



Engineers, Surveyors, Planners, Scientists

**VAUGHN ROAD FLOOD MITIGATION
BRECKSVILLE, OHIO
PROJECT NO. 1641
SWGES3 – 1497H
Task Order No. 6**

Technical Memorandum

Prepared For: Northeast Ohio Regional Sewer District

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EXECUTIVE SUMMARY

EMH&T has prepared this Technical Memorandum for the reconstruction of Vaughn Road immediately west of the Cuyahoga River in the City of Brecksville, Cuyahoga County, Ohio. Supporting improvements to the existing Vaughn Road bridge substructure are located along the county line in Brecksville and in Sagamore Hills Township in Summit County. The Vaughn Road roadway is frequently overtopped by floodwaters from the Cuyahoga River that have occurred multiple times in a given year. The floodwaters disrupt traffic and deposit debris on the roadway requiring maintenance cleanup by NEORSD forces. The goal of this project is to elevate Vaughn Road to prevent floodwaters from overtopping the roadway for up to the 10 year flood event.

Chagrin Valley Engineering performed field surveying and utility identification in support of this project. Two existing utilities (a 4-inch medium pressure gas main and a fiber optic line) are present along the roadway and will be subject to increased burial depths due to the roadway raising. The fiber optic line is located inside the public right-of-way, while the gas line location varies with portions located inside and others located outside of the right-of-way. Coordination with the utility owners occurred following the 60% submittal to NEORSD, and “no conflict” letters were received from each utility owner. CTL Engineering performed the subsurface investigation and geotechnical engineering for the project. Nine soil borings were performed along Vaughn Road within the project limits. Recommendations were provided for unsuitable subgrade replacement and rubblizing of the existing pavement to serve as a bridging course.

EMH&T performed a detailed hydrologic and hydraulic investigation of the Cuyahoga River streamflow and flood elevations in the immediate project area. Peak streamflow discharge rates were estimated using stream gage records for the USGS gaging station in Independence with extension to the Vaughn Road project site using methods published by the USGS. Hydraulic calculations were performed in a 1D/2D HEC-RAS model. The 2-dimensional analysis method was utilized for enhanced evaluation of floodwaters overtopping the Vaughn Road roadway in the west overbank. Manning’s n values and model boundary conditions were calibrated by comparing model results to the USGS rating curve for the gaging station at Jaite, located immediately downstream of Vaughn Road. Calibrated model results were further validated against annual peak high water elevations measured at the Jaite gaging station.

The design parameters for the proposed roadway were coordinated with NEORSD, City of Brecksville, and National Park Service staff. The existing two lane roadway will be reconstructed for approximately 1,500 LF at a minimum elevation of 646.0 to achieve the desired level of flood protection. The roadway will include two 11-foot asphalt lanes, each with an 8-foot asphalt shoulder. Roadway embankment side slopes will be protected with grass seed and a composite turf reinforcement mat to mitigate erosion during future floodwater overtopping events for floods up to the 100 year frequency. Interim measures are proposed to reinforce the existing bridge substructure with steel sheet piling to mitigate adverse impacts from increased stream velocities associated with the road raising and overtopping reduction. The bridge is expected to be replaced in the future with a larger waterway opening. The roadway is planned to be fully closed during construction with vehicular traffic detours using State Route 82. No additional streambank stabilization measures for the Cuyahoga River are proposed under Project 1641. The Army Corps of Engineers is advancing a river channel lengthening project near Vaughn Road, which will affect the streambanks on the south side (upstream) of Vaughn Road.

Real estate / easement acquisition totaling 2.00 acres is proposed in order to construct and maintain the proposed improvements. The easements are located on property that is owned by the federal government (National Park Service) and Cleveland Metroparks. NEORSD may also desire to obtain approval from these agencies for increases in flood elevations on their parcels that are located upstream of the project.

Construction of Project 1641 will require permit approvals from multiple regulatory agencies. These agencies include the US Army Corps of Engineers (Section 10 and Section 404 Nationwide Permit #3 with OhioEPA conditions), City of Brecksville approvals for general construction and floodplain development, Summit County approvals for floodplain development, and Summit County Engineer's Office approvals for the bridge reinforcement work. The project will disturb more than one acre of land; therefore, coverage under the OhioEPA National Pollutant Discharge Elimination System (NPDES) General Permit Authorization for Storm Water Discharges Associated with Construction Activity is required with post-construction stormwater management practices (using the proposed roadside ditches).

EMH&T prepared an Engineer's Opinion of Probable Construction Cost for the 90% submittal. The current Base Bid estimate is \$2.0M, and total estimate with allowances is \$2.3M.

1.0 PROJECT INTRODUCTION

This Technical Memorandum pertains to the design of Project 1641, which involves reconstruction to raise the elevation of Vaughn Road immediately west of the Cuyahoga River, as well as reinforcing the substructure of the existing Vaughn Road bridge over the river. The project is located in the City of Brecksville, Cuyahoga County, Ohio and Sagamore Hills Township, Summit County, Ohio. The purpose of this Technical Memorandum is to document the engineering data collection, field reconnaissance, and design analysis associated with the proposed improvements.

EMH&T is providing design and engineering services in support of this project as part of Task Order #6 of our Stormwater General Engineering Services 3 contract to NEORSD. The authorization for this Task Order is documented in PSAR No. 5 and No. 6 under our 1497H contract with the District, initiated in August and December, 2021. The project is planned to follow the traditional Design-Bid-Build format. The design of this project is a collaboration between EMH&T, Chagrin Valley Engineering (CVE), and CTL Engineering (CTL).

2.0 PROJECT DESCRIPTION

Project 1641 is located along NEORSD Regional Stormwater System (RSS) assets CY00397 and CY00398 and includes approximately 1,500 LF of Vaughn Road extending westward from the existing bridge over the Cuyahoga River. The City of Brecksville and NEORSD staff have noted the river has frequently overtopped the roadway at the project location, sometimes on multiple occasions in a given year, disrupting traffic and depositing debris along the roadway. The current level of service for overtopping events is estimated as less than the one-year flood. The location of the project site is shown on Figures 2-1 and 2-2.

The project also includes the reinforcement of the substructure for the existing Vaughn Road bridge over the Cuyahoga River. The raising of Vaughn Road on a fill embankment will reduce the frequency of floodwaters overtopping the roadway, redirecting additional peak streamflow and velocity through the bridge opening during major flood events. Substructure reinforcement is proposed to protect the existing bridge pier foundations from the increase in flow and velocity.

The Summit County Engineer's Office (SCEO) is the lead agency with jurisdiction over the existing Vaughn Road Bridge (aka Highland Road, Summit County Road 111), which was constructed 55 years ago in 1967. At the time of this report, SCEO has not programmed the replacement of the Vaughn Road bridge. EMH&T has provided NEORSD with a separate Project Definition Memo with recommendations for the future replacement bridge structure, including an increase in the bridge waterway opening area to reduce stream velocity and scour potential during major flood events. The proposed substructure reinforcement work included in Project 1641 should be considered an interim measure, until the future bridge replacement project is completed.

The project is located within the Cuyahoga Valley National Park and Brecksville Reservation, which bring the National Park Service and Cleveland Metroparks into the project as stakeholders. NEORSD has coordinated with both agencies to solicit feedback on the proposed project during the design process. Real estate and/or easements will be required from both agencies to enable construction of Project 1641. Additional discussion on this topic is included in Section 8.

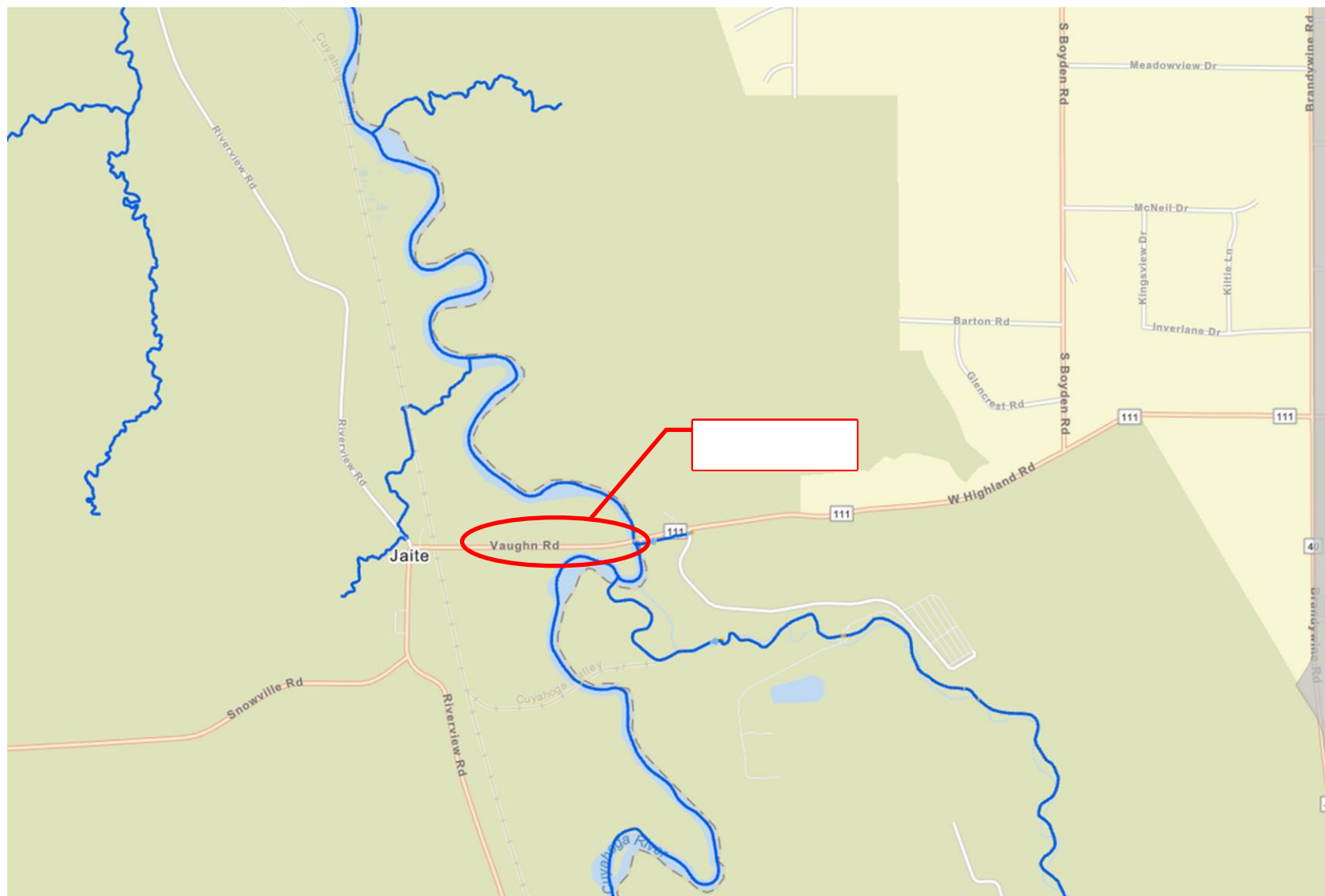


FIGURE 2-1
Project Vicinity Map



FIGURE 2-2
Project Area Map

3.0 EXISTING DATA COLLECTION

The following data resources have been collected and applied to the design analysis and recommendation for improvements for Project 1641.

TABLE 3-1
Existing Data Resources

Document	Project Relevance
District GIS Dataset (Date Varies)	These files provide general information pertaining to the project area, including aerial imagery, topographic contours, utilities, and collected field data.
NEORS D Cuyahoga River Mainstem Stormwater Master Plan, Section 11 (March 2019)	Watershed scale study of hydrologic and hydraulic conditions along the Cuyahoga River.
Arcadis Cuyahoga River HEC-RAS Study (January 2007)	This document details the HEC-RAS model of the Cuyahoga River prepared for Friends of the Crooked River which studied the impacts of removing the Brecksville Dam.
Arcadis Cuyahoga River HEC-RAS Hydraulic Model (January 2007)	Hydraulic model used as a baseline for EMH&T's hydraulic modeling and calculations.
ODOT Bridge Inventory and Appraisal Report (July 2021)	Bridge inspection report completed by ODOT for Vaughn/Highland Road crossing over the Cuyahoga River.
Summit County Underwater Inspection Report (April 2021)	Report completed by Integrity Aquatic for Summit County for crossing of Highland Road over the Cuyahoga River.
Relocation of Highland Rd, C.H. III Plans (1967)	Record plans detailing the realignment of Highland Road and bridge replacement over the Cuyahoga River.
AMATS 2017 and 2021 Traffic Counts	Average Daily Traffic notation on the proposed bridge reinforcement plans and consideration in detour planning.
FEMA Flood Insurance Study (FIS) and Digital Flood Insurance Rate Map (DFIRM) for Cuyahoga and Summit Counties	Mapping of existing 100-year floodplain extents.

4.0 FIELD TOPOGRAPHIC AND BOUNDARY SURVEY

CVE performed detailed field surveying in support of this project. Topographic data was surveyed along Vaughn Road from the Cuyahoga Valley Scenic Railroad at the west end of the project, to the Ohio & Erie Canal Towpath Trail located east of the bridge over the Cuyahoga River. In addition, surface features were surveyed, such as individual trees and property pins. A topographic, property boundary, and utility base map was compiled and provided by CVE in AutoCAD .DWG file format with points on the Ohio State Plane North Coordinate System and the North American Vertical Datum (NAVD) 1988. A copy of the survey basemap is included in Appendix A.

CVE filed an 811 utility locate request as part of their efforts and collected mapping from utility owners that was accounted for in the preparation of the aforementioned base map. A 4-inch medium pressure gas main (Dominion Energy) and a fiber optic communication line

(CenturyLink/LUMEN) are located in the project area. Subsurface Utility Engineering (SUE) Level A utility locates were not performed for this project.

5.0 HYDROLOGIC AND HYDRAULIC (H&H) ANALYSIS AND ALTERNATIVE EVALUATION

EMH&T performed hydrologic and hydraulic calculations to estimate the extent and frequency of existing roadway overtopping by floodwaters from the Cuyahoga River, as well as the hydraulic impacts associated with the proposed project.

5.1 Previous Modeling Efforts

Neither NEORSD nor FEMA maintain an existing hydrologic or hydraulic study for this portion of the Cuyahoga River. A previous hydraulic study was prepared by Arcadis for the OhioEPA to analyze potential modifications to the Brecksville Dam located downstream of Vaughn Road. EMH&T obtained the HEC-RAS model from the Arcadis study, and utilized the cross section geometry information as a downstream boundary condition for hydraulic models developed by EMH&T for Project 1641.

5.2 USGS Stream Gaging Stations

The USGS operates three stream gaging stations on the Cuyahoga River in this portion of the watershed between Akron and Independence. The station locations are shown in Figure 5-1.

1. USGS Gaging Station 04208000: This station is located on the Cuyahoga River downstream of Old Rockside Road in Independence, Ohio. This location is downstream of Project 1641 and has a documented tributary drainage area of 707 square miles. The USGS has published peak annual streamflow values for this station covering 92 years from 1922 to 2020 (record is not continuous).
2. USGS Gaging Station 04206000: This station is located on the Cuyahoga River upstream Portage Path in Akron (Old Portage), Ohio. This location is upstream of Project 1641 and has a documented tributary drainage area of 404 square miles. The USGS has published peak annual streamflow values for this station covering 97 years from 1922 to 2020.
3. USGS Gaging Station 04206425: This station is located on the Cuyahoga River immediately downstream of Vaughn Road in Brecksville (Jaite), Ohio. This location is at Project 1641 and has a documented tributary drainage area of 555 square miles. The USGS has published peak annual streamflow values for this station covering 9 years from 2012 to 2020. The period of record is not long enough to rely solely on this information for design purposes.

5.3 Hydrology

EMH&T estimated peak streamflow values and recurrence intervals for the Cuyahoga River at Vaughn Road. First, a statistical analysis was performed on streamflow records from the Independence gaging station using methods published in USGS Bulletin 17C "Guidelines for Determining Flood Flow Frequency" as implemented by the HEC-SSP computer program. Once the peak streamflow values and recurrence intervals were estimated for the Independence gaging station, EMH&T estimated similar values at the Vaughn Road project site following the method for gage adjusted peak discharge values published in USGS WRIR 03-4164 "Techniques for Estimating

Flood-Peak Discharges of Rural, Unregulated Streams in Ohio”. These calculations are included in Appendix B, with peak values listed in Table 5-1. A comparison to peak streamflow values published by FEMA at Independence is also included in Table 5-1 for comparison. The values estimated through the EMH&T Bulletin 17C analysis compare favorably to the published FEMA values.

FIGURE 5-1: USGS Stream Gaging Stations on the Cuyahoga River

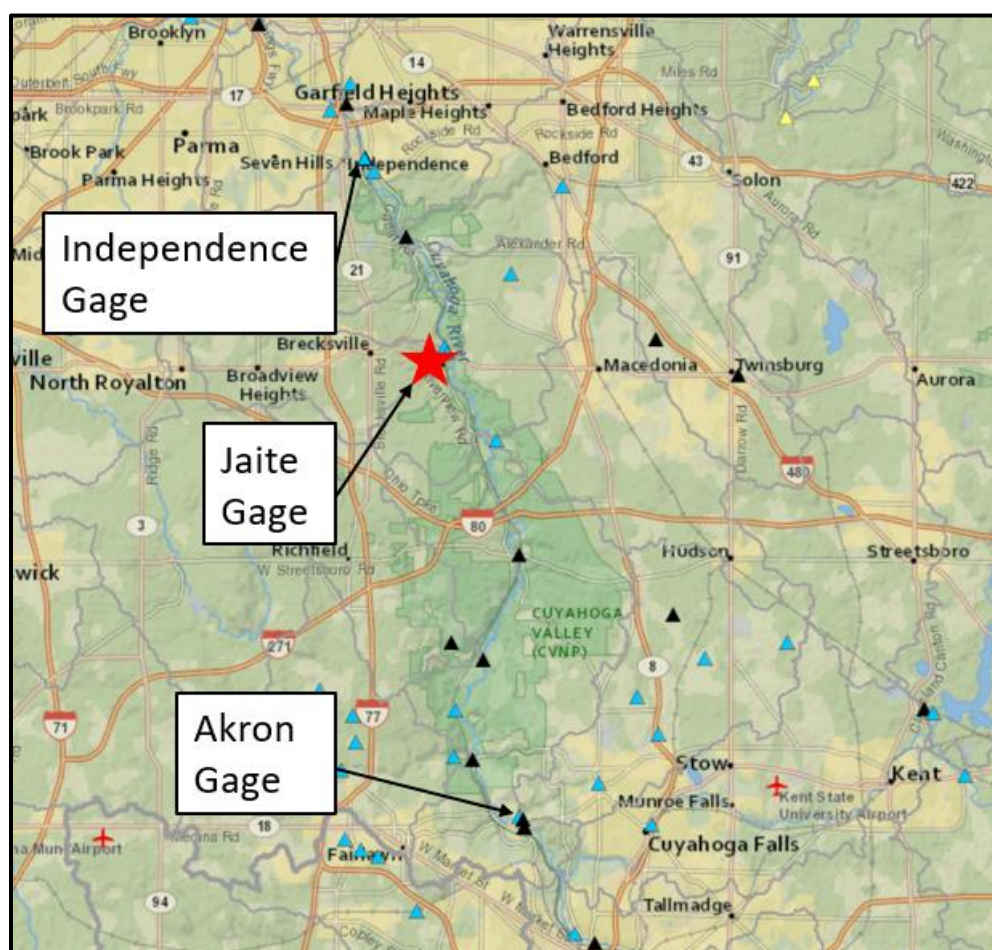


**TABLE 5-1
Estimated Cuyahoga River Peak Streamflow Values**

Flood Frequency	EMH&T Estimated Cuyahoga River at Vaughn Road	EMH&T Estimated Cuyahoga River at Independence	FEMA Published Cuyahoga River at Independence
2 Year	8,600 cfs	9,370 cfs	-
5 Year	11,800 cfs	12,650 cfs	-
10 Year	14,100 cfs	14,910 cfs	14,300 cfs
25 Year	16,900 cfs	17,160 cfs	-
50 Year	19,600 cfs	20,170 cfs	19,500 cfs
100 Year	22,200 cfs	22,530 cfs	21,900 cfs

5.4 Hydraulics

EMH&T developed a hydraulic model of the local portion of the Cuyahoga River to analyze flood conditions near Vaughn Road using the HEC-RAS computer program. 2-dimensional (2D) computational methods were utilized to analyze overbank flood routing outside of the main channel in order to more accurately represent the effects of floodwaters overtopping Vaughn Road in existing conditions. Flood routing through the river channel was represented by traditional 1-dimensional (1D) routing techniques.

1D Channel Geometry Development

The 1D channel area includes two downstream (north of Vaughn Road) cross sections sourced from the 2007 Arcadis model. The 2007 model was slightly irregular in spatial positioning, and as a result the cross sections had to be geospatially corrected based on river stationing. Placement was validated by comparing the cross section profiles to overbank terrain. An additional channel section was placed at the downstream extents of the model, with the channel geometry of cross section river station 23.741 from the 2007 model. EMH&T utilized a Manning's n value of 0.040 for the channel, which was confirmed through calibration.

EMH&T utilized detailed channel geometry from four cross sections surveyed by CVE in support of this project. Additional channel cross sections were added to the model by interpolation in order to improve model stability.

Geometry data for the existing Vaughn Road bridge and roadway overtopping profile was sourced from field survey data collected for this project and record plans.

After initial model testing, it was determined that cross section 5205 was likely capturing a scour pool from the confluence with Brandywine Creek. For the purpose of model stability, the majority of the scour depth was filled to improve stability of the 1D channel calculations.

2D Floodplain Geometry Development

Continuous 2D perimeters were created using the RASMapper tool built into HEC-RAS. The initial 2D mesh was generated with a base 20'x20' cell grid pattern. A Manning's n value of 0.080 was assigned to the 2D mesh to capture the predominantly forested floodplain area and refinement regions were created to accurately reflect surface roughness.

The Brandywine Creek channel was artificially filled in the 2D mesh to simplify the model and prevent flow from the Cuyahoga River from artificially backing up into the tributary. The purpose of this model was not to analyze the impact of timing or differential flows between the Cuyahoga River and Brandywine Creek, therefore, this is a reasonable simplification.

Lateral structures were modeled along the banks of the river which serve to connect the 1D channel areas to the 2D floodplain areas. Model refinement was performed using the RASMapper's breaklines and refinement region tools. Key locations for mesh refinement include roadways, the adjacent drainage channel west of the river, and the peninsula formed right before the bridge. Additional refinement areas were placed near the lateral structures at points where the terrain was notably elevated, as well as an elevated area at the west end of Vaughn Road.

Hydrograph Loading

Flood event simulation was performed using the HEC-RAS unsteady-state routing module. The point of interest for the analysis is the hydraulic performance of the river system under peak streamflow conditions. Further, runoff volume and hydrograph timing estimates were not performed in the hydrologic calculations. Therefore, EMH&T developed an artificial hydrograph for each flood event to be analyzed. The hydrographs each start at a minimal flow rate and gradually increase to the estimated peak streamflow rate for the event under consideration, as shown in Table 5-1. Once the hydrograph reaches the peak streamflow rate, the rate is held constant for multiple hours in order for the model to reach a steady-state condition where results were evaluated. All hydrographs were loaded at the upstream channel cross section (RS 7083).

Calibration

EMH&T calibrated the HEC-RAS model to match the USGS published rating curve for the Cuyahoga River at Jaite (gaging station located immediately downstream of Vaughn Road) for streamflow rates up to the initial overtopping of the roadway under existing conditions. During roadway overtopping conditions, it is not verified if the USGS rating curve accurately represents the current roadway overtopping flows; therefore, these values were not utilized in the calibration process. Through calibration, Manning's n values were set for the channel and overbanks areas as discussed earlier, and the downstream boundary conditions for the channel and overbank areas were set at a normal depth slope of 0.0003 ft/ft.

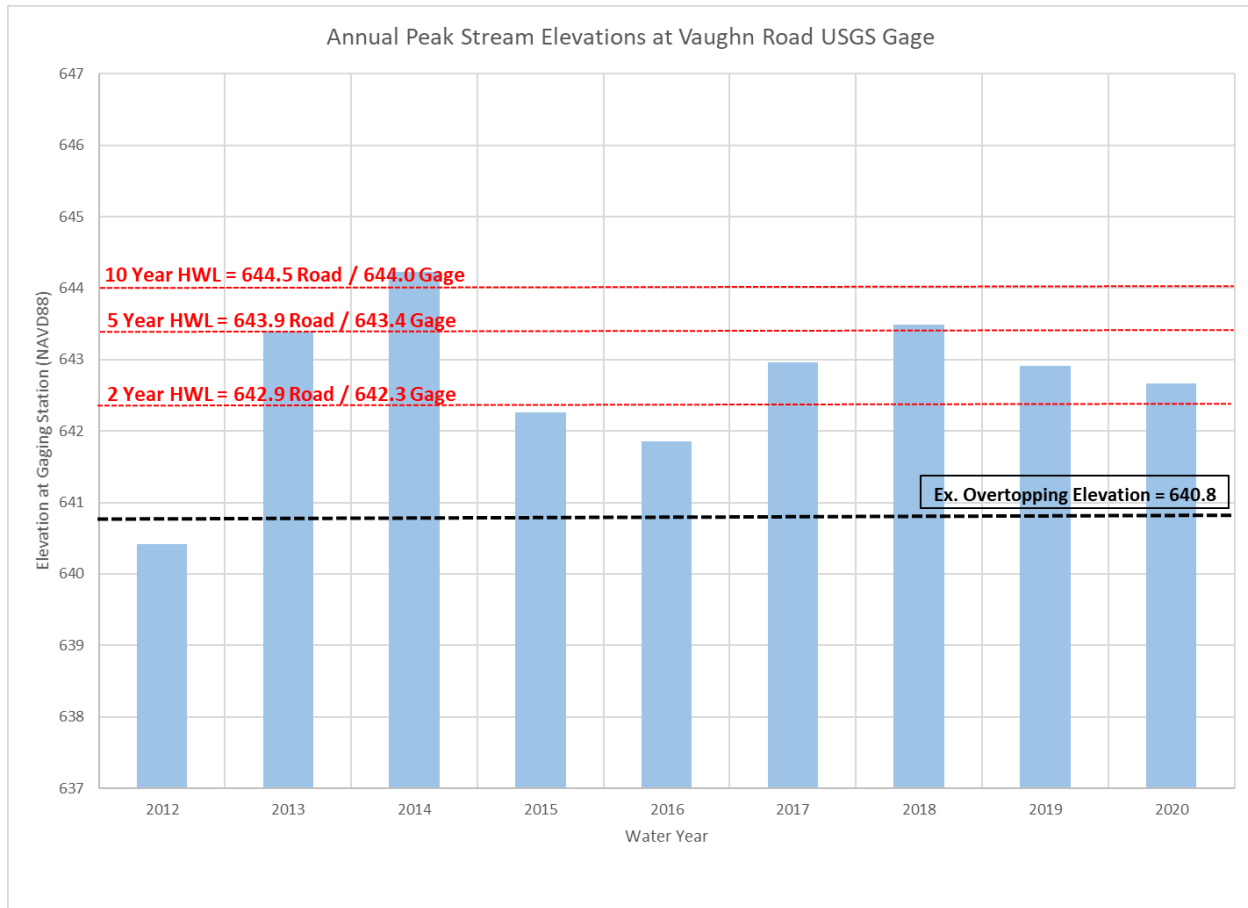
Existing Condition Headwater Elevations

Using the calibrated HEC-RAS model, EMH&T calculated peak water surface elevations at the Vaughn Road bridge and at the roadway overtopping location, as shown in Table 5-2. EMH&T also compared the hydraulic model results against the annual peak stream elevations as published by USGS for the Jaite gaging station. This data correlates well, as is shown in Figure 5-2.

TABLE 5-2
Existing Condition Peak Water Surface Elevations

Flood Frequency	EMH&T Estimated Cuyahoga River Qpeak at Vaughn Road	WSL at Vaughn Road Bridge	WSL at Vaughn Road Overtopping Location	Vpeak at Vaughn Road Bridge
Initial Roadway Overtopping			640.8	
2 Year	8,600 cfs	642.4	642.9	8.0 fps
5 Year	11,800 cfs	643.4	643.9	8.3 fps
10 Year	14,100 cfs	644.0	644.5	8.7 fps
50 Year	19,600 cfs	645.2	645.7	9.4 fps
100 Year	22,200 cfs	645.8	646.2	9.7 fps

FIGURE 5-2: Comparison of Estimated High Water Elevation Return Period and Measured Annual Peak Water Surface Elevations at USGS Gaging Station at Vaughn Road



5.5 Alternative Analysis

EMH&T studied two separate options for raising Vaughn Road under this project. The first alternative considered raising Vaughn Road from the western approach of the existing bridge over the Cuyahoga River to a crest location in the roadway profile located approximately 900 feet west of the bridge. This alternative would increase the elevation where Vaughn Road initially overtops by floodwaters from 640.8 to 643.0, which corresponds to approximately a 2 year level of service (LOS). The second alternative extends the project approximately 600 feet further west to a location near the existing Jaite Trailhead parking area. This alternative increases the roadway overtopping elevation to 646.0, which corresponds to a 10 year LOS. Through conversations with staff from NEORSD, the City of Brecksville, Cleveland Metroparks, and the National Park Service, a consensus was reached to advance the 10 year LOS alternative.

Raising Vaughn Road to reduce the frequency of floodwater overtopping will redirect floodwaters through the river channel and existing bridge opening. EMH&T modeled this condition, with key results shown in Table 5-3. EMH&T has recommended interim measures to reinforce the existing bridge substructure from scour associated with the increased velocities until the bridge is replaced with a larger structure in the future. Refer to Section 7.3 for additional discussion on the proposed bridge substructure reinforcement.

The proposed alternative will not prevent all floodwaters from overtopping Vaughn Road in the future. Floods that exceed the 10 year LOS are expected to overtop the proposed roadway, and may result in erosion on the downstream (northern) embankment slope. EMH&T has recommended overtopping protection for this embankment slope to reduce the erosion risk. Refer to Section 7.1.3 for additional discussion on the proposed embankment overtopping protection.

TABLE 5-3
Proposed Condition Hydraulic Results

Flood Frequency	EMH&T Estimated Cuyahoga River Qpeak at Vaughn Road	WSL at Vaughn Road Bridge*	WSL at Vaughn Road Overtopping Location	Vpeak at Vaughn Road Bridge
2 Year	8,600 cfs	642.4	643.5	8.2 fps
5 Year	11,800 cfs	643.4	645.0	10.2 fps
10 Year	14,100 cfs	644.1	646.0	11.6 fps
Initial Roadway Overtopping			646.0	
50 Year	19,600 cfs	645.3	647.1	12.9 fps
100 Year	22,200 cfs	645.7	647.4	13.1 fps

*Note: Some WSL values at the bridge are slightly lower under proposed conditions as compared to existing conditions. This outcome is due to the increased velocity head associated with the proposed alternative. Review of energy grade line results in the HEC-RAS model confirms a higher EGL value for the proposed alternative, as expected.

6.0 GEOTECHNICAL INVESTIGATION

CTL Engineering performed the geotechnical investigation for this project, which included nine borings along the roadway alignment with depths ranging from 10 to 30 feet below existing grade. The soils encountered below the surface material generally consisted of fill material (loose clayey silt, loose silt/silty sand, and loose to medium dense sandy silt) at a depth of 2.5 to 5.5 feet, followed by natural alluvial deposits to depths of 10 to 18 feet. Soil boring logs and laboratory analysis results are included in the project Geotechnical Data Report (separate document).

CTL provided additional guidance for the roadway design based on the soil boring results. CTL confirmed that the proposed roadway embankment side slopes would be stable with five feet of additional fill and slopes up to 2:1 (H:V). CTL also estimated a maximum settlement of up to 2.1 inches may be observed at the peak fill locations, which is generally acceptable for embankment construction. Settlement monitoring can be performed during construction to verify subgrade conditions are acceptable for pavement installation. Finally, CTL identified locations of the roadway alignment where unsuitable subgrade materials are anticipated and recommended for removal and replacement. This will generally apply at the west end of the project where proposed fill is less than 18 inches in depth. In other locations, the existing pavement will be rubblized and left in place to serve as a bridging course. Refer to the project Geotechnical Design Memo (separate document) for additional information.

7.0 PROPOSED IMPROVEMENTS

This section of the Technical Memorandum provides additional information on the proposed improvements associated with Project 1641. This section is intended to be read alongside the project construction drawings, as references are made to information contained on the various plan sheets.

7.1 Roadway Design

7.1.1 Work Limits

Approximately 1,500 LF of Vaughn Road will be reconstructed from the western approach of the existing bridge over the Cuyahoga River to a point approximately 200 feet east of the Jaite Trailhead parking lot.

7.1.2 Alignment and Typical Section

Project 1641 will maintain the existing horizontal alignment for Vaughn Road. The proposed typical section for the roadway, shown on plan sheet G-0-07, was developed with input provided by the City of Brecksville Engineer. The project will provide two 11-foot wide travel lanes each with a 3/16 inch/ft cross slope crowned along the roadway centerline. An 8-foot wide asphalt shoulder with 4% cross slope is provided on each side of the road, which can be used as future bike lanes. The roadway will be constructed on a fill embankment with 4:1 side slopes on the upstream (south) side of the road, and 8:1 side slopes on the downstream (north) side of the road. Roadway Stations 7+57.95 to 22+78.00 will have roadside swales running on both the north and south sides of the roadway. Additional information on side slope protection during overtopping events is provided in Section 7.1.3.

The roadway will consist of an asphalt concrete pavement section with the following buildup, as requested by the City of Brecksville:

- 1-1/4" Asphalt Concrete Surface Course, Type 1
- 1-3/4" Asphalt Concrete Intermediate Course, Type 2
- 6" Bituminous Asphalt Concrete Base
- 6" Aggregate Base

7.1.3 Roadway Drainage

Drainage will be collected in grassed roadside swales that will discharge to either the Cuyahoga River, the minor tributary near Station 10+35, or adjacent floodplain areas. The roadside swales will also serve to satisfy post-construction stormwater management requirements for the OhioEPA NPDES Construction Stormwater Permit. Additional information on this topic is provided in Section 9.

The existing 15-inch diameter culvert located at Station 10+35 will be replaced and extended to accommodate the proposed widened roadway embankment for Project 1641. The profile view of the culvert, shown on plan sheet C-2-05, shows the existing culvert is backpitched with a negative slope. EMH&T is not proposing additional stream grading under Project 1641 to correct this issue. Instead, EMH&T is proposing to replace the culvert using the existing stream bed elevations for the

pipe inverts, but also increasing the pipe diameter to 24-inches to account for sedimentation caused by the higher outlet invert elevation.

7.1.4 Roadway Retaining Wall and Toe Protection

A steel sheet pile wall is proposed on the south side of the roadway between Stations 17+20 and 19+00, near the existing roadway overtopping location where the Cuyahoga River meanders adjacent to the roadway. The sheet pile wall will be buried and provide additional protection against future river migration from eroding the roadway embankment toe.

7.1.5 Overtopping Protection

The proposed roadway embankment will be overtopped by floodwaters from the Cuyahoga River for events that exceed the 10 year LOS. EMH&T evaluated multiple options to mitigate embankment erosion during overtopping conditions, ranging from turf grass to a structural concrete surface. Guidance from the City of Brecksville, Cleveland Metroparks, and the National Park Service unanimously requested a natural, vegetated solution consistent with the park setting.

EMH&T reviewed the HEC-RAS model developed for the project to estimate the overtopping flows and shear stress values on the downstream roadway embankment for the higher magnitude flood events, up to the 100 year event. These values are shown in Table 7-1. Note these values are associated with the 8:1 (H:V) embankment side slope shown in the typical section. This side slope is much flatter than commonly used for roadway fills, and was intentionally chosen to reduce the shear stress values. The upstream roadway embankment will not be subjected to the same erosive forces as the downstream embankment and is therefore planned at a 4:1 slope.

TABLE 7-1
Proposed Roadway Overtopping Conditions

Flood Frequency	WSL at Vaughn Road Overtopping Location	Roadway Overtopping Depth	Shear Stress on Downstream Embankment Slope
50 Year	647.1	1.1 ft	3.9 psf
100 Year	647.4	1.4 ft	4.6 psf

Based on the shear stress values shown in Table 7-1, EMH&T is recommending protecting the downstream roadway embankment with grass seed and a permanent turf reinforcing mat. Specifically, EMH&T is recommending use of a composite turf reinforcing mat (North American Green C350 or equal) that incorporates a permanent polypropylene netting with a temporary coconut matrix for immediate stabilization prior to grass germination. The matting will be anchored with permanent, metal staples (wooden stakes typically used are not desired for permanent applications). Permissible shear stress values published by North American Green are 10.0 psf for the fully vegetated, long duration flow condition, and 3.0 for the unvegetated condition. These values result in a factor of safety of 2.2 for the vegetated 100 year flood event, but a failure result for the unvegetated scenario prior to the 50 year event. NEORS D should expect erosion may occur on the embankment should the roadway overtop following installation of the matting, but prior to grass germination. Further, the grass coverage on the embankment slope will require long term maintenance to ensure long term functionality of the overtopping protection. Risks to the

operation of the overtopping protection include denuding of the grass coverage by pedestrians using the bridle trails.

Unreinforced turf grass has a permissible shear stress value of 0.4 psf, as published by the Ohio Department of Transportation (Location & Design Manual, Volume 2), and is not considered to be a viable solution for this application. Other overtopping protection options that were discussed are non-vegetative and include: riprap, tied concrete block mats (i.e. Flex-a-mat), articulating concrete block revetment systems (cable-tied or loose block systems), and concrete slope lining. As discussed earlier, these solutions were not desirable by the project stakeholders for aesthetic concerns along the 1,500 LF project length.

7.1.6 Bridle Trails

Replacement of the existing bridle trails will occur on both sides of Vaughn Road where the existing trail enters the project work limits. The replacement trails have been designed based on a typical section provided by the National Park Service. Additional rock channel protection is provided beneath the trails where they are located on the roadway embankment for erosion protection during roadway overtopping events.

7.2 Existing Utility Impacts

Two utility lines have been identified within the project corridor: a 4-inch gas main and a fiber optic conduit, as discussed in Section 4. At this time, potential impacts to these utility lines are limited to the additional burial depth associated with the proposed road raising and fill embankment, and temporary cover by aggregate associated with access ramps for the proposed bridge substructure reinforcement, discussed in Section 7.3. EMH&T obtained no conflict letters from each utility owner following the 60% submittal.

7.3 Bridge Substructure Reinforcement

EMH&T has recommended reinforcement of the existing bridge substructure to mitigate concerns associated with the increased stream velocities associated with Project 1641 as an interim solution until the bridge is replaced in the future with a larger waterway opening. The bridge reinforcement plans are shown on plan sheets S-1-01 through S-1-03 and consist of steel sheet piling driven in the river channel along the inside pier face and tying into the concrete slope protection for each abutment. Steel sheets will be welded during placement due to low clearance conditions under the bridge deck. Repairs to the concrete slope protection for each abutment are also proposed, which include removal and replacement of select concrete panels, patching of spalled areas, epoxy crack treatment, vegetation removal, and construction joint sealing.

EMH&T anticipates the Contractor will construct the improvements in phases to maintain streamflow, with work on the west side of the river performed in one phase, and work on the right side of the river in a separate phase. The Contractor is expected to construct a temporary aggregate access ramp from the north side of the roadway to access the river, with additional aggregate placed in the channel to create a causeway / work platform for the equipment to operate above the water level. The causeway will be at risk of inundation by floodwaters during high flow events. EMH&T

will coordinate with NEORSD staff to edit the Control of Water specification for this project to reflect this expectation.

EMH&T has previously discussed the intent of the bridge substructure reinforcement plans and shared 60% plans with SCEO staff. EMH&T will continue to coordination with NEORSD and SCEO following the 90% design submittal to NEORSD.

7.4 Maintenance of Traffic

Project 1641 is intended to be completed with Vaughn Road closed to traffic. A draft detour plan is shown on plan sheet T-1-01. Vehicular barricades are proposed to be installed on Vaughn Road immediately west of the Cuyahoga Valley Scenic Railroad crossing and at the east side of the Vaughn Road bridge over the Cuyahoga River. Vehicles will be detoured from Vaughn Road to State Route 82 using Brecksville Road and Boyden Road. Access will be maintained to the trailhead and parking lots on the east side of the river.

EMH&T recommends further discussion of the proposed detour route with the various project stakeholders following the 90% submittal.

7.5 Staging Area

The Project 1641 work area provides limited opportunities for staging areas. However, it is expected that project deliveries for the roadway project will be primarily on a just-in-time basis, with limited need for prolonged stockpiling. EMH&T has identified the gravel parking area for the Jaite Trailhead for use as a contractor staging area. The Contractor may also use portions of the roadway that are outside of the current work limits. A temporary chain link fence will not be provided to enclose the staging area, based on discussion with NEORSD staff.

7.6 Construction Phasing

EMH&T recommends that the Contractor construct the bridge reinforcement improvements in advance of the roadway raising. This approach will ensure the existing bridge piers and abutments are not subject to increased streamflows and velocities prior to the proposed reinforcement, as well as the construction traffic associated with the bridge improvements will be traveling on the existing roadway surface and not the newly placed asphalt surface.

7.7 Streambank Stabilization

No additional streambank stabilization is proposed under Project 1641. NEORSD is coordinating with the US Army Corps of Engineers regarding the extents of their Cuyahoga River channel lengthening project.

8.0 REAL ESTATE COORDINATION

EMH&T has designated approximate easement acquisition areas necessary to construct and maintain the proposed improvements for this project on the 90% Design Plans, sheet G-1-09. The easement areas are summarized in Table 8-1. Legal descriptions for the designated easement

boundaries have not been provided to the District at this time, to allow for further coordination with the stakeholders. A land swap may be required to obtain property from the federal government in lieu of easements.

**TABLE 8-1
Summary of Proposed Easements**

Parcel Number	Owner	Total Easement Acquisition Area
606-16-005	United States of America	0.09 acres
606-17-001	United States of America	0.14 acres
606-17-002	Cleveland Metroparks	1.01 acres
606-20-006	Cleveland Metroparks	0.70 acres
4502032	United States of America	0.03 acres
4502361	United States of America	0.02 acres
Total Estimated Easement Acquisition Area		2.00 acres

In addition to the above easement areas associated with the construction of Project 1641, NEORS D may desire to obtain approvals from the affected property owners for the proposed 100 year flood elevation increases upstream of Vaughn Road that will result from the project. From an initial review of Cuyahoga and Summit County parcel mapping, these lands are also owned by the federal government and Cleveland Metroparks. EMH&T recommends coordination with NEORS D legal staff regarding the necessity and appropriate mechanism for this documentation.

9.0 REGULATORY SETTING AND PERMITTING REQUIREMENTS

Floodplain Permitting

The project area is located on the FEMA Flood Insurance Rate Map (FIRM) for Cuyahoga County, Ohio and incorporated areas, Number 39035C, panel 0337E, effective date December 3, 2010. The project area is also located on the FIRM for Summit County, Ohio and incorporated areas, Number 39153C, panel 0040F, effective date April 19, 2016. The FIRMs depicts flood zones within the project area, as listed in Table 9-1.

**TABLE 9-1
Flood Zone Mapping for Project 1641 Improvements**

Proposed Improvement	Flood Zone
Cuyahoga River	Zone A (Special Flood Hazard Areas Subject to Inundation by the 1% Annual Chance Flood without Base Flood Elevations Determined)

A floodplain permit from the City of Brecksville is required under Chapter 1159 (Flood Damage Reduction) of the City's codified ordinances. Specific requirements of the City's flood code are referenced below.

- Section 1159.17(k), states that proposed fill that is placed in the 100-year floodplain will require an equal or greater volume of excavation to maintain available flood storage volume (floodplain compensatory storage). This topic was discussed with the City Engineer in December 2021. EMH&T stated that the project will result in an increase in 100-year flood elevations upstream of the project, with additional floodplain volume utilized. The City Engineer agreed that the incremental additional floodplain volume above the existing condition flood elevation can be considered as credit to offset the proposed floodplain fill volume for compliance with the Section of the City Code. Additional excavation to create floodplain compensatory storage is not expected.
- Section 1159.12 and 1159.13 of the City's regulations describe the floodplain permit application requirements and the City's review process. The City typically requires a \$500 permit application fee. This fee will be waived per the Stormwater Service Agreement between the City and NEORSD.
- The City Code does not have a regulation regarding acceptable increases in 100-year flood elevations in a Zone A Special Flood Hazard Area. This topic was also discussed with the City Engineer in December 2021. EMH&T stated that the project will result in an increase in 100-year flood elevations of approximately one foot at the railroad bridge located ½ mile upstream of the project. There are no insurable structures located in the floodplain in this area. The City Engineer stated that this would not adversely affect the floodplain permit for the project.

A portion of the bridge substructure improvements are located in Sagamore Hills Township, Summit County. Therefore, a separate floodplain permit is required from Summit County under Chapter 1345 (Flood Damage Reduction). EMH&T reviewed the County Code and determined the following:

- Summit County does not require floodplain compensatory storage. This higher standard required for the City of Brecksville does not apply to the Summit County approval.
- Similar to the City of Brecksville, Summit County also does not have a regulation regarding acceptable increases in 100-year flood elevations in a Zone A Special Flood Hazard Area. Work within Summit County's jurisdiction is limited to the reinforcement of the eastern bridge pier and abutment, which would generally be considered as "bridge maintenance". EMH&T does not anticipate a permit concern on this item.

Riparian Setbacks

The City of Brecksville does not have riparian setback requirements that would affect this project.

Summit County requires riparian setbacks for projects located within the County limits as adopted under Chapter 937 of the Summit County Codified Ordinances. The proposed bridge reinforcement work appears to qualify as a "crossing", which is a permitted use by right with prior approval of the design under Section 937.06(b)(2).

Waterway Permitting

The proposed project will involve the placement of multiple fills below the Ordinary High Water Mark (OHWM) of jurisdictional waterways. As such, the project is subject to regulation under Section 404 of the Clean Water Act. An Ecological Assessment was performed in support of this project by EMH&T, dated June 6, 2022 (separate document). Waterway impact areas include the following:

- Cuyahoga River (Perennial), Bridge Substructure Reinforcement: Temporary non-erodible rock for causeway / work platform construction and permanent fills associated with steel sheet piling and concrete.
- Stream 1 (Intermittent), Culvert Replacement: Temporary non-erodible rock for check dam and bypass pumping, and permanent fills associated with culvert conduit replacement, concrete headwalls, and rock channel protection.
- Wetland 1, Roadway Fill: Permanent soil fill for roadside ditch construction.

The Ecological Assessment recommended the following additional coordination items:

- US Fish and Wildlife coordination for potential impacts to federally-listed species.
- ODNR coordination regarding:
 - any required species specific surveys,
 - mussel survey (required for this project), and
 - in-water work restrictions.

EMH&T has prepared a Section 404 Nationwide Permit #3 application for review by NEORS staff.

OhioEPA Permit to Install (Not Required)

Coverage under an OhioEPA Permit to Install (PTI) is not anticipated for this project.

NPDES Stormwater Construction General Permit Coverage

The construction of the proposed project will disturb land area in excess of one acre. Therefore, NEORS will require coverage under the Ohio EPA's National Pollutant Discharge Elimination System (NPDES) General Permit Authorization for Storm Water Discharges Associated with Construction Activity. The project will also require post-construction stormwater best management practices (BMPs).

Section G.2.e of the Ohio EPA Permit allows for roadway improvement projects by public entities to implement post construction BMPs in compliance with ODOT's "Location & Design Manual, Volume Two Drainage Design." Per Section 1111.7 of the ODOT L&D manual, all areas within the existing right-of-way are considered 100% impervious and if they do not add new impervious area in new permanent right of way, they are considered redevelopment projects. The Vaughn Road reconstruction project falls into this redevelopment category and allows for a reduction of the required water quality treatment to a treatment percentage of 20% of the total Estimated Disturbed Area. Utilizing ODOT's BMP calculation spreadsheet, the Vaughn Road project is required to treat 0.85 acres of the impervious area within the existing Right-of-Way.

This required treatment can be provided by a series of Vegetated Biofilters and Vegetated Filter Strips, designed per the ODOT specifications. Vegetated Biofilters consist of grassed ditches along the roadway that have a minimum ditch bottom width constructed of 4" of topsoil and protected with erosion control matting. Vegetated Filter Strips are grassed portions of the graded shoulder that have a minimum width related to the tributary pavement width. The Vegetated Filter Strips are also required to be constructed with 4" of topsoil and protected with erosion control matting. Based upon the drainage areas, five Vegetated Bio Filters and one Vegetated Filter Strip will be needed to meet the required 0.85 acre of water quality treatment. EMH&T has incorporated these features in the design of the proposed roadside ditches.



FIGURE 9-1
Published Flood Hazard Information (FEMA NFHL)

10.0 ENGINEER'S ESTIMATE OF PROBABLE CONSTRUCTION COSTS

EMH&T has prepared an estimate of probable construction costs (EOPCC) for the proposed improvements as part of the preparation and submittal of the 90% Design Plans. The Base Bid estimate is \$2.0M, and the total estimate with allowances is \$2.3M.

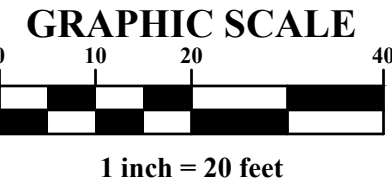
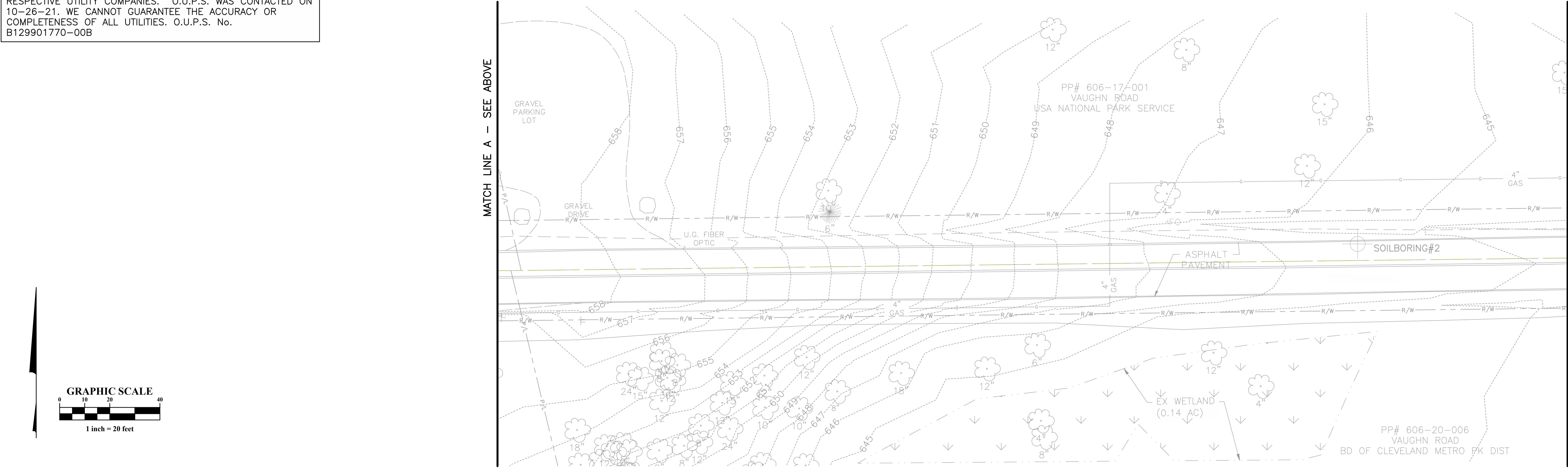
APPENDIX A:
Survey Basemap and Utility Identification

BENCHMARK TABLE		
POINT	ELEVATION	DESCRIPTION
BM 100	644.021	½" DIAMETER IRON PIN WITH RED CAP ON NORTH SIDE OF VAUGHN ROAD APPROXIMATELY 90 FEET FROM METROPARKS WILDLIFE REFUGE SIGN ON NORTH SIDE OF ROAD
BM 101	642.892	½" DIAMETER IRON PIN WITH RED CAP ON SOUTH SIDE OF VAUGHN ROAD APPROXIMATELY 425 FEET FROM METROPARKS WILDLIFE REFUGE SIGN ON SOUTH SIDE OF ROAD
BM 102	644.765	1" DIAMETER IRON IN MONUMENT BOX IN CENTER OF VAUGHN ROAD APPROXIMATELY 40 FEET FROM SPEED LIMIT SIGN ON SOUTH SIDE OF ROAD BEFORE GOING EAST OVER CUYAHOGA RIVER BRIDGE
BM 103	649.868	½" DIAMETER IRON PIN WITH RED CAP ON NORTH SIDE OF VAUGHN ROAD APPROXIMATELY 185 FEET FROM WEIGHT LIMIT SIGN ON NORTH SIDE OF ROAD BEFORE GOING WEST OVER CUYAHOGA RIVER BRIDGE

CONTROL POINT TABLE				
POINT #	NORTHING	EASTING	ELEVATION	DESCRIPTION
104	592279.3	2224145	642.514	MAGS
105	592285.7	2224267	642.936	MAGS
106	592254.0	2224451	643.619	MAGS
107	592287.4	2224692	639.883	MAGS

UTILITY NOTE:

THE UTILITIES AND SEWER INFORMATION SHOWN HEREON EITHER ON OR ABOVE GROUND WAS PHYSICALLY LOCATED IN THE FIELD AND IS ACCURATE. ALL UNDERGROUND INFORMATION SHOWN WAS TAKEN FROM PLANS PROVIDED BY THEIR RESPECTIVE UTILITY COMPANIES. O.U.P.S. WAS CONTACTED ON 10-26-21. WE CANNOT GUARANTEE THE ACCURACY OR COMPLETENESS OF ALL UTILITIES. O.U.P.S. No. B129901770-00B



REV NO	DATE	ISSUED BY

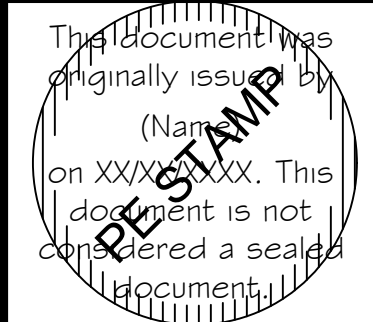
PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

PLAN SET DATE

JUNE 2022

DESIGNED BY: _____
DRAWN BY: _____
SHEET CHK'D BY: _____
CROSS CHK'D BY: _____
APPROVED BY: _____
ISSUED DATE: _____



CITY OF BRECKSVILLE, OHIO
VAUGHN ROAD FLOOD MITIGATION
PROJECT 1641

EXISTING SITE PLAN

WARNING

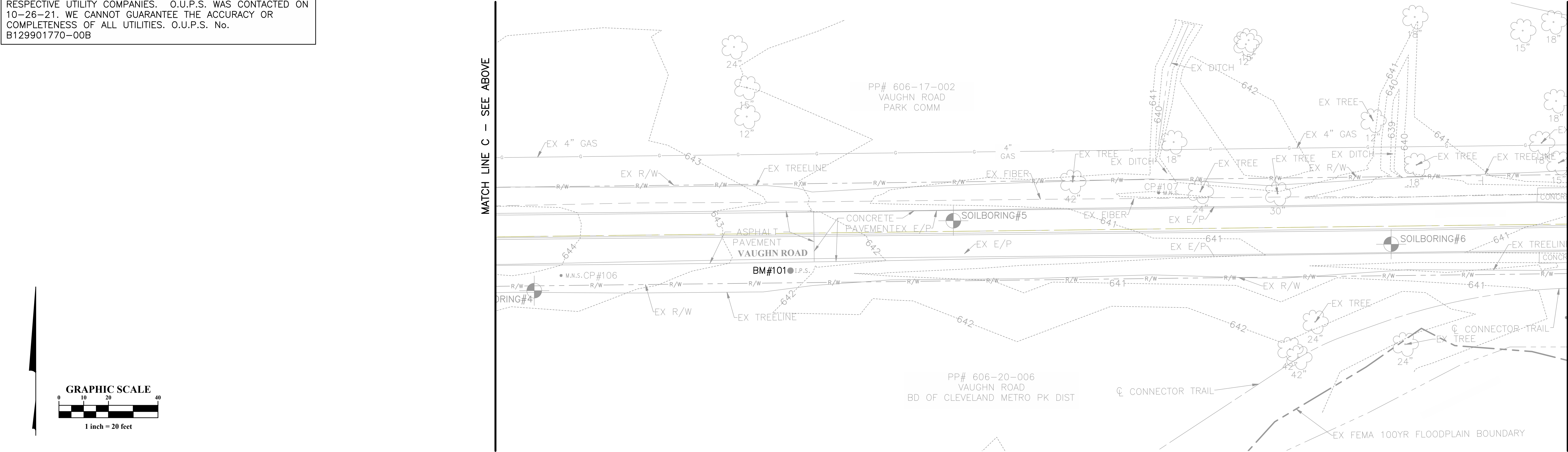
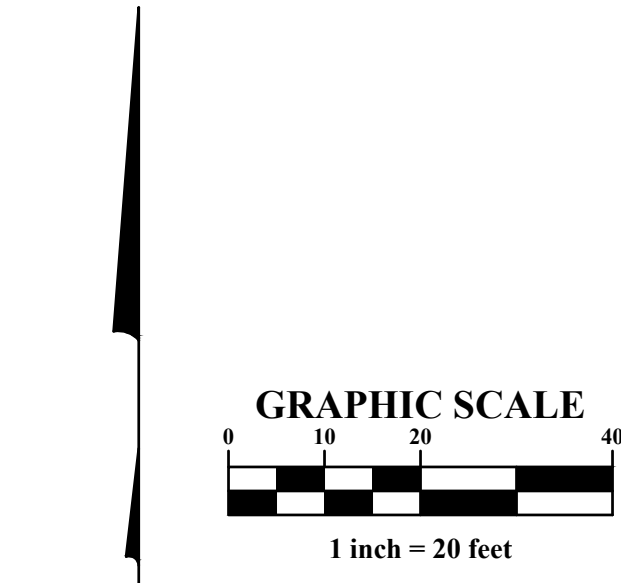
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

PROJECT SET: 04 OF 36
SHEET: 04 OF 09
SHEET NO.:

BENCHMARK TABLE		
POINT	ELEVATION	DESCRIPTION
BM 100	644.021	1/2" DIAMETER IRON PIN WITH RED CAP ON NORTH SIDE OF VAUGHN ROAD APPROXIMATELY 90 FEET FROM METROPARKS WILDLIFE REFUGE SIGN ON NORTH SIDE OF ROAD
BM 101	642.892	1/2" DIAMETER IRON PIN WITH RED CAP ON SOUTH SIDE OF VAUGHN ROAD APPROXIMATELY 425 FEET FROM METROPARKS WILDLIFE REFUGE SIGN ON SOUTH SIDE OF ROAD
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BM 103	649.868	1/2" DIAMETER IRON PIN WITH RED CAP ON NORTH SIDE OF VAUGHN ROAD APPROXIMATELY 185 FEET FROM WEIGHT LIMIT SIGN ON NORTH SIDE OF ROAD BEFORE GOING WEST OVER CUYAHOGA RIVER BRIDGE

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104	592279.3	2224145	642.514	MAGS
105	592285.7	2224267	642.936	MAGS
106	592254.0	2224451	643.619	MAGS
107	592287.4	2224692	639.883	MAGS

UTILITY NOTE:
THE UTILITIES AND SEWER INFORMATION SHOWN HEREON EITHER ON OR ABOVE GROUND WAS PHYSICALLY LOCATED IN THE FIELD AND IS ACCURATE. ALL UNDERGROUND INFORMATION SHOWN WAS TAKEN FROM PLANS PROVIDED BY THEIR RESPECTIVE UTILITY COMPANIES. O.U.P.S. WAS CONTACTED ON 10-26-21. WE CANNOT GUARANTEE THE ACCURACY OR COMPLETENESS OF ALL UTILITIES. O.U.P.S. No. B129901770-00B



Evans, Mechwart, Hambleton & Titon, Inc.
Engineers • Surveyors • Planners • Scientists
6300 New Albany Road, Columbus, OH 43254
Phone: 614.775.4500 Toll Free: 888.775.3648
emht.com

Northeast Ohio
Regional Sewer District

REV NO	DATE	ISSUED BY

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NOT TO BE USED FOR
CONSTRUCTION

PLAN SET DATE
JUNE 2022

DESIGNED BY: _____
DRAWN BY: _____
SHEET CHK'D BY: _____
CROSS CHK'D BY: _____
APPROVED BY: _____
ISSUED DATE: _____

This document was originally issued by (Name) on XX/XX/XX. This document is not considered a sealed document.

25 JUNE 2022

CITY OF BRECKSVILLE, OHIO
VAUGHN ROAD FLOOD MITIGATION
PROJECT 1641

EXISTING SITE PLAN

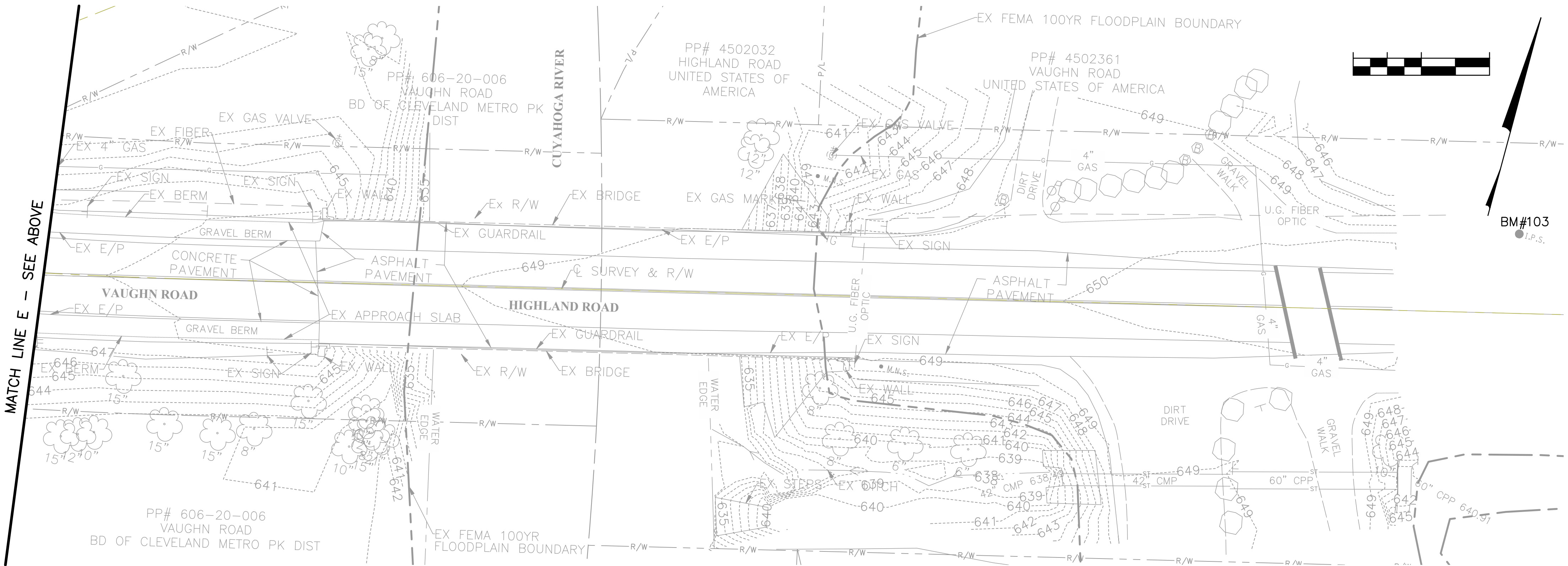
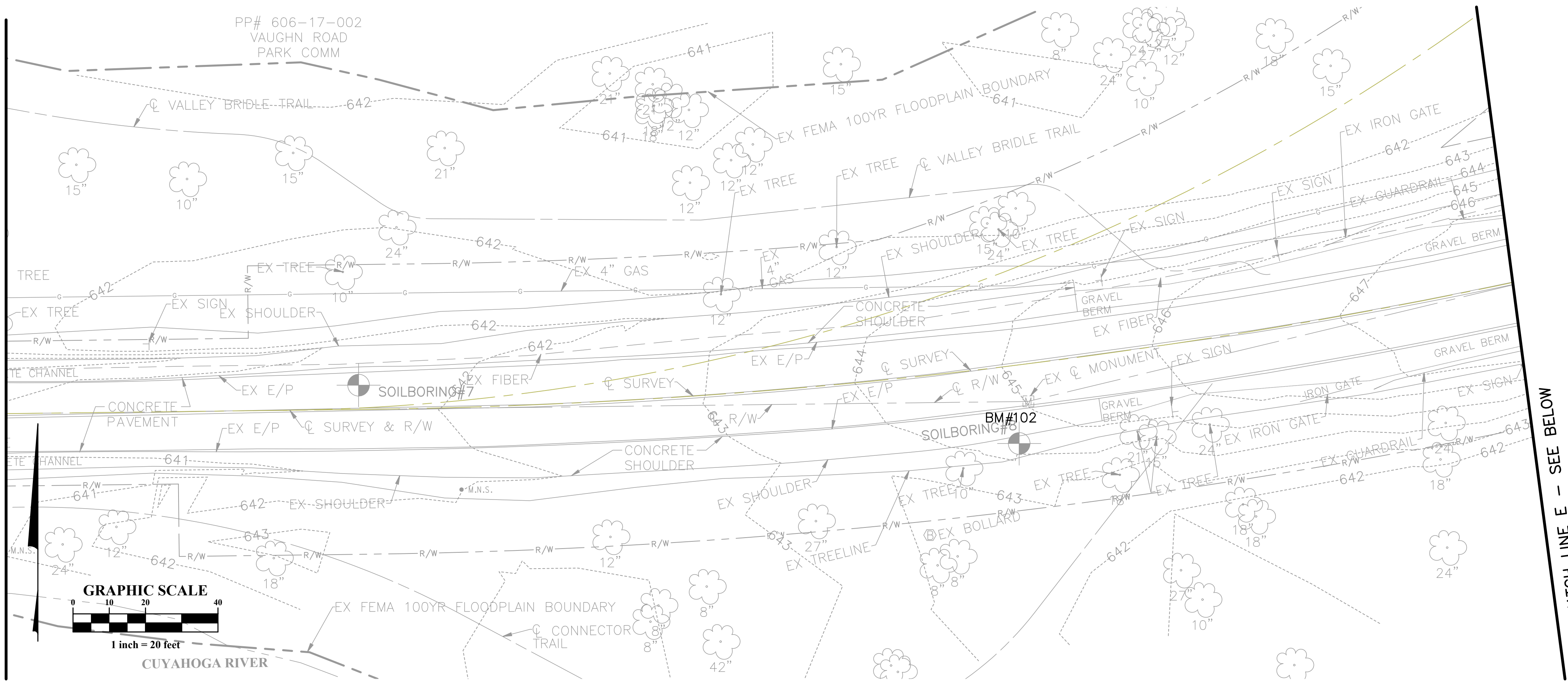
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IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

PROJECT SET: 05 OF 36
SHEET: 05 OF 09
SHEET NO.:

BENCHMARK TABLE		
POINT	ELEVATION	DESCRIPTION
BM 100	644.021	1/2" DIAMETER IRON PIN WITH RED CAP ON NORTH SIDE OF VAUGHN ROAD APPROXIMATELY 90 FEET FROM METROPARKS WILDLIFE REFUGE SIGN ON NORTH SIDE OF ROAD
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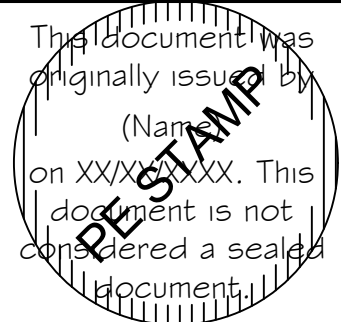
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REV NO	DATE	ISSUED BY

PRELIMINARY
NOT TO BE USED FOR
CONSTRUCTION
PLAN SET DATE
JUNE 2022

DESIGNED BY: _____
DRAWN BY: _____
SHEET CHK'D BY: _____
CROSS CHK'D BY: _____
APPROVED BY: _____
ISSUED DATE: _____



CITY OF BRECKSVILLE, OHIO
VAUGHN ROAD FLOOD MITIGATION
PROJECT 1641

EXISTING SITE PLAN

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

PROJECT SET: 06 OF 36
G SHEET: 06 OF 09
SHEET NO.:

10/27/2021

TIM MILLER
CHAGRIN VALLEY ENGINEERIN
22999 FORBES RD., UNIT B
BEDFORD, OH 44146

Re: OUPS Request # B129901770-00B
0 VAUGHN RD, BRECKSVILLE, CUYAHOGA COUNTY

Dear TIM MILLER,

We received your Ohio Utilities Protection Service (OUPS) inquiry referenced above. The approximate locations of Dominion Energy Ohio's (DEO) facilities are illustrated on the enclosed map.

As required by statute, DEO acknowledges its pipelines, as a rule, were installed at approximately 36" deep. At concerned points where you need to know the location and elevation of DEO's pipeline, you may excavate by hand digging to temporarily expose the pipeline enabling you to obtain the necessary information. Contact the Ohio Utility Protection Service (OUPS) (1-800-362-2764 or 811) prior to your excavation and submit an excavation ticket. In addition to hand digging, you may use non-destructive pipeline location methods, such as those performed by companies like So-Deep or T2 Utility Engineers (330-486-0932).

FOR RESIDENTIAL SERVICES AND SERVICE LINE DISCONNECTS: Please contact the Ohio Construction Support Group at 888-619-0786 or email: ohioconstructionsupport@dominionenergy.com.

FOR MAINLINE EXTENSIONS AND COMMERCIAL SERVICES (NEW AND LOAD ADDITIONS): Please contact the Ohio Construction Support Group at 888-619-0786 or email: ohioconstructionsupport@dominionenergy.com.

FOR RELOCATIONS: Please send a copy of your proposed plans to this office for review and resolution of any conflicts between your plans and DEO facilities at least 4 months prior to your constructions. Please send all plans and correspondence to the following address:

Dominion Energy Ohio
Attn: 2nd Floor Relocation Design
320 Springside Dr, Suite 320
Akron, Ohio 44333
Email: relocation@dominionenergy.com
Ph: 330-664-2409
Fax: 888-504-0126

DEO's response is based on the project information you or others provided for this project. The location of DEO facilities within the project area are based on the records of the original installation, and are therefore approximate, and not guaranteed. DEO has no knowledge or information of changes that may have been made to the site after the original installation. Any reliance on the information provided is solely at the risk of the user, who agrees to indemnify, defend and hold DEO, its owners, officers, affiliates and subsidiaries harmless, to the fullest extent permitted by law, from and against any and all loss, claims, demands, damages, injuries or suits in anyway arising out of or incident to its use.

Dominion Energy requests that the following note be added to your plans for the benefit of your contractor:

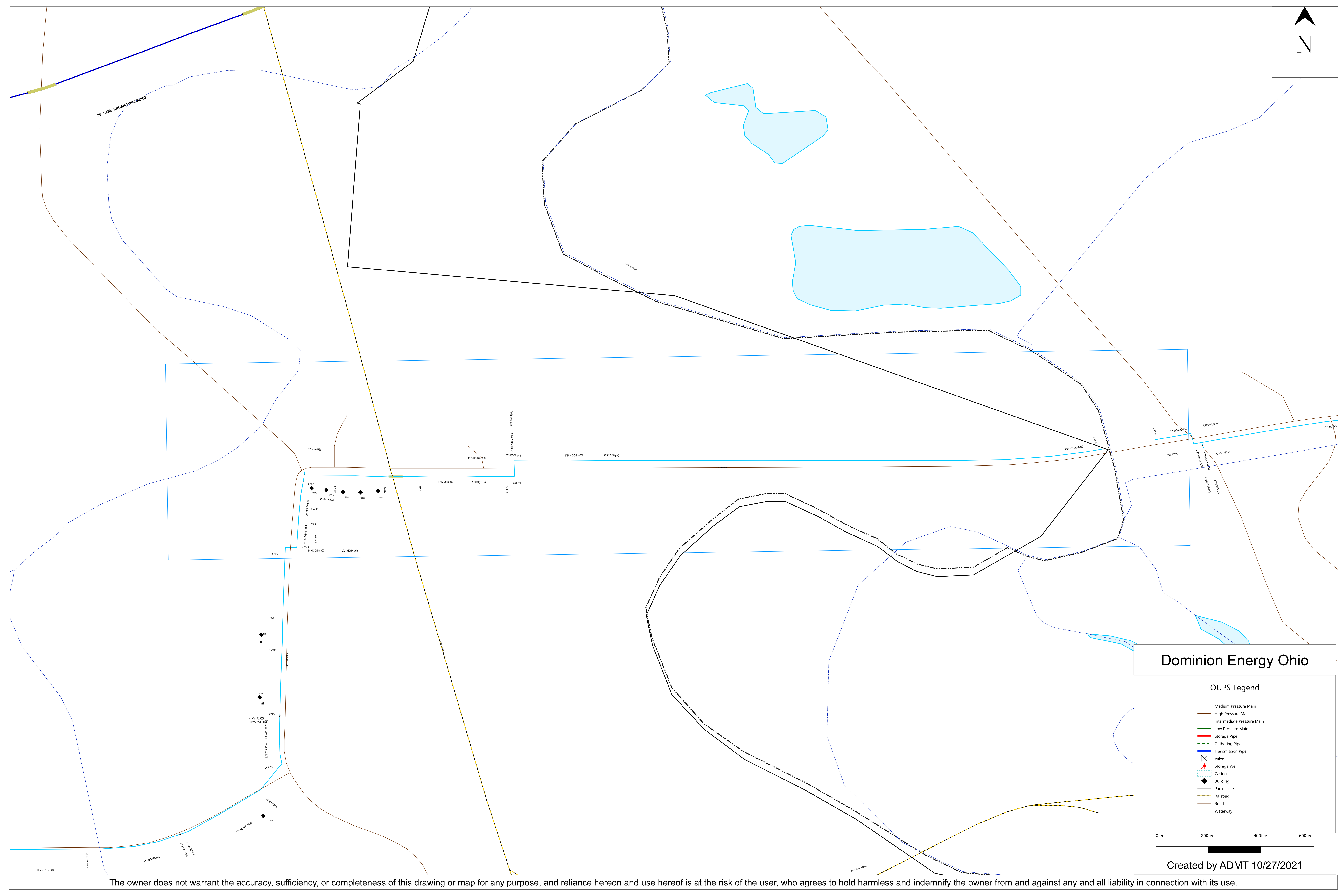
"It is the contractor's responsibility to maintain the lateral and subjacent support of Dominion Energy's pipeline(s), in compliance to 29 CFR, Part 1926, subpart P, (safe excavation & shoring). One-foot minimum vertical and horizontal clearance must be maintained between Dominion Energy Ohio's (DEO) existing pipeline(s) and all other improvements. Extreme care should be taken not to harm any DEO facility (pipelines, etc.) or appurtenance (pipe coating, tracer wire, cathodic protection test station wires & devices, valve boxes, etc.). DEO facilities must be protected with a tarp during bridge construction. The contractor will be responsible and liable for ensuring that all DEO existing facilities, above and below ground, remain undamaged, accessible and in working order. The crossing of DEO's pipeline with another steel facility may create a potential corrosion issue for the proposed facility and the existing DEO facility. Please contact Dominion Energy Ohio's Corrosion Department: Dave Cutlip (330-266-2121), Rick McDonald (330-266-2122), or Al Humrichouser (330-478-3757)."

Since over 1000 gas companies now operate in Ohio, proper pipeline identification is necessary to assure minimum critical response time. We request that you add the following general note to your construction plans: DEO = Dominion Energy Ohio, 1-800-362-7557. Dominion Energy's facilities should be identified appropriately on your construction plans.

DEO will not be liable for nor accept any contractor delay costs that the company has not had an opportunity to review, dispute and/or resolve.

Sincerely,

Dominion Energy Ohio



Dominion Energy Ohio

OUPS Legend

-
-  Medium Pressure Main
 High Pressure Main
 Intermediate Pressure Main
 Low Pressure Main
 Storage Pipe
 Gathering Pipe
 Transmission Pipe
 Valve
 Storage Well
 Casing
 Building
 Parcel Line
 Railroad
 Road
 Waterway

0feet	200feet	400feet	600feet

Created by ADMT 10/27/2021

The owner does not warrant the accuracy, sufficiency, or completeness of this drawing or map for any purpose, and reliance hereon and use hereof is at the risk of the user, who agrees to hold harmless and indemnify the owner from and against any and all liability in connection with its use.

APPENDIX B:
Hydrology Calculations

Bulletin 17C (Java) Frequency Analysis
02 Feb 2022 12:44 PM

--- Input Data ---

Analysis Name: Independence - Cuyahoga
Description:

Data Set Name: Cuyahoga River-Independence OH-FLOW-ANNUAL PEAK
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Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.975
Lower Confidence Level: 0.025

Use non-standard frequencies

Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 5.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>

Cuyahoga River-Independence OH-FLOW-ANNUAL PEAK

		Value		Threshold			
Year	Peak	Low	High	Low	High	Type	
-----		-----		-----		-----	
1922	6,910.0	6,910.0	6,910.0	1.0E-99	1.0E99	Syst	
1923	6,810.0	6,810.0	6,810.0	1.0E-99	1.0E99	Syst	
1924	---	3,810.0	25,000.0	1.0E-99	1.0E99	Cens	
1925	---	3,810.0	25,000.0	1.0E-99	1.0E99	Cens	
1926	---	3,810.0	25,000.0	1.0E-99	1.0E99	Cens	
1927	---	3,810.0	25,000.0	1.0E-99	1.0E99	Cens	

1928	10,600.0		10,600.0	10,600.0		1.0E-99	1.0E99	Syst	
1929	12,300.0		12,300.0	12,300.0		1.0E-99	1.0E99	Syst	
1930	7,900.0		7,900.0	7,900.0		1.0E-99	1.0E99	Syst	
1931	3,810.0		3,810.0	3,810.0		1.0E-99	1.0E99	Syst	
1932	5,860.0		5,860.0	5,860.0		1.0E-99	1.0E99	Syst	
1933	7,900.0		7,900.0	7,900.0		1.0E-99	1.0E99	Syst	
1934	6,760.0		6,760.0	6,760.0		1.0E-99	1.0E99	Syst	
1935	5,990.0		5,990.0	5,990.0		1.0E-99	1.0E99	Syst	
1936	8,600.0		8,600.0	8,600.0		1.0E-99	1.0E99	Syst	
1937	---		3,810.0	25,000.0		1.0E-99	1.0E99	Cens	
1938	---		3,810.0	25,000.0		1.0E-99	1.0E99	Cens	
1939	---		3,810.0	25,000.0		1.0E-99	1.0E99	Cens	
1940	12,200.0		12,200.0	12,200.0		1.0E-99	1.0E99	Syst	
1941	6,620.0		6,620.0	6,620.0		1.0E-99	1.0E99	Syst	
1942	8,970.0		8,970.0	8,970.0		1.0E-99	1.0E99	Syst	
1943	8,600.0		8,600.0	8,600.0		1.0E-99	1.0E99	Syst	
1944	7,750.0		7,750.0	7,750.0		1.0E-99	1.0E99	Syst	
1945	9,240.0		9,240.0	9,240.0		1.0E-99	1.0E99	Syst	
1946	5,430.0		5,430.0	5,430.0		1.0E-99	1.0E99	Syst	
1947	12,700.0		12,700.0	12,700.0		1.0E-99	1.0E99	Syst	
1948	8,700.0		8,700.0	8,700.0		1.0E-99	1.0E99	Syst	
1949	5,500.0		5,500.0	5,500.0		1.0E-99	1.0E99	Syst	
1950	11,000.0		11,000.0	11,000.0		1.0E-99	1.0E99	Syst	
1951	7,990.0		7,990.0	7,990.0		1.0E-99	1.0E99	Syst	
1952	11,300.0		11,300.0	11,300.0		1.0E-99	1.0E99	Syst	
1953	4,480.0		4,480.0	4,480.0		1.0E-99	1.0E99	Syst	
1954	9,360.0		9,360.0	9,360.0		1.0E-99	1.0E99	Syst	
1955	14,300.0		14,300.0	14,300.0		1.0E-99	1.0E99	Syst	
1956	8,890.0		8,890.0	8,890.0		1.0E-99	1.0E99	Syst	
1957	9,000.0		9,000.0	9,000.0		1.0E-99	1.0E99	Syst	
1958	6,730.0		6,730.0	6,730.0		1.0E-99	1.0E99	Syst	
1959	24,800.0		24,800.0	24,800.0		1.0E-99	1.0E99	Syst	
1960	7,860.0		7,860.0	7,860.0		1.0E-99	1.0E99	Syst	
1961	11,800.0		11,800.0	11,800.0		1.0E-99	1.0E99	Syst	

1962	5,960.0		5,960.0	5,960.0		1.0E-99	1.0E99	Syst	
1963	6,830.0		6,830.0	6,830.0		1.0E-99	1.0E99	Syst	
1964	12,300.0		12,300.0	12,300.0		1.0E-99	1.0E99	Syst	
1965	6,830.0		6,830.0	6,830.0		1.0E-99	1.0E99	Syst	
1966	7,720.0		7,720.0	7,720.0		1.0E-99	1.0E99	Syst	
1967	6,370.0		6,370.0	6,370.0		1.0E-99	1.0E99	Syst	
1968	8,630.0		8,630.0	8,630.0		1.0E-99	1.0E99	Syst	
1969	13,600.0		13,600.0	13,600.0		1.0E-99	1.0E99	Syst	
1970	6,570.0		6,570.0	6,570.0		1.0E-99	1.0E99	Syst	
1971	7,160.0		7,160.0	7,160.0		1.0E-99	1.0E99	Syst	
1972	8,750.0		8,750.0	8,750.0		1.0E-99	1.0E99	Syst	
1973	7,180.0		7,180.0	7,180.0		1.0E-99	1.0E99	Syst	
1974	8,700.0		8,700.0	8,700.0		1.0E-99	1.0E99	Syst	
1975	12,200.0		12,200.0	12,200.0		1.0E-99	1.0E99	Syst	
1976	14,000.0		14,000.0	14,000.0		1.0E-99	1.0E99	Syst	
1977	7,970.0		7,970.0	7,970.0		1.0E-99	1.0E99	Syst	
1978	12,900.0		12,900.0	12,900.0		1.0E-99	1.0E99	Syst	
1979	19,700.0		19,700.0	19,700.0		1.0E-99	1.0E99	Syst	
1980	9,120.0		9,120.0	9,120.0		1.0E-99	1.0E99	Syst	
1981	10,600.0		10,600.0	10,600.0		1.0E-99	1.0E99	Syst	
1982	6,960.0		6,960.0	6,960.0		1.0E-99	1.0E99	Syst	
1983	10,400.0		10,400.0	10,400.0		1.0E-99	1.0E99	Syst	
1984	9,090.0		9,090.0	9,090.0		1.0E-99	1.0E99	Syst	
1985	9,080.0		9,080.0	9,080.0		1.0E-99	1.0E99	Syst	
1986	8,630.0		8,630.0	8,630.0		1.0E-99	1.0E99	Syst	
1987	10,500.0		10,500.0	10,500.0		1.0E-99	1.0E99	Syst	
1988	6,190.0		6,190.0	6,190.0		1.0E-99	1.0E99	Syst	
1989	14,300.0		14,300.0	14,300.0		1.0E-99	1.0E99	Syst	
1990	12,200.0		12,200.0	12,200.0		1.0E-99	1.0E99	Syst	
1991	15,000.0		15,000.0	15,000.0		1.0E-99	1.0E99	Syst	
1992	8,780.0		8,780.0	8,780.0		1.0E-99	1.0E99	Syst	
1993	10,800.0		10,800.0	10,800.0		1.0E-99	1.0E99	Syst	
1994	12,900.0		12,900.0	12,900.0		1.0E-99	1.0E99	Syst	
1995	10,500.0		10,500.0	10,500.0		1.0E-99	1.0E99	Syst	

1996	9,680.0		9,680.0	9,680.0		1.0E-99	1.0E99	Syst	
1997	13,500.0		13,500.0	13,500.0		1.0E-99	1.0E99	Syst	
1998	9,450.0		9,450.0	9,450.0		1.0E-99	1.0E99	Syst	
1999	6,430.0		6,430.0	6,430.0		1.0E-99	1.0E99	Syst	
2000	7,730.0		7,730.0	7,730.0		1.0E-99	1.0E99	Syst	
2001	7,910.0		7,910.0	7,910.0		1.0E-99	1.0E99	Syst	
2002	7,180.0		7,180.0	7,180.0		1.0E-99	1.0E99	Syst	
2003	14,200.0		14,200.0	14,200.0		1.0E-99	1.0E99	Syst	
2004	15,000.0		15,000.0	15,000.0		1.0E-99	1.0E99	Syst	
2005	11,900.0		11,900.0	11,900.0		1.0E-99	1.0E99	Syst	
2006	25,400.0		25,400.0	25,400.0		1.0E-99	1.0E99	Syst	
2007	12,400.0		12,400.0	12,400.0		1.0E-99	1.0E99	Syst	
2008	12,300.0		12,300.0	12,300.0		1.0E-99	1.0E99	Syst	
2009	11,500.0		11,500.0	11,500.0		1.0E-99	1.0E99	Syst	
2010	5,350.0		5,350.0	5,350.0		1.0E-99	1.0E99	Syst	
2011	19,400.0		19,400.0	19,400.0		1.0E-99	1.0E99	Syst	
2012	10,600.0		10,600.0	10,600.0		1.0E-99	1.0E99	Syst	
2013	13,800.0		13,800.0	13,800.0		1.0E-99	1.0E99	Syst	
2014	10,500.0		10,500.0	10,500.0		1.0E-99	1.0E99	Syst	
2015	11,900.0		11,900.0	11,900.0		1.0E-99	1.0E99	Syst	
2016	8,420.0		8,420.0	8,420.0		1.0E-99	1.0E99	Syst	
2017	10,700.0		10,700.0	10,700.0		1.0E-99	1.0E99	Syst	
2018	13,800.0		13,800.0	13,800.0		1.0E-99	1.0E99	Syst	
2019	10,000.0		10,000.0	10,000.0		1.0E-99	1.0E99	Syst	
2020	14,700.0		14,700.0	14,700.0		1.0E-99	1.0E99	Syst	
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Fitted log10 Moments	Mean	Variance	Std Dev	
Skew				

EMA at-site data w/o regional info	3.977333	0.022653	0.150508
0.230089			
EMA w/ regional info and B17b MSE(G)	3.977333	0.022653	0.150508
0.230089			
EMA w/ regional info and specified MSE(G)	3.977333	0.022653	0.150508
0.230089			

EMA Estimate of MSE[G at-site]	0.064874
MSE[G at-site systematic]	0.069200
Equivalent Record Length [G at-site]	98.133919
Equivalent Record Length [Syst+Hist-LowOutl]	92.000000
Grubbs-Beck Critical Value	0.000000

--- Final Results ---

<< Plotting Positions >>

Cuyahoga River-Independence OH-FLOW-ANNUAL PEAK

Events Analyzed				Ordered Events			
Day	Mon	Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
15	Apr	1922	6,910.0	1	2006	25,400.0	1.00
21	Jan	1923	6,810.0	2	1959	24,800.0	2.00
01	Jan	1924	---	3	1979	19,700.0	3.00
01	Jan	1925	---	4	2011	19,400.0	4.00
01	Jan	1926	---	5	2004	15,000.0	5.00
01	Jan	1927	---	6	1991	15,000.0	6.00
01	Dec	1927	10,600.0	7	2020	14,700.0	7.00

	19 Jan 1929	12,300.0		8	1989	14,300.0	8.00	
	12 Jan 1930	7,900.0		9	1955	14,300.0	9.00	
	26 Apr 1931	3,810.0		10	2003	14,200.0	10.00	
	22 Mar 1932	5,860.0		11	1976	14,000.0	11.00	
	31 Dec 1932	7,900.0		12	2018	13,800.0	12.00	
	04 Apr 1934	6,760.0		13	2013	13,800.0	13.00	
	26 Feb 1935	5,990.0		14	1969	13,600.0	14.00	
	27 Feb 1936	8,600.0		15	1997	13,500.0	15.00	
	01 Jan 1937	---		16	1994	12,900.0	16.00	
	01 Jan 1938	---		17	1978	12,900.0	17.00	
	01 Jan 1939	---		18	1947	12,700.0	18.00	
	20 Apr 1940	12,200.0		19	2007	12,400.0	19.00	
	29 Dec 1940	6,620.0		20	2008	12,300.0	20.00	
	16 Mar 1942	8,970.0		21	1964	12,300.0	21.00	
	30 Dec 1942	8,600.0		22	1929	12,300.0	22.00	
	11 Apr 1944	7,750.0		23	1990	12,200.0	23.00	
	18 May 1945	9,240.0		24	1975	12,200.0	24.00	
	27 Feb 1946	5,430.0		25	1940	12,200.0	25.00	
	02 Jun 1947	12,700.0		26	2015	11,900.0	26.00	
	22 Mar 1948	8,700.0		27	2005	11,900.0	27.00	
	28 Jan 1949	5,500.0		28	1961	11,800.0	28.00	
	16 Jan 1950	11,000.0		29	2009	11,500.0	29.00	
	08 Dec 1950	7,990.0		30	1952	11,300.0	30.00	
	27 Jan 1952	11,300.0		31	1950	11,000.0	31.00	
	18 Jan 1953	4,480.0		32	1993	10,800.0	32.00	
	25 Mar 1954	9,360.0		33	2017	10,700.0	33.00	
	16 Oct 1954	14,300.0		34	2012	10,600.0	34.00	
	25 Feb 1956	8,890.0		35	1981	10,600.0	35.00	
	20 May 1957	9,000.0		36	1928	10,600.0	36.00	
	08 Aug 1958	6,730.0		37	2014	10,500.0	37.00	
	22 Jan 1959	24,800.0		38	1995	10,500.0	38.00	
	13 Dec 1959	7,860.0		39	1987	10,500.0	39.00	
	26 Apr 1961	11,800.0		40	1983	10,400.0	40.00	
	27 Feb 1962	5,960.0		41	2019	10,000.0	41.00	

	13 Mar 1963	6,830.0		42	1996	9,680.0	49.00	
	05 Mar 1964	12,300.0		43	1998	9,450.0	50.00	
	24 Jan 1965	6,830.0		44	1954	9,360.0	51.00	
	11 Feb 1966	7,720.0		45	1945	9,240.0	52.00	
	11 May 1967	6,370.0		46	1980	9,120.0	53.00	
	17 Jul 1968	8,630.0		47	1984	9,090.0	54.00	
	20 Jul 1969	13,600.0		48	1985	9,080.0	55.00	
	29 Jan 1970	6,570.0		49	1957	9,000.0	56.00	
	23 Feb 1971	7,160.0		50	1942	8,970.0	57.00	
	15 Apr 1972	8,750.0		51	1956	8,890.0	58.00	
	15 Mar 1973	7,180.0		52	1992	8,780.0	59.00	
	19 Jan 1974	8,700.0		53	1972	8,750.0	60.00	
	22 May 1975	12,200.0		54	1974	8,700.0	61.00	
	17 Feb 1976	14,000.0		55	1948	8,700.0	62.00	
	24 Feb 1977	7,970.0		56	1986	8,630.0	63.00	
	14 Dec 1977	12,900.0		57	1968	8,630.0	64.00	
	15 Sep 1979	19,700.0		58	1943	8,600.0	65.00	
	25 Dec 1979	9,120.0		59	1936	8,600.0	66.00	
	19 Feb 1981	10,600.0		60	2016	8,420.0	67.00	
	23 Dec 1981	6,960.0		61	1951	7,990.0	68.00	
	02 Jul 1983	10,400.0		62	1977	7,970.0	69.00	
	21 Mar 1984	9,090.0		63	2001	7,910.0	70.00	
	29 Mar 1985	9,080.0		64	1933	7,900.0	71.00	
	05 Nov 1985	8,630.0		65	1930	7,900.0	72.00	
	02 Jul 1987	10,500.0		66	1960	7,860.0	73.00	
	26 Mar 1988	6,190.0		67	1944	7,750.0	74.00	
	26 May 1989	14,300.0		68	2000	7,730.0	75.00	
	07 Sep 1990	12,200.0		69	1966	7,720.0	76.00	
	30 Dec 1990	15,000.0		70	2002	7,180.0	77.00	
	31 Jul 1992	8,780.0		71	1973	7,180.0	78.00	
	31 Dec 1992	10,800.0		72	1971	7,160.0	79.00	
	13 Aug 1994	12,900.0		73	1982	6,960.0	80.00	
	16 Jan 1995	10,500.0		74	1922	6,910.0	81.00	
	23 Apr 1996	9,680.0		75	1965	6,830.0	82.00	

	01 Jun 1997	13,500.0		76	1963	6,830.0	83.00	
	17 Apr 1998	9,450.0		77	1923	6,810.0	84.00	
	24 Jan 1999	6,430.0		78	1934	6,760.0	85.00	
	08 Apr 2000	7,730.0		79	1958	6,730.0	86.00	
	17 Dec 2000	7,910.0		80	1941	6,620.0	87.00	
	13 May 2002	7,180.0		81	1970	6,570.0	88.00	
	22 Jul 2003	14,200.0		82	1999	6,430.0	89.00	
	22 May 2004	15,000.0		83	1967	6,370.0	90.00	
	12 Jan 2005	11,900.0		84	1988	6,190.0	91.00	
	23 Jun 2006	25,400.0		85	1935	5,990.0	92.00	
	06 Jan 2007	12,400.0		86	1962	5,960.0	93.00	
	06 Feb 2008	12,300.0		87	1932	5,860.0	94.00	
	09 Mar 2009	11,500.0		88	1949	5,500.0	95.00	
	14 Mar 2010	5,350.0		89	1946	5,430.0	96.00	
	28 Feb 2011	19,400.0		90	2010	5,350.0	97.00	
	06 Dec 2011	10,600.0		91	1953	4,480.0	98.00	
	30 Oct 2012	13,800.0		92	1931	3,810.0	99.00	
	22 Dec 2013	10,500.0		93	1939	---	42.00	
	27 Jun 2015	11,900.0		94	1938	---	43.00	
	27 Dec 2015	8,420.0		95	1937	---	44.00	
	12 Jan 2017	10,700.0		96	1927	---	45.00	
	16 Apr 2018	13,800.0		97	1926	---	46.00	
	21 Jun 2019	10,000.0		98	1925	---	47.00	
	01 Jan 2020	14,700.0		99	1924	---	48.00	
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* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>

Cuyahoga River-Independence OH-FLOW-ANNUAL PEAK

	Computed	Variance	
	Curve	Log (EMA)	
		Percent	
		Chance	
		Confidence Limits	
		0.975	
		0.025	

FLOW, CFS		Exceedance	FLOW, CFS	
-----		-----	-----	
28,359.3	0.00409	0.200	22,972.7	45,473.4
24,971.3	0.00281	0.500	20,905.6	36,539.0
22,526.6	0.00203	1.000	19,311.1	30,833.4
20,168.6	0.00140	2.000	17,676.7	25,904.2
17,879.4	0.00093	4.000	15,985.3	21,652.7
17,153.1	0.00081	5.000	15,425.1	20,413.3
14,912.2	0.00052	10.000	13,619.8	16,926.9
12,648.2	0.00035	20.000	11,677.4	13,896.6
9,366.2	0.00027	50.000	8,693.2	10,093.4
7,067.6	0.00027	80.000	6,531.3	7,606.8
6,145.2	0.00035	90.000	5,579.1	6,644.6
5,495.4	0.00049	95.000	4,856.1	5,999.7
4,496.1	0.00118	99.000	3,696.0	5,117.7
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<< Multiple Grubbs-Beck Test P-Values >>

Cuyahoga River-Independence OH-FLOW-ANNUAL PEAK

Number Of	P-Values
Low Outliers	

1	3.103E-1
2	3.881E-1
3	8.899E-1
4	8.035E-1
5	6.917E-1
6	8.784E-1
7	8.506E-1
8	7.531E-1
9	8.313E-1
10	8.872E-1

	11		8.506E-1	
	12		8.820E-1	
	13		8.414E-1	
	14		8.544E-1	
	15		7.902E-1	
	16		7.380E-1	
	17		6.375E-1	
	18		4.954E-1	
	19		4.689E-1	
	20		3.996E-1	
	21		5.546E-1	
	22		4.462E-1	
	23		3.134E-1	
	24		8.960E-1	
	25		8.384E-1	
	26		7.742E-1	
	27		8.090E-1	
	28		7.643E-1	
	29		6.575E-1	
	30		5.495E-1	
	31		5.105E-1	
	32		4.114E-1	
	33		8.630E-1	
	34		9.360E-1	
	35		8.914E-1	
	36		8.552E-1	
	37		7.771E-1	
	38		7.663E-1	
	39		6.642E-1	
	40		6.172E-1	
	41		5.376E-1	
	42		5.670E-1	
	43		5.544E-1	
	44		4.706E-1	

	45		4.516E-1	
	46		3.414E-1	
	----- -----			

* = p-value corresponds to a zero flow value.

<< Systematic Statistics >>

Cuyahoga River-Independence OH-FLOW-ANNUAL PEAK

Log Transform:		Number of Events	
FLOW, CFS			
----- -----		----- -----	
Mean	3.977	Historic Events	0
Standard Dev	0.151	High Outliers	0
Station Skew	0.230	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	7
Adopted Skew	0.230	Systematic Events	92
		Historic Period	99
----- -----		----- -----	

--- End of Analytical Frequency Curve ---

Peak Streamflow Estimate for Cuyahoga River at Vaughn Road

Drainage Area = 555 square miles

Use method presented in WRIR 03-4164 "Techniques for Estimating Flood-Peak Discharges of Rural, Unregulated Streams in Ohio

Base Calculations off USGS Gaging Station at Independence

Drainage Area = 707 square miles

Ratio of Drainage Areas = 0.79 $.5 < r < 1.5$, OK

Difference in Drainage Area = 152 square miles

Calculate Revised Weighted Streamflows

Period of Record = 92 years

Year	2	5	10	25	50	100
EMH&T 2021 B17C	9,366	12,648	14,912	17,153	20,168	22,527
Streamstats	9,560	13,200	15,700	18,800	21,100	23,300
Equivaent Record	2.2	3.5	4.7	6.2	7.1	7.8
Weighted	9,370	12,668	14,949	17,253	20,233	22,586

Peak Streamflow Values from WRIR 03-4164

Year	2	5	10	25	50	100
Weighted	9,370	12,668	14,949	17,253	20,233	22,586
Regression	9,560	13,200	15,700	18,800	21,100	23,300
R	0.98	0.96	0.95	0.92	0.96	0.97

Streamstats Results for Vaughn Road Site

Year	2	5	10	25	50	100
Regression	8,700	12,100	14,500	17,700	20,100	22,600

Gage Adjusted Peak Discharge for Vaughn Road Site

Year	2	5	10	25	50	100
Q (cfs)	8,600	11,800	14,100	16,900	19,600	22,200

PHOTOGRAPHS



IMAGE 1

Looking upstream at the Cuyahoga River from the Vaughn Road bridge.



IMAGE 2

Looking downstream at the Cuyahoga River from the Vaughn Road bridge.



IMAGE 3

View from underneath the Vaughn Road bridge.



IMAGE 4 & IMAGE 5

General condition of abutments underneath the bridge.



IMAGE 6

Looking west over the Vaughn Road bridge



IMAGE 7

Looking west along Vaughn Road from the bridge approach.



IMAGE 8

The Cuyahoga River flows in close proximity to Vaughn Road within the project area.