DAWOOD
ENGINEERS ▸ PLANNERS ▸ SURVEYORS

February 28, 2019

JOHNSON, MIRMIRAN & THOMPSON, INC.
220 St. Charles Way
York, PA 17402

Attn: Mr. Neil Beach, P.E. Vice President

Re: Eisenhower Drive Extension – Phase II
Dawood Project No. 205094.12

Dear Mr. Beach:

1.0 GENERAL

1.1 PURPOSE AND SCOPE

Dawood Engineering, Inc. (Dawood) was authorized to prepare this Geological Desktop Study and related work by Agreement No. 00187 with Johnson, Mirmiran, & Thompson, Inc. (JMT) and the Pennsylvania Department of Transportation (PennDOT).

This letter provides an analysis and evaluation of the geological and topographic conditions at the site in relation to proposed extensions of Eisenhower Drive for JMT, and outlines any karst related geological conditions with regards to soil, rock and groundwater, which may require considerations for the project design analysis. The analysis included available literature review.

1.2 SITE LOCATION AND DESCRIPTION

The proposed Eisenhower Drive Extension project is located in Conewago Township, Penn Township, and Hanover Borough, Adams and York Counties, Pennsylvania. The project involves extending Eisenhower Drive through Conewago Township, from where it currently ends at High Street to Hanover Road (SR0116) west of McSherrystown. Five alternatives were reviewed with various sub alternatives. The preferred alternative at this time is Alternative 5. The project location is shown in Figure 1.

2.0 LITERATURE REVIEW

2.1 TOPOGRAPHY

The Site Topographic Maps (Figures 3A and 3B) indicates that the project area is moderately populated. The approximate ground surface elevations at the site range from approximately 520 to 560 feet. In general, the site is relatively flat to gently sloping to the northwest.

2.2 SOIL

The Soil Maps (Figures 6A and 6B) of the project site indicates that the soil at the project site is characterized as four different soil classifications. Properties of the soils are presented below.

CONESTOGA SILT LOAM (CnB)

Slope:	3 to 8 percent
Depth to restrictive feature:	60 to 99 inches to lithic bedrock
Drainage class:	Well drained

All areas are considered as prime farmland

CLARKSBURG SILT LOAM (CkA)

Slope:	0 to 3 percent
Depth to restrictive feature:	60 to 99 inches to lithic bedrock
Drainage class:	moderately Well drained

All areas are considered as prime farmland

PENLAW SILT LOAM (Pa)

Slope:	0 to 3 percent
Depth to restrictive feature:	40 to 72 inches to lithic bedrock
Drainage class:	some poorly drained

All areas are not considered as prime farmland

CONESTOGA SILT LOAM (CnA)

Slope:	0 to 3 percent
Depth to restrictive feature:	60 to 99 inches to lithic bedrock
Drainage class:	Well drained

All areas are considered as prime farmland

2.3 GEOLOGY

The Geologic Map (Figure 2) indicates the project site is located within proximity to a contact zone of the Conestoga formation (OCc) Formation and Kinzers Formation (Ck).

The Conestoga Formation of the late Cambrian and early Ordovician Periods consists of medium gray, impure limestone having black, graphitic shale partings. It is conglomeratic at the base. Its total thickness is unknown, but it is at least 300 feet thick.

The rock is crudely bedded to poorly bedded, thin and highly crumpled. Joints have an irregular pattern. They are poorly formed, moderately abundant, and widely spaced having uneven regularity. Many are open, but some are filled with quartz and calcite. The formation is moderately resistant to weathering. It is slightly weathered to a shallow depth. Impure layers weather to a higher relief. Large, irregularly shaped fragments result from weathering. Mantle thickness is highly variable and may be extremely thick. The bedrock-mantle interface is pinnacled in most areas. The formation forms rolling valleys and hills of low relief. Natural slopes are gentle and stable.

Excavation is difficult. Bedrock pinnacles and numerous quartz veins are special problems. The drilling rate is fast, but quartz veins slow the drilling rate. Cut-slope stability is good. Foundation stability is good. A thorough investigation for possible collapse areas should be undertaken. The formation is a good source of road material, riprap, building stone, and fill.

Specific gravity ranges from 2.70 to 2.71. Absorption ranges from 0.12 to 0.40%. Compressive strength ranges from 182 to 600 tsf for decomposed micaceous limestone, broken limestone, and solid micaceous limestone.

Median groundwater yield is 25 gallons per minute. Some wells encounter solution openings for very large yields. The water may be very hard. The formation has good surface drainage and minor subsurface drainage. A few sinkholes can occur. Joint and some solution channel openings provide a secondary porosity of low magnitude. Permeability is moderate to low.

The Kinzers Formation of the Cambrian Period consists of a dark brown shale at the base. The middle is a gray and white spotted limestone and, locally, marble having irregular partings. The upper portion is a sandy limestone which weathers to a fine-grained, friable, porous, sandy mass. The thickness of the member is 150 feet.

The rock is moderately well bedded and fissile. Joint and cleavage planes display a seamy pattern. They are moderately developed, highly abundant, irregularly distributed, very closely spaced, open, and steeply to moderately dipping. The member is moderately resistant to weathering. It is highly and deeply weathered. Complete breakup of rock occurs in many places, resulting in medium to small sized fragments. The overlying mantle is thin. The member forms undulating hills of low relief. Natural slopes are moderately steep and stable.

Excavation is moderately easy, but difficult in unweathered rock. Quartz boulders are a special problem. The drilling rate is moderate. Cut-slope stability is fair. Rapid disintegration occurs when the rock is exposed to moisture for a relatively short time. Foundation stability is good. Rock should be excavated to sound material. The formation is a good source of road material and fill.

Median groundwater yield is 30 gallons per minute (gpm). Well yields range from less than 1 gpm upto 400 gpm. The member has good surface drainage. Joint and cleavage plane openings provide a secondary porosity of moderate magnitude. Permeability is moderate.

2.4 KARST FEATURES

The Lithology map (Figure 1) indicates numerous closed depressions and sinkholes within the project area. Seven recorded sinkholes and seven surface mines are also present within a 4-miles radius.

2.5 GROUNDWATER

An online search of the Pennsylvania Groundwater Information System (PaGWIS) (compiled by the Pennsylvania Topographic and Geological Survey) was conducted for approximate depths to bedrock and static water levels at the vicinity of the project site. According to well data within a 2½-miles radius of the site, the depth to bedrock varied between 5 and 35 feet below ground surface (ft. bgs), with an average depth of approximately 15 ft. bgs. The depth to static water levels varied between 8 and 187 ft. bgs, with an average depth of approximately 53 ft. bgs.

2.6 OVERLAY ANALYSIS

The Overlay Analysis Map (Figure 5) shows areas that were deemed as having a high probability of being a karst feature in conjunction with areas with lower probability of karst for contrast. The possible karst features were determined by analyzing the elevation of the project area. The study searched for low-lying areas where water was likely to pool and penetrate the surface. The ground's relative elevation to its surroundings, slope, and change in shape were the focus of the study.

To create this karst information, elevation data was put through Esri geoprocessing tools and then combined using a weighted overlay. Digital Elevation Model (DEM) raster tiles were merged together into one mosaic to cover the entire project area. Three tools were run on the DEM: Slope, Aspect, and Curvature. The tool's defaults were kept for simplicity. The slope analyzes the change in elevation while aspect determined the downslope direction. Curvature determined the shape of the land. The three output rasters were then added to a weighted over tool in which their weights were set. For the slope, a greatest weight was given to areas with low slope where water was less likely to runoff. Areas deemed as flat by the aspect tool were given the greatest weight as that is where water would flow down to. Areas with little curvature were given the greatest weight as there was less chance for water to collect and run off as a stream. The results were then symbolized to only show the highest and lowest areas of karst probability.

With this information, low lying areas where water will flow to, infiltrate, and potentially cause sinkholes can be determined.

3.0 CONCLUSIONS AND RECOMMENDATIONS

From the information presented above, the project site is underlain by carbonate bedrock (limestone and/or dolomite) and karst like features are present throughout portions of the project site. From Figures 1 and 5, numerous noted closed depressions and potential sinkholes exist throughout the project location. Based on the analysis of the figures, it appears that sinkholes are more likely to occur along Alignments 3 and 4. At the western end of the project, Alternatives B and C each traverse through an area with numerous noted closed depressions. However, the majority of the depressions are located to the west of these alternatives.

As indicated in the desktop study, there is very good potential for sinkholes during construction along the proposed route. The following recommendations are provided to limit the potential for sinkholes during construction.

- Utilize staged construction methods to minimize the exposure of the subgrade soils to atmospheric conditions. Do not allow water to pond.

- During construction activity, all excavations shall be protected against stormwater entering the excavation. Remove any water that enters an excavation.

- Pinnacles may be encountered during construction. If the rock must be removed, use a hydraulic hammer. Do not blast.

- A special provision for remediation of sinkholes will be required, for instances in which a sinkhole occurs. Sinkhole remediation should be tailored to whether the sinkhole is in a structural situation or whether water infiltration is possible.

4.0 LIMITATIONS AND QUALIFICATIONS

The conclusions and recommendations presented in this report have been based upon the available geological information and site observations. If deviations from the noted foundation conditions are encountered during construction, they should also be brought to the attention of the geotechnical engineer.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practice. DAWOOD ENGINEERING, INC. is not responsible for the conclusions made by others based upon the data herein.

Should you require any additional information, I can be reached at 717-732-8576 or powen@dawood.cc

Sincerely,
Dawood Engineering, Inc.

Nasir Iqbal
Geotechnical Technician
Geotechnical Services

Patrick Owen, P.E.
Project Manager
Geotechnical Services

REFERENCES

TOPOGRAPHIC AND GEOLOGIC MAPS

Atlas of Preliminary Geologic Quadrangle Maps of Pennsylvania, 7.5-minute Topographic Quadrangle: Mechanicsburg, Pennsylvania, Berg, T. M. and Dodge C. M., 1981.

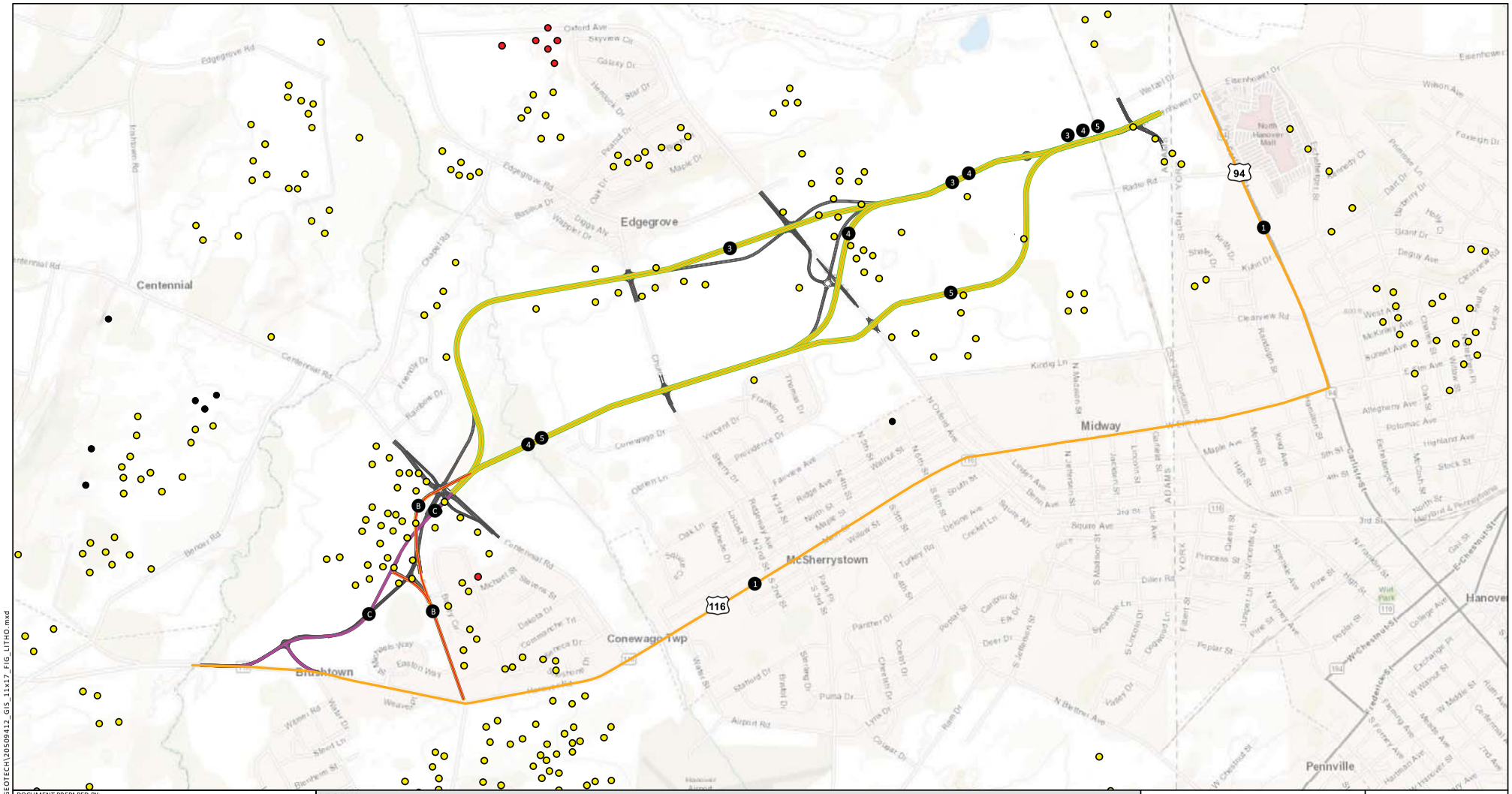
United States Department of Agriculture: Natural Resources Conservation Service, Web Soil Survey, 2013.

PAGWIS database, Department of Conservation and Natural Resources, http://www.dcnr.state.pa.us/topogeo/groundwater/pagwis/index.htm, 2013.

PUBLICATIONS

Engineering Characteristics of the Rocks of Pennsylvania, Geyer, Alan R. and Wilshusen, J. Peter, Pennsylvania Geological Survey, 1982.

FIGURES



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LEGEND:

KARST FEATURES

- SINKHOLE
- SURFACE DEPRESSION
- SURFACE MINE

ALIGNMENT ALTERNATIVES

- TRANSPORTATION SYSTEMS MANAGEMENT (TSM) ALTERNATIVE
- ALIGNMENT ALTERNATIVE
- ALTERNATIVE B
- ALTERNATIVE C

Data Source: Pennsylvania Geological Survey & Others, 1980

Basemap Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

EISENHOWER DRIVE EXTENSION PROJECT

FIGURE 1

LITHOLOGY MAP

ADAMS & YORK COUNTIES, PENNSYLVANIA

SCALE: 1 " = 1,500 '

1,500 750 0 1,500 FEET

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DATE:	02/28/2019
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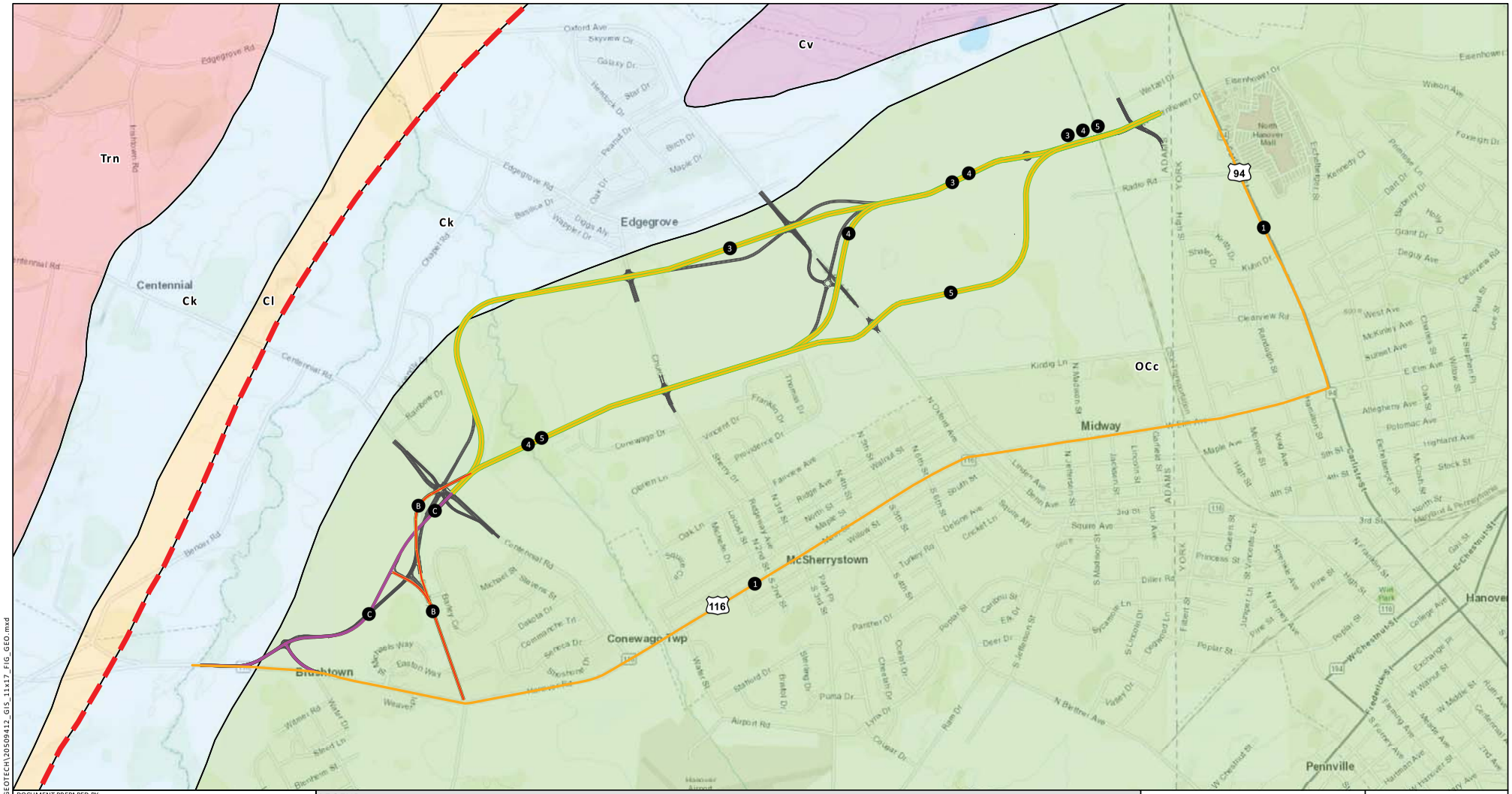

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LEGEND:

ALIGNMENT ALTERNATIVES

- TRANSPORTATION SYSTEMS MANAGEMENT (TSM) ALTERNATIVE
- ALIGNMENT ALTERNATIVE
- ALTERNATIVE B
- ALTERNATIVE C

BEDROCK GEOLOGY

- FAULT LINE
- Ck - KINZERS FORMATION
- Cl - LEDGER FORMATION
- Cv - VINTAGE FORMATION
- OCc - CONESTOGA FORMATION
- Trn - NEW OXFORD FORMATION

Data Source: Pennsylvania Geological Survey & Others, 1980

Basemap Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

EISENHOWER DRIVE EXTENSION PROJECT

FIGURE 2
GEOLOGIC MAP

ADAMS & YORK COUNTIES, PENNSYLVANIA

SCALE: 1 " = 1,500 '

1,500 750 0 1,500 FEET

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LEGEND:

ALIGNMENT ALTERNATIVES

- TRANSPORTATION SYSTEMS MANAGEMENT (TSM) ALTERNATIVE
- ALIGNMENT ALTERNATIVE
- ALTERNATIVE B
- ALTERNATIVE C
- CONTOUR (10' INDEX)
- CONTOUR (2' INTERVAL)
- DEPRESSION CONTOUR

Data Source: PAMAP Program, Bureau of Topographic and Geologic Survey, PA Department of Conservation and Natural Resources
Basemap Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

EISENHOWER DRIVE EXTENSION PROJECT

FIGURE 3A
TOPOGRAPHIC MAP

ADAMS & YORK COUNTIES, PENNSYLVANIA

SCALE: 1 " = 1,000 '
1,000 500 0 1,000 FEET

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- ALIGNMENT ALTERNATIVE
- ALTERNATIVE B
- ALTERNATIVE C
- CONTOUR (10' INDEX)
- CONTOUR (2' INTERVAL)
- DEPRESSION CONTOUR

Data Source: PAMAP Program, Bureau of Topographic and Geologic Survey, PA Department of Conservation and Natural Resources
Basemap Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

EISENHOWER DRIVE EXTENSION PROJECT

FIGURE 3B
TOPOGRAPHIC MAP

ADAMS & YORK COUNTIES, PENNSYLVANIA

SCALE: 1 " = 1,000 '

1,000 500 0 1,000 FEET

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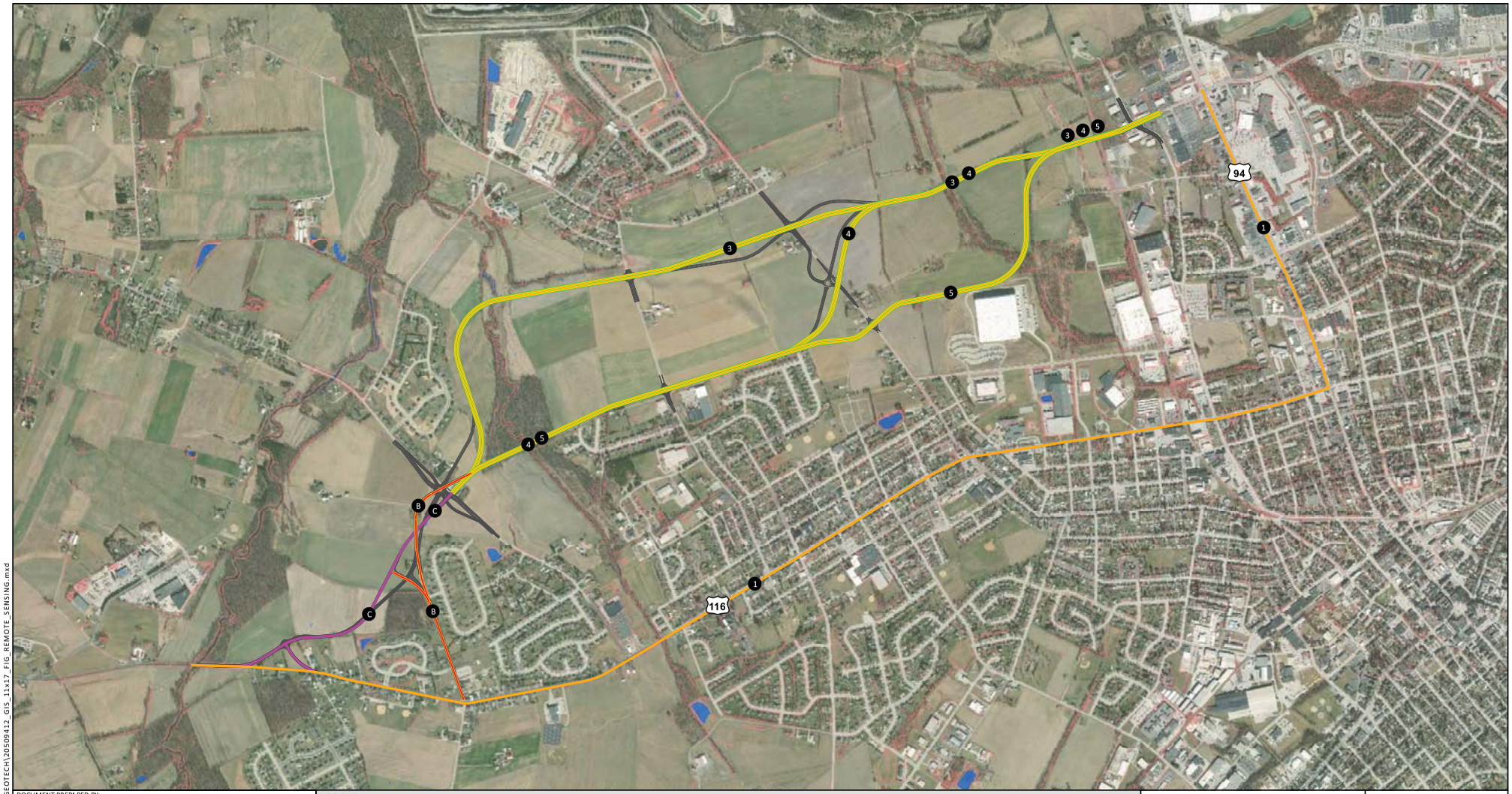

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LEGEND:

ALIGNMENT ALTERNATIVES

- TRANSPORTATION SYSTEMS MANAGEMENT (TSM) ALTERNATIVE
- ALIGNMENT ALTERNATIVE
- ALTERNATIVE B
- ALTERNATIVE C

ANALYSIS RESULTS

- LOWEST PROBABILITY OF KARST
- POSSIBLE KARST FEATURE

Data Source: Pennsylvania Department of Conservation & Natural Resources, PAMAP Program DEM, 2008; Slope, Aspect, and Curvature were run on the DEM and their results were used in a Weighted Overlay to determine probable areas of karst.
Basemap Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

EISENHOWER DRIVE EXTENSION PROJECT

FIGURE 5
OVERLAY ANALYSIS RESULTS

ADAMS & YORK COUNTIES, PENNSYLVANIA

SCALE: 1 " = 1,500 '

1,500 750 0 1,500 FEET

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JMT

LEGEND:

ALIGNMENT ALTERNATIVES

- TRANSPORTATION SYSTEMS MANAGEMENT (TSM) ALTERNATIVE
- ALIGNMENT ALTERNATIVE
- ALTERNATIVE B
- ALTERNATIVE C
- SOIL TYPE

SOIL TYPE

CkA - Clarksburg silt loam, 0 to 3 percent slopes	Dy - Dunning silty clay loam
CkB - Clarksburg silt loam, 3 to 8 percent slopes	Pa - Penlaw silt loam
CnA - Conestoga silt loam, 0 to 3 percent slopes	Uc - Urban land
CnB - Conestoga silt loam, 3 to 8 percent slopes	UeB - Urban land-Conestoga complex, 0 to 8 percent slopes

Data Source: PAMAP Program, Bureau of Topographic and Geologic Survey, PA Department of Conservation and Natural Resources
Basemap Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

EISENHOWER DRIVE EXTENSION PROJECT

FIGURE 6A
SOIL MAP

ADAMS & YORK COUNTIES, PENNSYLVANIA

SCALE: 1 " = 1,000 '
1,000 500 0 1,000 FEET

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ALIGNMENT ALTERNATIVES

- TRANSPORTATION SYSTEMS MANAGEMENT (TSM) ALTERNATIVE
- ALIGNMENT ALTERNATIVE
- ALTERNATIVE B
- ALTERNATIVE C
- SOIL TYPE

SOIL TYPE

CkA - Clarksburg silt loam, 0 to 3 percent slopes	Dy - Dunning silty clay loam
CkB - Clarksburg silt loam, 3 to 8 percent slopes	Pa - Penlaw silt loam
CnA - Conestoga silt loam, 0 to 3 percent slopes	Uc - Urban land
CnB - Conestoga silt loam, 3 to 8 percent slopes	UeB - Urban land-Conestoga complex, 0 to 8 percent slopes

Data Source: PAMAP Program, Bureau of Topographic and Geologic Survey, PA Department of Conservation and Natural Resources
Basemap Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

EISENHOWER DRIVE EXTENSION PROJECT

FIGURE 6B
SOIL MAP

ADAMS & YORK COUNTIES, PENNSYLVANIA

SCALE: 1 " = 1,000 '

1,000 500 0 1,000 FEET

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APPENDIX A

GROUNDWATER DATA

Project Name: Eisenhower Drive Extension
Search Radius: Approximate 2.5 Miles.
Date: December 19, 2018
Search Performed bY:

PAWellID	County	Municipality	QuadName	DateDrilled	LatitudeDD	LongitudeDD	WellDepth(ft)	DepthToBedrock(ft)	StaticWaterLevel(ft)	FormationName
500188	ADAMS			41060	39.80828	-77.00296	13			
500187	ADAMS			41060	39.80838	-77.00221	16			
478169	ADAMS	CONEWAGO TWP.		40624	39.80814	-77.00283	15			
478168	ADAMS	CONEWAGO TWP.		40624	39.80811	-77.00266	11			
477401	ADAMS	CONEWAGO TWP.		40624	39.80801	-77.00266	13			
425148	ADAMS	CONEWAGO TWP.		39696	39.81833	-77.02033	265	18		
425147	ADAMS	CONEWAGO TWP.		39696	39.81944	-77.02278	265	18		
419029	ADAMS	OXFORD TWP.		39059	39.82639	-77.02972	650			
418841	ADAMS	OXFORD TWP.		39058	39.82639	-77.03333	600		154	
418840	ADAMS	OXFORD TWP.		39056	39.82639	-77.02972	800		187	
414464	ADAMS	MT PLEASANT TWP.		38253	39.825	-77.05083	100	13	8	
3015	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	21551	39.81861	-77.03972	424		27	KINZERS FORMATION
3011	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	28522	39.8025	-77.03639	300		12.8	CONESTOGA FORMATION
2682	ADAMS	OXFORD TWP.	MCSHERRYSTOWN	22493	39.8325	-77.02194	395		60	KINZERS FORMATION
2678	ADAMS	OXFORD TWP.	MCSHERRYSTOWN		39.83	-77.04361	17		8.43	NEW OXFORD FORMATION
2677	ADAMS	OXFORD TWP.	MCSHERRYSTOWN		39.82972	-77.04389	300			KINZERS FORMATION
2666	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN		39.82417	-77.02222	310		36.4	VINTAGE FORMATION
2664	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN		39.82361	-77.02222	100			CONESTOGA FORMATION
2626	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN		39.81083	-77.01528	24		19.4	CONESTOGA FORMATION
2604	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN		39.805	-77.00139	210			CONESTOGA FORMATION
2599	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN		39.80333	-77.04111	30		21.8	CONESTOGA FORMATION
						Average:	231	16	53	

Project Name: Eisenhower Drive Extension
Search Radius: Approximate 2.5 Miles.
Date: December 19, 2018
Search Performed bY:

PAWellID	County	Municipality	QuadName	DateDrilled	LatitudeDD	LongitudeDD	WellDepth(ft)	DepthToBedrock(ft)	StaticWaterLevel(ft)	FormationName
668144	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	37846	39.81164	-77.01516	500	15		
668144	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	37846	39.81164	-77.01516	500	15		
663818	ADAMS	CONEWAGO TWP.		43299	39.80914	-77.0005	13			
663794	ADAMS	CONEWAGO TWP.		43299	39.80935	-77.00024	9.7			
663711	ADAMS	CONEWAGO TWP.		43299	39.80923	-77.00056	26			
663710	ADAMS	CONEWAGO TWP.		43299	39.80918	-77.00056	13			
655944	ADAMS	MT PLEASANT TWP.	MCSHERRYSTOWN	43055	39.82502	-77.04892	240	35		
653398	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42902	39.82367	-77.00684	32	7		
653398	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42902	39.82367	-77.00684	32	7		
653397	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42902	39.8191	-77.00222	61	17		
653397	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42902	39.8191	-77.00222	61	17		
646856	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42579	39.81979	-77.01642	24.5	5		
646855	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42579	39.8199	-77.01276	7.5			
646854	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42579	39.82363	-77.00955	7.5			
646847	YORK	HANOVER BORO	MCSHERRYSTOWN	42579	39.81751	-77.00001	23			
646838	YORK	HANOVER BORO	HANOVER	42579	39.81946	-76.9995	15			
646827	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42579	39.81866	-77.00123	21			
646825	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42579	39.81803	-77.00191	24			
646800	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42579	39.82338	-77.00486	7.5			
646578	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42579	39.82373	-77.007	6.4			
646577	ADAMS	CONEWAGO TWP.	MCSHERRYSTOWN	42579	39.82316	-77.0037	16.4			
						Average:	78	15	)	