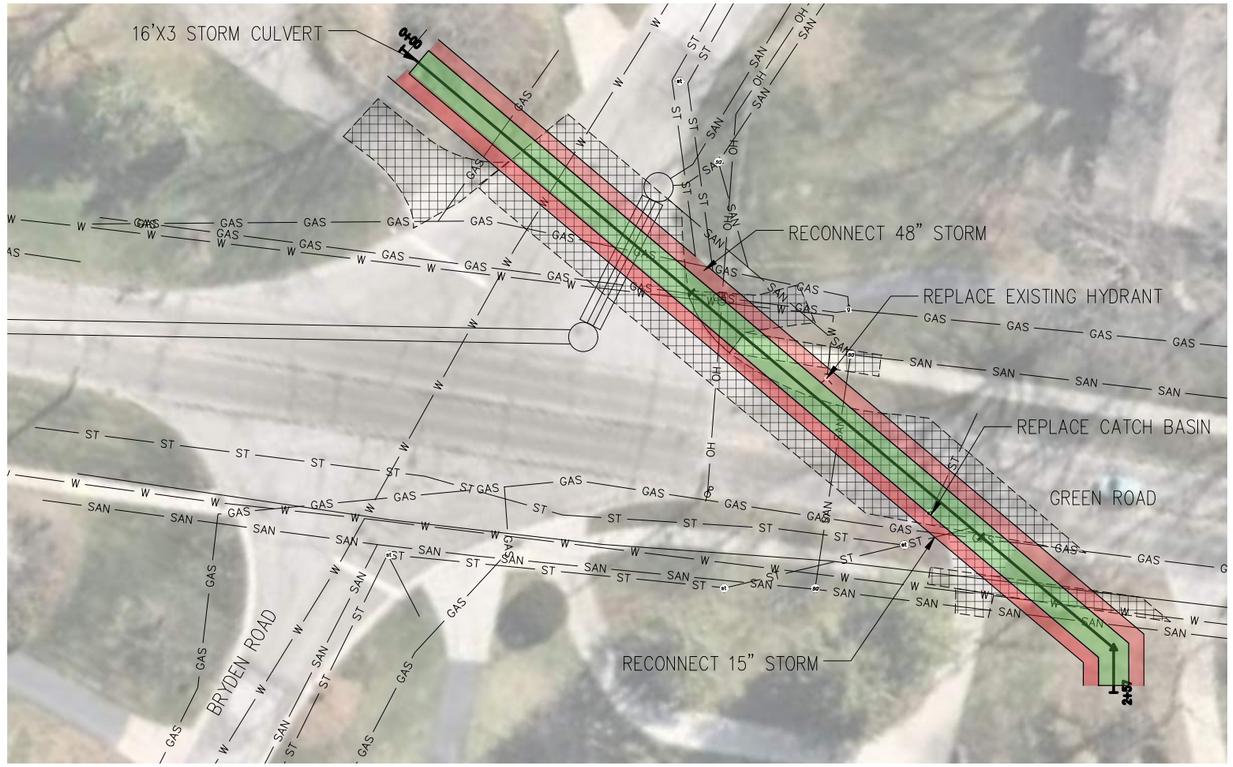
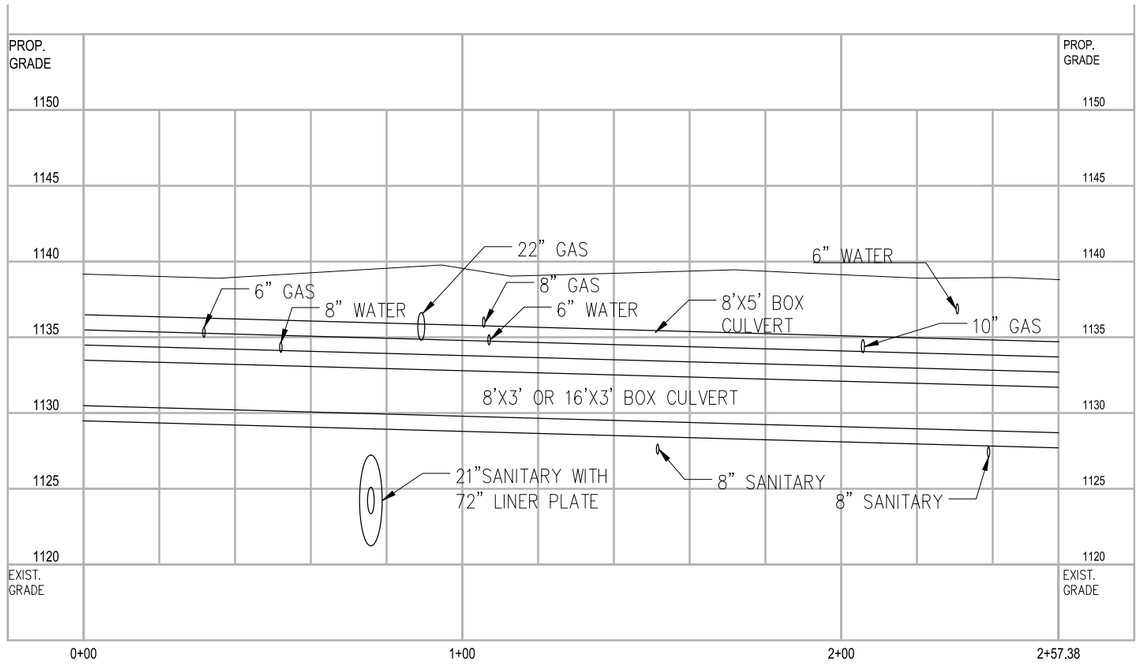
Appendix B

Plan and Profile Exhibits



16'X3' CULVERT



TYPICAL PROFILE FOR ALL ALTERNATIVES

PAVEMENT RESTORATION

16' WIDE X 3' TALL CULVERT

8' WIDE X 5' TALL CULVERT

0 20
10 40
Horizontal Scale in Feet

0 20
10 40
Vertical Scale in Feet

GPD GROUP
Glaus, Pyle, Schomer, Burns & DeHaven, Inc.
520 South Main Street
Akron, OH 44311
330.572.2100 Fax 330.572.2102

CLIENT LOGO

REV.	DATE	DESCRIPTION

Green-Bryden Culvert Study
Shaker Heights, Ohio

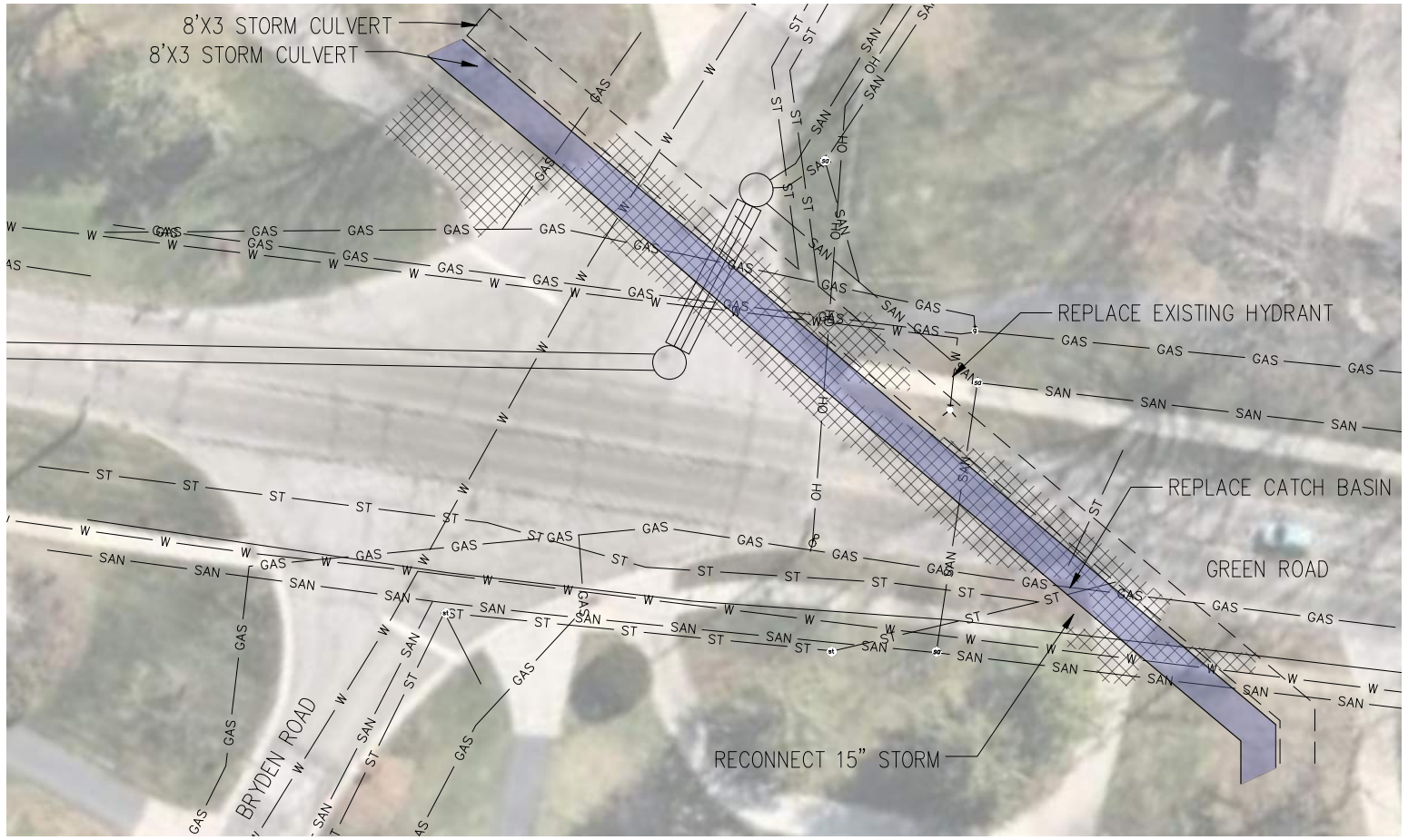
Culvert Replacement Alternatives

ISSUED FOR:	
PERMIT	-
BID	-
CONSTRUCTION	-
RECORD	-

JOB NO. 2020119.07

SHEET: C-01

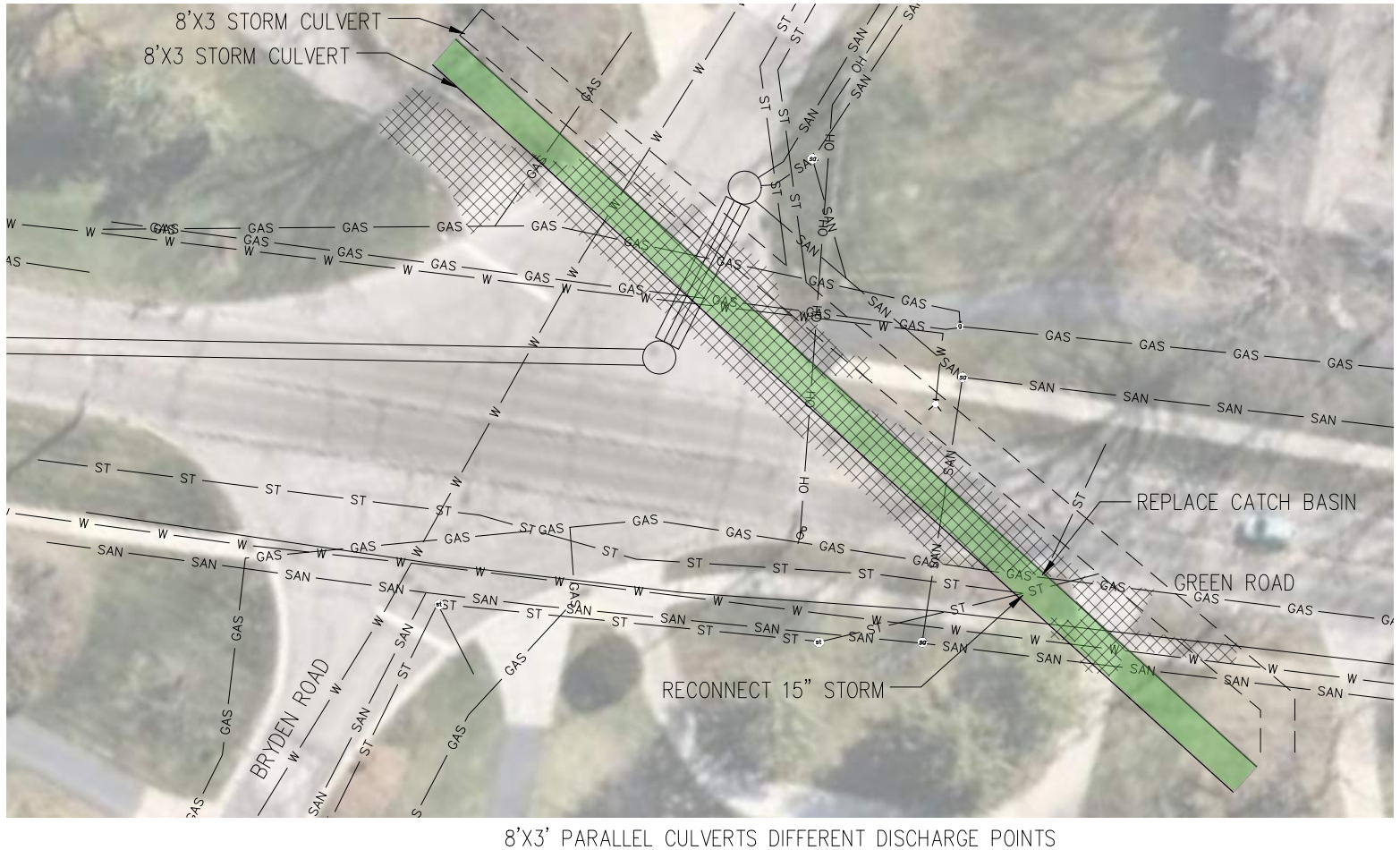
SHEET NO: SHEET 1/2



8'X3' PARALLEL CULVERTS

PAVEMENT RESTORATION

PROPOSED 8'X3' CULVERT



8'X3' PARALLEL CULVERTS DIFFERENT DISCHARGE POINTS

PAVEMENT RESTORATION

PROPOSED 8'X3' CULVERT

0 20
10 40
Horizontal
Scale in Feet

GPD GROUP
Glaus, Pyle, Schomer, Burns & DeHaven, Inc.
520 South Main Street
Akron, OH 44311
330.572.2100 Fax 330.572.2102

CLIENT LOGO

REV.	DATE	DESCRIPTION

Green-Bryden Culvert Study
Shaker Heights, Ohio

Culvert Replacement Alternatives

ISSUED FOR:	
PERMIT	-
BID	-
CONSTRUCTION	-
RECORD	-

JOB NO. 2020119.07

SHEET: C-02

SHEET NO: EXHIBIT 2/2

Appendix C

Opinion of Probable Construction Cost

GPD GROUP

Engineer's Opinion of Probable Construction Cost
Green/Bryden - Culvert Improvements - Alternative 1 - 8x5 Culvert

Date: 06/11/20

ODOT ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	COST
	ROADWAY				
SPEC	PRE CONSTRUCTION VIDEO	1	LUMP	$ 2,500.00	$2,500.00
202	PAVEMENT REMOVED ASPHALT ROADWAY	2,840	SF	$2.50	$7,100.00
202	CURB REMOVED	100	FT	$12.00	$1,200.00
202	PIPE REMOVED 24" AND UNDER	20	FT	$18.00	$360.00
202	PIPE REMOVED OVER 24", BOX CULVERT	250	FT	$100.00	$25,000.00
202	CATCH BASIN OR INLET REMOVED	2	EACH	$500.00	$1,000.00
202	HEADWALL REMOVED	2	EACH	$1,500.00	$3,000.00
202	SIDEWALK REMOVED	250	SF	$6.00	$1,500.00
202	PAVEMENT REMOVED, DRIVEWAY	75	SY	$25.00	$1,875.00
				ROADWAY SUBTOTAL	**$43,535.00**
	DRAINAGE				
601	CONCRETE BOX CULVERT - 8x5	250	FT	$1,300.00	$325,000.00
602	CONCRETE HEADWALLS	2	EACH	$10,000.00	$20,000.00
611	ODOT 3A CATCH BASIN	2	EACH	$3,000.00	$6,000.00
611	15" CONDUIT, TYPE B	11	FT	$200.00	$2,200.00
638	HYDRANT REMOVED AND RESET	1	EACH	$3,000.00	$3,000.00
651	TOPSOIL STOCKPILED	15	CY	$15.00	$232.27
659	TOPSOIL, SEEDING AND MULCHING	93	SY	$7.00	$651.00
				DRAINAGE SUBTOTAL	**$357,083.27**
	PAVEMENT				
301	ASPHALT CONCRETE BASE	240	CY	$265.00	$63,600.00
304	AGGREGATE BASE	160	CY	$120.00	$19,200.00
441	ASPHALT CONCRETE SURFACE COURSE, TYPE 1 (448), PG64-22	40	CY	$400.00	$16,000.00
441	ASPHALT CONCRETE INTERMEDIATE COURSE, TYPE 2 (448), PG64-22	40	CY	$350.00	$14,000.00
407	TACK COAT (0.075 GAL/SY)	24	GAL	$100.00	$2,400.00
407	TACK COAT FOR INTERMEDIATE COURSE (0.04 GAL/SY)	13	GAL	$100.00	$1,300.00
451	CONCRETE DRIVEWAY	75	SY	$125.00	$9,375.00
451	CONCRETE SIDEWALK	250	SF	$9.00	$2,250.00
609	TYPE 6 CURB	100	FT	$40.00	$4,000.00
				PAVEMENT SUBTOTAL	**$132,125.00**
	INCIDENTALS				
623	CONSTRUCTION LAYOUT STAKING	1	LS	$2,000.00	$2,000.00
670	EROSION CONTROL	1	LS	$2,000.00	$2,000.00
614	MAINTAINING TRAFFIC	1	LS	$10,000.00	$10,000.00
624	MOBILIZATION	1	LS	$30,000.00	$30,000.00
SPEC	CONTROL OF WATER	1	LS	$25,000.00	$25,000.00
SPEC	UTILIY ALLOWANCE	1	LS	$100,000.00	$100,000.00
				INCIDENTALS SUBTOTAL	**$169,000.00**

CONSTRUCTION SUBTOTAL	**$701,743.00**
CONTINGENCY (10%)	**$70,174.00**
CONSTRUCTION TOTAL	**$771,917.00**
ENGINEERING AND PERMITTING (10% OF CONSTRUCTION)	**$77,192.00**
PROJECT TOTAL	**$849,109.00**

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GPD GROUP

Engineer's Opinion of Probable Construction Cost
Green/Bryden - Culvert Improvements - Alternative 2 - 16x3 Culvert

Date: 06/11/20

ODOT ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	COST
	ROADWAY				
SPEC	PRE CONSTRUCTION VIDEO	1	LUMP	$ 2,500.00	$2,500.00
202	PAVEMENT REMOVED ASPHALT ROADWAY	3,545	SF	$2.50	$8,862.50
202	CURB REMOVED	140	FT	$12.00	$1,680.00
202	PIPE REMOVED 24" AND UNDER	20	FT	$18.00	$360.00
202	PIPE REMOVED OVER 24", BOX CULVERT	250	FT	$100.00	$25,000.00
202	CATCH BASIN OR INLET REMOVED	2	EACH	$500.00	$1,000.00
202	HEADWALL REMOVED	2	EACH	$1,500.00	$3,000.00
202	SIDEWALK REMOVED	358	SF	$6.00	$2,148.00
202	PAVEMENT REMOVED, DRIVEWAY	125	SY	$25.00	$3,125.00
				ROADWAY SUBTOTAL	**$47,675.50**
	DRAINAGE				
601	CONCRETE BOX CULVERT - 16x3	250	FT	$1,800.00	$450,000.00
602	CONCRETE HEADWALLS	2	EACH	$15,000.00	$30,000.00
611	ODOT 3A CATCH BASIN	2	EACH	$3,000.00	$6,000.00
611	15" CONDUIT, TYPE B	11	FT	$200.00	$2,200.00
638	HYDRANT REMOVED AND RESET	1	EACH	$3,000.00	$3,000.00
651	TOPSOIL STOCKPILED	15	CY	$15.00	$232.27
659	TOPSOIL, SEEDING AND MULCHING	93	SY	$7.00	$651.00
				DRAINAGE SUBTOTAL	**$492,083.27**
	PAVEMENT				
301	ASPHALT CONCRETE BASE	296	CY	$265.00	$78,440.00
304	AGGREGATE BASE	197	CY	$120.00	$23,640.00
441	ASPHALT CONCRETE SURFACE COURSE, TYPE 1 (448), PG64-22	49	CY	$400.00	$19,600.00
441	ASPHALT CONCRETE INTERMEDIATE COURSE, TYPE 2 (448), PG64-22	49	CY	$350.00	$17,150.00
407	TACK COAT (0.075 GAL/SY)	30	GAL	$100.00	$3,000.00
407	TACK COAT FOR INTERMEDIATE COURSE (0.04 GAL/SY)	16	GAL	$100.00	$1,600.00
451	CONCRETE DRIVEWAY	125	SY	$125.00	$15,625.00
451	CONCRETE SIDEWALK	358	SF	$9.00	$3,222.00
609	TYPE 6 CURB	140	FT	$40.00	$5,600.00
				PAVEMENT SUBTOTAL	**$167,877.00**
	INCIDENTALS				
623	CONSTRUCTION LAYOUT STAKING	1	LS	$2,000.00	$2,000.00
670	EROSION CONTROL	1	LS	$2,000.00	$2,000.00
614	MAINTAINING TRAFFIC	1	LS	$10,000.00	$10,000.00
624	MOBILIZATION	1	LS	$30,000.00	$30,000.00
SPEC	CONTROL OF WATER	1	LS	$25,000.00	$25,000.00
SPEC	UTILIY ALLOWANCE	1	LS	$50,000.00	$50,000.00
				INCIDENTALS SUBTOTAL	**$119,000.00**

CONSTRUCTION SUBTOTAL	**$826,636.00**
CONTINGENCY (10%)	**$82,664.00**
CONSTRUCTION TOTAL	**$909,300.00**
ENGINEERING AND PERMITTING (10% OF CONSTRUCTION)	**$90,930.00**
PROJECT TOTAL	**$1,000,230.00**

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GPD GROUP

Engineer's Opinion of Probable Construction Cost
Green/Bryden - Culvert Improvements - Alternative 3 - Two 8x3 Culverts in Parallel

Date: 06/11/20

ODOT ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	COST
	ROADWAY				
SPEC	PRE CONSTRUCTION VIDEO	1	LUMP	$ 2,500.00	$2,500.00
202	PAVEMENT REMOVED ASPHALT ROADWAY	2,560	SF	$2.50	$6,400.00
202	CURB REMOVED	96	FT	$12.00	$1,152.00
202	PIPE REMOVED 24" AND UNDER	20	FT	$18.00	$360.00
202	CATCH BASIN OR INLET REMOVED	2	EACH	$500.00	$1,000.00
202	HEADWALL REMOVED	2	EACH	$1,500.00	$3,000.00
202	SIDEWALK REMOVED	270	SF	$6.00	$1,620.00
202	PAVEMENT REMOVED, DRIVEWAY	113	SY	$25.00	$2,825.00
				ROADWAY SUBTOTAL	**$18,857.00**
	DRAINAGE				
601	CONCRETE BOX CULVERT - 8x3	250	FT	$1,000.00	$250,000.00
602	CONCRETE HEADWALLS	2	EACH	$10,000.00	$20,000.00
611	ODOT 3A CATCH BASIN	2	EACH	$3,000.00	$6,000.00
611	15" CONDUIT, TYPE B	8	FT	$200.00	$1,600.00
638	HYDRANT REMOVED AND RESET	1	EACH	$3,000.00	$3,000.00
651	TOPSOIL STOCKPILED	17	CY	$15.00	$249.75
659	TOPSOIL, SEEDING AND MULCHING	100	SY	$7.00	$700.00
				DRAINAGE SUBTOTAL	**$281,549.75**
	PAVEMENT				
301	ASPHALT CONCRETE BASE	214	CY	$265.00	$56,710.00
304	AGGREGATE BASE	142	CY	$120.00	$17,040.00
441	ASPHALT CONCRETE SURFACE COURSE, TYPE 1 (448), PG64-22	36	CY	$400.00	$14,400.00
441	ASPHALT CONCRETE INTERMEDIATE COURSE, TYPE 2 (448), PG64-22	36	CY	$350.00	$12,600.00
407	TACK COAT (0.075 GAL/SY)	22	GAL	$100.00	$2,200.00
407	TACK COAT FOR INTERMEDIATE COURSE (0.04 GAL/SY)	12	GAL	$100.00	$1,200.00
451	CONCRETE DRIVEWAY	113	SY	$125.00	$14,125.00
451	CONCRETE SIDEWALK	270	SF	$9.00	$2,430.00
609	TYPE 6 CURB	96	FT	$40.00	$3,840.00
				PAVEMENT SUBTOTAL	**$124,545.00**
	INCIDENTALS				
623	CONSTRUCTION LAYOUT STAKING	1	LS	$2,000.00	$2,000.00
670	EROSION CONTROL	1	LS	$2,000.00	$2,000.00
614	MAINTAINING TRAFFIC	1	LS	$10,000.00	$10,000.00
624	MOBILIZATION	1	LS	$30,000.00	$30,000.00
SPEC	CONTROL OF WATER	1	LS	$10,000.00	$10,000.00
SPEC	UTILITY ALLOWANCE	1	LS	$50,000.00	$50,000.00
				INCIDENTALS SUBTOTAL	**$104,000.00**

CONSTRUCTION SUBTOTAL	**$528,952.00**
CONTINGENCY (10%)	**$52,895.00**
CONSTRUCTION TOTAL	**$581,847.00**
ENGINEERING AND PERMITTING (10% OF CONSTRUCTION)	**$58,185.00**
PROJECT TOTAL	**$640,032.00**

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GPD GROUP

Engineer's Opinion of Probable Construction Cost
Green/Bryden - Culvert Improvements - Alternative 4 - Two 8x3 Culverts with Downstream Tie in

Date: 06/11/20

ODOT ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	COST
	ROADWAY				
SPEC	PRE CONSTRUCTION VIDEO	1	LUMP	$ 2,500.00	$2,500.00
202	PAVEMENT REMOVED ASPHALT ROADWAY	2,785	SF	$2.50	$6,962.50
202	CURB REMOVED	97	FT	$12.00	$1,164.00
202	PIPE REMOVED 24" AND UNDER	20	FT	$18.00	$360.00
202	CATCH BASIN OR INLET REMOVED	2	EACH	$500.00	$1,000.00
202	HEADWALL REMOVED	2	EACH	$1,500.00	$3,000.00
202	SIDEWALK REMOVED	235	SF	$6.00	$1,410.00
202	PAVEMENT REMOVED, DRIVEWAY	102	SY	$25.00	$2,550.00
				ROADWAY SUBTOTAL	**$18,946.50**
	DRAINAGE				
601	CONCRETE BOX CULVERT - 8x3	252	FT	$1,000.00	$252,000.00
602	CONCRETE HEADWALLS	2	EACH	$10,000.00	$20,000.00
611	ODOT 3A CATCH BASIN	2	EACH	$3,000.00	$6,000.00
611	15" CONDUIT, TYPE B	2	FT	$200.00	$400.00
638	HYDRANT REMOVED AND RESET	1	EACH	$3,000.00	$3,000.00
651	TOPSOIL STOCKPILED	16	CY	$15.00	$239.76
659	TOPSOIL, SEEDING AND MULCHING	96	SY	$7.00	$672.00
				DRAINAGE SUBTOTAL	**$282,311.76**
	PAVEMENT				
301	ASPHALT CONCRETE BASE	232	CY	$265.00	$61,480.00
304	AGGREGATE BASE	155	CY	$120.00	$18,600.00
441	ASPHALT CONCRETE SURFACE COURSE, TYPE 1 (448), PG64-22	39	CY	$400.00	$15,600.00
441	ASPHALT CONCRETE INTERMEDIATE COURSE, TYPE 2 (448), PG64-22	39	CY	$350.00	$13,650.00
407	TACK COAT (0.075 GAL/SY)	24	GAL	$100.00	$2,400.00
407	TACK COAT FOR INTERMEDIATE COURSE (0.04 GAL/SY)	13	GAL	$100.00	$1,300.00
451	CONCRETE DRIVEWAY	102	SY	$125.00	$12,765.00
451	CONCRETE SIDEWALK	235	SF	$9.00	$2,115.00
609	TYPE 6 CURB	97	FT	$40.00	$3,880.00
				PAVEMENT SUBTOTAL	**$131,790.00**
	INCIDENTALS				
623	CONSTRUCTION LAYOUT STAKING	1	LS	$2,000.00	$2,000.00
670	EROSION CONTROL	1	LS	$2,000.00	$2,000.00
614	MAINTAINING TRAFFIC	1	LS	$10,000.00	$10,000.00
624	MOBILIZATION	1	LS	$30,000.00	$30,000.00
SPEC	CONTROL OF WATER	1	LS	$10,000.00	$10,000.00
SPEC	UTILITITY ALLOWANCE	1	LS	$50,000.00	$50,000.00
				INCIDENTALS SUBTOTAL	**$104,000.00**

CONSTRUCTION SUBTOTAL	**$537,048.00**
CONTINGENCY (10%)	**$53,705.00**
CONSTRUCTION TOTAL	**$590,753.00**
ENGINEERING AND PERMITTING (10% OF CONSTRUCTION)	**$59,075.00**
PROJECT TOTAL	**$649,828.00**

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Appendix D

Rainfall Data

Time (H:M)	10-yr Intensity (in/hr)	25-yr Intensity (in/hr)
0:00	0.0375	0.0452
0:15	0.0375	0.0452
0:30	0.0375	0.0452
0:45	0.0375	0.0452
1:00	0.0375	0.0452
1:15	0.0375	0.0452
1:30	0.0375	0.0452
1:45	0.0375	0.0452
2:00	0.0443	0.0534
2:15	0.0443	0.0534
2:30	0.0443	0.0534
2:45	0.0443	0.0534
3:00	0.0443	0.0534
3:15	0.0443	0.0534
3:30	0.0443	0.0534
3:45	0.0443	0.0534
4:00	0.0546	0.0658
4:15	0.0546	0.0658
4:30	0.0546	0.0658
4:45	0.0546	0.0658
5:00	0.0546	0.0658
5:15	0.0546	0.0658
5:30	0.0546	0.0658
5:45	0.0546	0.0658
6:00	0.0614	0.074
6:15	0.0614	0.074
6:30	0.0614	0.074
6:45	0.0614	0.074
7:00	0.075	0.0904
7:15	0.075	0.0904
7:30	0.075	0.0904
7:45	0.075	0.0904
8:00	0.0887	0.107
8:15	0.0887	0.107
8:30	0.0955	0.115
8:45	0.0955	0.115
9:00	0.109	0.132
9:15	0.109	0.132
9:30	0.123	0.148
9:45	0.123	0.148
10:00	0.157	0.189
10:15	0.157	0.189
10:30	0.211	0.255
10:45	0.211	0.255
11:00	0.327	0.395
11:15	0.327	0.395

Time (H:M)	10-yr Intensity (in/hr)	25-yr Intensity (in/hr)
11:30	1.009	1.217
11:45	4.174	5.031
12:00	0.491	0.592
12:15	0.491	0.592
12:30	0.252	0.304
12:45	0.252	0.304
13:00	0.184	0.222
13:15	0.184	0.222
13:30	0.143	0.173
13:45	0.143	0.173
14:00	0.102	0.123
14:15	0.102	0.123
14:30	0.102	0.123
14:45	0.102	0.123
15:00	0.102	0.123
15:15	0.102	0.123
15:30	0.102	0.123
15:45	0.102	0.123
16:00	0.0614	0.074
16:15	0.0614	0.074
16:30	0.0614	0.074
16:45	0.0614	0.074
17:00	0.0614	0.074
17:15	0.0614	0.074
17:30	0.0614	0.074
17:45	0.0614	0.074
18:00	0.0614	0.074
18:15	0.0614	0.074
18:30	0.0614	0.074
18:45	0.0614	0.074
19:00	0.0614	0.074
19:15	0.0614	0.074
19:30	0.0614	0.074
19:45	0.0614	0.074
20:00	0.0409	0.0493
20:15	0.0409	0.0493
20:30	0.0409	0.0493
20:45	0.0409	0.0493
21:00	0.0409	0.0493
21:15	0.0409	0.0493
21:30	0.0409	0.0493
21:45	0.0409	0.0493
22:00	0.0409	0.0493
22:15	0.0409	0.0493
22:30	0.0409	0.0493
22:45	0.0409	0.0493

Time (H:M)	10-yr Intensity (in/hr)	25-yr Intensity (in/hr)
23:00	0.0409	0.0493
23:15	0.0409	0.0493
23:30	0.0409	0.0493
23:45	0.0409	0.0493