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Schoonmaker Creek Watershed Preliminary Engineering Analysis

A review and evaluation of stormwater design alternatives in the Schoonmaker Creek Watershed.

City of Wauwatosa, Milwaukee County, WI

Schoonmaker Creek, Wauwatosa, WI

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Abbreviations

City: City of Wauwatosa

GIS: Geographic Information Systems

SEWRPC: Southeast Wisconsin Regional Planning Commission

MMSD: Milwaukee Metropolitan Sewerage District

1 Executive Summary

The Schoonmaker Creek watershed within the City of Wauwatosa (the City) has experienced numerous heavy storm events which have caused flooding to streets, homes, and businesses. The City has studied the watershed for the purpose of improving drainage and reducing flooding since the 1990s. The most recent study was completed by the Southeast Wisconsin Regional Planning Commission (SEWRPC) in 2020 and evaluated 16 alternatives for flood reduction in the watershed. In July 2022 the City recommended that two of the alternatives be further studied for feasibility, including the preparation of 30% construction plans, construction cost estimates, and a thorough review of construction-related issues related to each option. The City's direction was to evaluate these two options, working only within the public right-of-way and not within the open channel portion of Schoonmaker Creek. Refer to the Committee Affairs Committee meeting information from July 26th, 2022 for more information.

Since the two options to be evaluated were not wholly inclusive of all improvements necessary to achieve desired flood reduction levels for the watershed, the assessment of the two alternatives also included a higher-level estimate of the costs to construct all anticipated improvements in the watershed.

This study presents the following information:

- A comparison of the costs and issues associated with the construction of two alternatives evaluated in the 2020 SEWRPC study:
  - Construction of a Tunnel running from W. Lloyd Street south to the Menomonee River. This alternative was referred to as alternative 15 in the SEWRPC report but is known as **Option A** in this report.
  - Construction of a Storm Sewer running from W. Lloyd Street south along the alignment of Martha Washington Drive, W. Martin Drive, N. 60th Street and W. State Street to the Menomonee River. This alternative was referred to as alternative 16 in the SEWRPC report but is known as **Option B** in this report.

- A 'desktop analysis' of necessary improvements required to improve drainage within the watershed for the areas north of W. Lloyd Street, to provide a drainage and flood-reduction service level commensurate with both **Options A** and **B** as described above. This also includes improvements to sanitary and water infrastructure, as directed by City staff.

- Final deliverables include a summary report describing the stormwater modeling, 30% designs for **Options A** and **B**, cost estimates for the completion of each alternative, a matrix indicating the costs/benefits for each alternative, and figures of the flood extents for different size storm events under existing conditions and proposed future conditions.

*Note that **Option B** involves the installation of a very large box storm sewer which will require the complete reconstruction of Martha Washington Drive for the entire length of the project. Since the pavement and non-stormwater utilities within Martha Washington Blvd will need to be reconstructed in the near future regardless of which option the City selects, the non-stormwater related costs associated with reconstruction of Martha Washington Drive were added to **Option A** so as to facilitate better cost comparison.*

The alternatives evaluated in this study are based on the development of a new highly detailed watershed model to size the pipe sizing for both options. Modeling used the 100-yr 24-hr rainstorm (6.06-inches total depth applied with an MSE3 intensity distribution). **Option A** is a 10-foot diameter Tunnel, plus assumed improvements north of Lloyd Street. **Option B** is a 6-ft x 12-ft (increasing to 6-ft x 16-ft in the downstream reaches) Storm Sewer, plus assumed improvements north of Lloyd Street. Both options are effective at reducing estimated structure flooding from over 100 structures to less than 5 while also reducing peak flows in Schoonmaker Creek. It is anticipated that expansion of drainage improvements, to be completed in the next phase of this project, will address these remaining few structures.

Estimated Cost: The Preliminary cost determination for the **Option A** Tunnel is $48.5M (lowest cost of three potential tunnel alignments). Additional cost of reconstructing the Martha Washington Drive corridor increases the cost of the project to $63.6M. The Preliminary cost determination for the **Option B** Storm Sewer is $38.9M (inclusive of the associated street reconstruction cost). The estimated cost of constructing improvements north of W. Lloyd Street based on the desktop analysis is a range of $115M to $135M, which includes a contingency of 20% to 40% and engineering design cost of 10%. Note that these costs are based on 2024 costs.

The total estimated cost to construct **Option A Tunnel** including the Desktop Analysis area north of W. Lloyd Street is $180M to $200M

The total estimated cost to construct **Option B Storm Sewer** including the Desktop Analysis area north of W. Lloyd Street is $155M to $175M.

Route Alternative Matrix: A Route Alternatives Matrix was completed comparing both options against each other through a total of 26 qualitative factors. Each factor was provided a weighted score based upon its relative significance, and each factor's score was assigned either a positive, negative, or zero score with regard to its benefit or detraction relative to each option. The **Option A Tunnel** received a score of -1 while the **Option B Storm Sewer** received a score of +11.

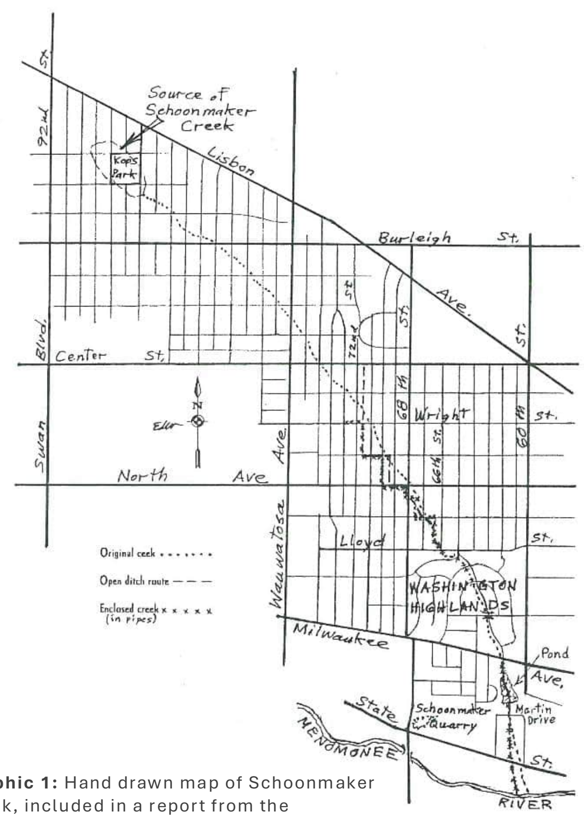
Conclusions: Both options are effective at achieving flood reduction goals while reducing peak flows within Schoonmaker Creek. Option **B Storm Sewer** is both the lower cost and higher scoring option based on the analysis documented in this report. Should the City choose to proceed with **Option B** the total estimated costs for systemic improvements within the watershed are $155M to $175M based on 2024 costs.

2 Introduction

2.1 Watershed Background

Schoonmaker Creek watershed is approximately 1,908 acres in size (**Figure 1**). The watershed flows from northwest to southeast, beginning in the City of Milwaukee and flowing into the City of Wauwatosa. A portion of the City of Milwaukee to the east of Wauwatosa also flows west into the watershed.

Historic reports (provided by the City from the Wauwatosa Historical Society) indicate that Schoonmaker Creek existed as an open channel beginning near what is now Kops Park. It ran southeasterly approximately ~3 miles to the Menomonee River near N 60th Street and W State Street. Over the years, portions of the creek were diverted through culverts, and in the 1930s, the portion of Schoonmaker Creek north (upstream) of W Lloyd Street and the portion south (downstream) from Milwaukee Avenue were enclosed in pipes. The length of channel between W Lloyd Street and Milwaukee Avenue remains as an open channel today.



Graphic 1: Hand drawn map of Schoonmaker Creek, included in a report from the Wauwatosa Historical Society titled "Schoonmaker Creek" by Ed Wilkommen.

The City of Wauwatosa reports that the watershed has experienced numerous heavy storm events which has caused flooding to streets, homes, and businesses. Modeling completed as part of this study predicts approximately 110 buildings and 4.6 miles of street within Wauwatosa to be flooded by more than six inches under 100-yr 24-hour conditions (refer to **Section 5.1** for more details). Nearly all the buildings predicted to be flooded are located along the historic open channel where it has been enclosed in pipe. Flooded streets are also predominantly in these areas; however, Martha Washington Drive, where it parallels the open channel portion of Schoonmaker Creek is also predicted to be flooded.

Flooding conditions with Schoonmaker Creek have been the subject of several studies since the 1990s. The most recent study of the watershed was completed in 2020 by the Southeastern Wisconsin Regional Planning Commission (SEWRPC). This study was quite comprehensive and involved the evaluation of 16 alternative stormwater management plans to reduce flooding in the watershed. The City of Wauwatosa selected alternatives 15 and 16 as described in the SEWRPC report for further consideration. Alternative 15 (hereafter referred to as **Option A**) consists of a new tunnel system (constructed mostly via underground/boring methods) to collect and convey flood flows from N 65th Street and W Lloyd Street to the Menomonee River along an alignment following N 68th Street. Alternative 16 (hereafter referred to as **Option B**) consists of a proposed storm sewer pipe running underneath Martha Washington Drive from N 65th Street and W Lloyd Street to the Menomonee River. See **Figure 2** to visualize the alignment of these two alternatives.

2.2 Project Purpose

This project reviews Options A and B, to compare the costs and issues associated with their possible construction. The project includes:

- Development of 30% plans for each alternative.
- A 'desktop analysis' for the improvements to improve drainage in the watershed north of W. Lloyd St. *Note this analysis also included estimates for improving sanitary and potable water utility infrastructure, based on future planning by City staff.*
- Stormwater modeling to support sizing of stormwater infrastructure and mapping the flooding extents under existing conditions and possible future improvements.
- Creation of an evaluation matrix, to support the City's decision making on selecting future improvements within the watershed.

Both selected alternatives from the SEWRPC report were defined as beginning at W Lloyd Street and extending downstream to the Menomonee River. As most (but not all) of the flooding in the watershed occurs upstream from W Lloyd Street, the SEWRPC study pre-supposed that systemic improvements to the drainage system serving areas north of W Lloyd Street were installed and that each of the alternatives evaluated would connect to this system and convey any increased flows from north of W Lloyd Street directly to the Menomonee River. Evaluations of the systemic improvements north of W Lloyd Street were not specifically part of the scope of this study; however, some conceptual evaluations were necessary to fully evaluate the effectiveness of the two alternatives that were the focus of this study.

2.3 Project Scope

This project consisted of several different elements, focused on data gathering, modeling the existing stormwater system, and aggregation of all the project elements to create a evaluation matrix to be used by the City when reviewing future stormwater design alternatives.

2.3.1 Survey Inventory

Survey data was provided by the City of Wauwatosa through a combination of GIS data and field collection. GIS data included pipe and structure sizes, materials, GPS locations where available, and elevations where available. Further detailed field survey collection was completed by the City in specific areas requested by MSA including intersections along the Martha Washington corridor. MSA evaluated existing GIS records for the City of Wauwatosa of all existing utilities, curb and gutter, sidewalk, lighting, and all additional appurtenances within the right-of-way for the proposed project path for each alternative.

2.3.2 Geotechnical Borings

GESTRA Engineering, Inc. (Gestra) was subcontracted to complete subsurface exploration and preliminary geotechnical engineering within the project limits. Included in the Appendix is the full report from Gestra which includes the results from the subsurface soil exploration and describes the field exploration, laboratory test results, and provides preliminary geotechnical engineering recommendations.

2.3.3 Alignment Analysis

Option A involves the construction of a tunnel, while **Option B** proposes a storm sewer within Martha Washington Drive. CDM Smith was subcontracted by MSA to complete the analysis and preliminary design of the tunnel. The intention was to evaluate the alignments independently of each other for the City to select a single option that would be advanced to final design.

During the early stages of the analysis, MSA, CDM Smith and City staff re-evaluated the scope in the following areas:

- **Option A**: The tunnel scope was modified based on input from CDM Smith to evaluate multiple tunnel alignments based on data acquired during a geotechnical analysis of the watershed south of Lloyd Street. A single alignment was selected and preliminary costs were generated by CDM Smith.
- **Option B**: Originally, two scenarios were to be evaluated within the Martha Washington Drive corridor based on reduced design flows within Schoonmaker Creek, each achieving varying results. One of the two scenarios is the current Option B within this report. A second scenario which consisted of a smaller diameter storm sewer pipe was not pursued. This was based on the minimal cost savings of installing a smaller diameter pipe weighed against a lesser reduction to

flows within Schoonmaker Creek. Based on this reasoning, Option B consisted of the evaluation of a single storm sewer design.

2.3.4 Desktop Analysis

A desktop analysis of the area north of W Lloyd Street was evaluated based on future improvements to the water, sanitary and storm sewer. The desktop analysis did not involve design of improvements and only included evaluation of improvements to generate an understanding of potential conflicts and cost opinions of the overall improvement area.

2.3.5 Hydrologic/Hydraulic Modeling Updates

An entirely new watershed (hydrologic/hydraulic) model was constructed for this study. This new model was guided by past modeling but represents an entirely new effort using new modeling software. Substantial additional detail was added to the modeling studies including an expanded study area, a more complete assessment of existing storm sewer systems and an overall much larger number of model elements. A detailed description of the model is included in Section 4 of this report.

2.3.6 Route Alternatives Matrix

Upon completion of the two options, an evaluation matrix was developed by MSA with weighted criteria to provide an impartial comparison between options.

2.3.7 Preliminary Estimate of Cost

MSA prepared high-level cost estimates for each alternative, with assistance from CDM Smith. Estimates were divided out by utility (storm, sanitary, and potable water) at the request of City staff. Estimates were also broken out by area, to better visualize relative costs between the alternatives. Elements include in the cost estimate are as follows:

- Option A Tunnel
  - Tunnel elements from CDM Smith preliminary analysis
  - Martha Washington corridor to include reconstruction costs
- Option B Storm Sewer
  - Full reconstruction of Martha Washington corridor to the Menomonee River
- Desktop Analysis North of W. Lloyd Street
  - Utility improvements for storm sewer, sanitary sewer and potable water (included in total costs for Option A and Option B)

3 Preliminary Engineering Analysis

3.1 Option A: Tunnel Alignment

The 2020 SEWRPC report described a large, deep tunnel to convey stormwater runoff and reduce flooding within the watershed. Details of the tunnel alignment, including preliminary layouts, cost estimates and major considerations, were completed by CDM Smith and are included in the attached **Appendix A**.

3.2 Option B: Storm Sewer improvements along Martha Washington Drive

MSA developed preliminary engineering plans and profile drawings within Martha Washington Drive between W Lloyd Street extending south to a proposed outlet structure located south of State Street, ultimately discharging to the Menomonee River. The storm sewer alternative within Martha Washington Drive includes improvements to the roadway crossings of Schoonmaker Creek at Revere Avenue, Washington Circle, and Upper Parkway. This option does not include any improvements to the open channel cross-section throughout this reach.

Plan and profile drawings were developed to a 30% level of detail included in the attached **Appendix C**. Improvements were based on the results of the hydrologic and hydraulic modeling as well as the feasibility to placing a large diameter storm sewer withing the Martha Washington Drive right-of-way. Improvements assumed the full replacement of existing sidewalk, curb and gutter, street pavement, street lights and removal and replacement of existing street trees located within the right-of-way. Existing utilities including City sanitary sewer, water main and MMSD MIS were considered for replacement, upsizing or left in place.

3.2.1 Street Corridor

Within the existing right-of-way, full reconstruction was assumed to include the following:

- removal and replacement of street trees
- replacement of existing light poles
- removal of existing sidewalk and replacement with 5’ wide sidewalk
- 31” curb and gutter
- full width pavement reconstruction

3.2.2 Storm Sewer

At the southern extent of the project, located south of W State Street, an outflow / siphon structure is planned to direct stormwater flows to the Menomonee River. The structure is preliminarily based on a similar structure outlined in the CDM report. Extending north from the outflow structure is a 6' x 16' box culvert extending beneath W State Street, N 60th Street, W Martin Drive and Martha Washington Drive to a vault located at the intersection of Milwaukee Avenue. The vault located at the intersection of Milwaukee Avenue and Martha Washinton Drive will serve as a junction of the upsized storm sewer as well as the extension of the existing 7' x 12' box culvert at the southern extents of Schoonmaker Creek. The proposed storm sewer extending north along Martha Washington Drive is proposed as a 6' x 12' box culvert which will extend north within Martha Washington Drive to a point in Revere Drive south of W Lloyd Street. The overall length of the proposed storm sewer between W Lloyd Street and the outfall structure south of W State Street is approximately 9,000 linear feet.

3.2.3 Sanitary Sewer (City)

The City sanitary sewer was planned to be reconstructed through the project corridor. This would be accomplished by a combination of replacing in kind, upsizing where necessary or moving within the right-of-way due to conflicts resulting from improvements to the City storm sewer or potential replacement of MMSD MIS. Improvements included replacement of sanitary structures, mains and laterals within City right-of-way.

Pipe sizing was in accordance with a prior modeling study of the sanitary system (see City report '*Investigation and Analysis of Sanitary Sewersheds WA4001, WA4004, WA4035'* completed by Brown and Caldwell in 2011). A separate effort to size the sanitary pipes will need to occur for final design based on planned improvements from the MMSD MIS which may require City sewer to be further upsized beyond the findings of the B&C report.

3.2.4 Sanitary Sewer (MMSD MIS)

Preliminary improvements to the MMSD MIS currently include the consolidation and replacement of existing dual lines and structures underneath the W Washington Boulevard bridge. Physical constraints with channel, roadway and planned improvements to City sanitary sewer, water main and storm sewer drove the need to relay this portion of sewer to allow for required separations between utilities. Additional improvements to MMSD MIS may be added as the project proceeds with design as determined by MMSD.

3.2.5 Water Main

Water main and services within City right-of-way were planned for replacement throughout the project corridor. Due to restrictions posed by both the existing and proposed large storm sewer lines, two water mains (one on either side of the storm sewer) were planned for the section of Martha Washington Drive between West Martin Drive and Milwaukee Avenue. Existing undersized water main is planned to be properly upsized as part of the reconstruction work. Areas where there are two mains present that can be consolidated into single pipes were also considered as part of the preliminary design process. Hydrants within the project corridor are planned to be replaced along with water services up to City right-of-way.

4 Hydrologic/Hydraulic Modeling Methodology

Two-dimensional modeling was completed for this study to determine the required size of the drainage infrastructure, for **Options A** and **B**. This in turn was used to support the development of cost estimates and to estimate construction impacts for the purpose of completing the Route Evaluation Matrix.

4.1 Modeling Software

This study was completed using two different modeling software packages. At the direction of the City of Wauwatosa, modeling of the watershed within the City of Wauwatosa and the portion of the City of Milwaukee east of Wauwatosa was completed using PC-SWMM.

There is currently no existing storm sewer pipe-connection between the portion of Schoonmaker Creek watershed north of W. Center Street in the City of Milwaukee to the portion of the watershed south of W. Center Street in the City of Wauwatosa. The natural topography of the watershed drainage is to the southeast; however, Milwaukee's storm sewer infrastructure in this area drains west, along Center Street, against the natural topography in the area. The existing storm sewer is insufficient to collect and convey peak flows from large events and excess flows travel overland into the City of Wauwatosa. Stormwater contributions from Milwaukee across this divide only occur through surface discharges.

To account for the surface discharges from the regions north of W Center Street, this portion of the watershed was modeled using XP-SWMM 2D version 2024.1 and rain-on-grid methods. Major trunk storm sewer systems were included in the XP-SWMM model to ensure that the frequency and magnitude of overflows into Wauwatosa were as accurately quantified as possible. Overland flow hydrograph outputs from the XP-SWMM model were tabulated at two locations; along the south side of W. Center Street where excess flows would run south along N 67th, N 68th, and N 69th Streets; and at N73rd Street at the saddle point between W. Center Street and W. Clark Street. These hydrographs were input into the PC-SWMM model as user-defined inflows at the corresponding locations within that model. This was the only interface between the two models.

As a final note, modeling completed for this study is based upon the implicit assumption that all elements of the drainage system are in a well-maintained condition. This is standard practice and is necessary as it is nearly impossible to meaningfully quantify the ramifications of transient physical conditions within a drainage system that change seasonally if not daily (i.e. accumulation of debris at inlets).

4.2 Data Sources

The following data sources were used for development of model input data:

- 2022 Aerial Photography obtained from Milwaukee County
- 2021 LiDAR DEM obtained from Milwaukee Metropolitan Sewerage District and 1-foot contours generated from that DEM
- Land use derived from Milwaukee County Parcel data (**Figure 3**)
- Impervious area developed based on the Milwaukee County Planimetric data (**Figure 4**)
- Soils data from the USDA NRCS (**Figure 5**). *Note that soils in this portion of the state are not digitally mapped at the time of the writing of this report.*
- Parcel data from Milwaukee County.
- Impervious area dataset obtained from Milwaukee County
- Parcel based land uses obtained from Milwaukee County
- GIS data describing storm drainage infrastructure provided by the City of Wauwatosa and the City of Milwaukee. Refer to **Figure 6** to see the complete mapped stormwater system and **Figure 7** to visualize the portion of the system used in the 1-D network in modeling.
- Survey data describing existing bridges along the open channel portion of Schoonmaker Creek provided by the City of Wauwatosa
- Original construction plans for the bridge over Schoonmaker Creek at W. Washington Boulevard.
- Site observations by MSA staff

4.3 Rainfall Events

Event based modeling was completed using the MSE3, 24-hr rainfall intensity distribution with the following countywide average rainfall depths as defined by the USDA NRCS using NOAA-14 rainfall atlas data.

Table 4-1. Event based rainfall events and depths.

Rainfall Event	Depth (in)
1-yr 24-hr	2.34
2-yr 24-hr	2.64
5-yr 24-hr	3.20
10-yr 24-hr	3.73
25-yr 24-hr	4.56
50-yr 24-hr	5.28
100-yr 24-hr	6.06

4.4 PC-SWMM Model Construction

4.4.1 Hydrologic Model

Hydrologic calculations were completed using SWMM hydrology. This method requires the following primary input parameters: Subwatershed area, total impervious area within the subwatershed, the fraction of impervious area that is disconnected from the drainage system, the subwatershed width, and the subwatershed slope. Additional secondary factors describing initial abstractions and soil infiltration capacity are also required.

Detailed data describing hydrologic model input and output data is included at the end of this appendix.

Subwatershed Area. 193 individually modeled subwatersheds with an average size of approximately 5.3 acres and a median size of approximately 4.1 acres were delineated to key points within the stormwater system (**Figure 8,** a mapbook). Subwatersheds were delineated based on aerial topographic mapping, mapped storm sewer alignments, and aerial photography.

Impervious Area. Total impervious area for each subwatershed as directly calculated in GIS by clipping mapped impervious area using subwatershed boundaries (**Figure 4**). The fraction of disconnected impervious area was calculated by classifying impervious area type (roof, sidewalk, street, etc.) by landuse and cross-referencing connectivity against published standard values by land use classification available from WDNR and the USGS (commonly obtained from WinSLAMM software references).

Width. Subwatershed widths were determined through a semiautomated process whereby flow paths within each subwatershed were first auto-delineated using GIS tools. Each of these paths was then manually adjusted to more closely follow actual anticipated flow paths based on actual land cover according to aerial photographs. The width value was calculated by dividing the subwatershed area by the final subwatershed length.

Slope. Subcatchment slope was calculated by using the calculating the average slope (using the ArcGIS slope tool) on the digitized longest flowpath.

Abstractions and infiltration rates. Modeling was completed using default values for initial abstractions as follows:

- Maximum infiltration rate = 1.0 in/hr
- Minimum infiltration rate = 0.2 in/hr
- Decay rate = 4.0/hr
- Drying time = 7.0 days

These are values used by MSA for other similar watershed studies to depict soils classified as hydrologic soil group C which is commonly applied within Milwaukee County (there is currently no countywide soil mapping available).

4.4.2 1-D Hydraulic Model

The 1-D network of pipes and open channel systems used in the modeling was constructed using GIS data itemized above. Pipe data was obtained from database information provided by the cities of Wauwatosa and Milwaukee. Data describing the cross-sections of open channel sections of Schoonmaker Creek was developed using the transect function within PC-SWMM.

In total 746 conduits and 729 junctions were used in the 1-D system modeling (this is the total number of all models; individual models for existing and improved conditions alternatives used slightly less). Detailed data describing 1-D hydraulic model input and output data is included in the appendix of this report. See **Figure 9** (a mapbook) showing the 1-D network for easier visualization of the output data.

Junction names were copied from labeling within each City's GIS databases. Conduit names for existing storm sewer were primary assigned by joining the names of upstream (from) junctions and downstream (to) junctions. Conduits added by MSA for the open channel sections of Schoonmaker Creek and the additional elements needed to define the tunnel or improved storm sewer options were arbitrarily assigned.

Manning's roughness. Manning's roughness values for conduits were assigned as follows; for concrete or clay pipes n=0.013, for plastic pipes (HDPE, PVC) n=0.011. Any pipes with unspecified materials were assumed to be concrete. Open channel conduits were assigned n=0.030.

Minor loss coefficients. Minor loss coefficients were assigned as conduit exit losses using the following criteria:

- Straight pipe sections = 0.1
- Pipe connections that are more gradual than a 90-degree bend [90<angle<180] = 0.5
- Pipe connections more severe than or equal to a 90-degree bend [angle<=90 deg.] = 1.0

The PC-SWMM model assumed a free outfall to the river, for all storm events simulated and for all scenarios evaluated. This condition was applied for both the 1-D and 2-D outfalls.

4.4.3 2-D Hydraulic Model

The 2D portion of the model was based entirely on the 2021 LiDAR DEM from MMSD. Any changes to the ground surface (e.g. re/new development) that have occurred since 2021 are not reflected in model input or output. A hexagonal spacing (2-D network mesh) for non-roadway areas was assigned as 30-ft. A rectangular spacing for roadways was assigned to be 15-ft.

The size selected for this model represents a comparatively high level of detail which comes at the expense of longer than desirable model solution run times (approximately 4 hours per solution).

Building footprints were included in the model as flow-obstructions, forcing water flowing across the 2-D layer to flow around existing buildings. A surface roughness value of n=0.016 was assigned for roadway surfaces and a surface roughness value of n=0.035 was assigned for all other surfaces.

A 2D outfall boundary line was added to the southern extent of the model in the vicinity of State Street to allow surface flow to freely leave the model. This outfall condition followed the topography as defined by the DEM and prevented the model from simulating flooding that would otherwise have been the result of an implied vertical wall that is automatically imposed around the perimeter of the 2D model area.

4.5 XP-SWMM Model Construction

As previously mentioned, XP-SWMM modeling was completed using rain-on-grid methods. The study area boundary was delineated using 2021 LiDAR DEM obtained from MMSD. A 10-foot grid cell was assigned to the study area.

Pervious and Impervious Surfaces. Impervious surfaces were assigned according to Milwaukee County Planimetric data. All areas not defined as impervious were assumed to be turf grass.

Abstractions and infiltration rates. Initial abstractions for pervious and impervious areas were assigned in the model using the same parameters described in the PC-SWMM model development section. Infiltration was not allowed for areas classified as impervious, but was allowed for pervious areas, again using the same parameters as applied for the PC-SWMM model.

2D Land Use and Roughness Values. The values itemized below were applied as Manning roughness values for the listed ground conditions. Buildings were assigned a variable roughness with lower values at shallower flow depths to allow runoff that originates in a grid cell occupied by a building to leave that cell. Experience has shown that application of a high manning roughness value as might be applied for a traditional hydrology solution to force runoff from upstream areas to flow around the building will result in the trapping of direct rainfall/runoff within the building footprint.

- Buildings (variable)
  - n = 0.01 from 0ft to 0.3ft of depth
  - n = 0.1 at 0.31ft
  - n = 0.3 at 10ft
- Other impervious surfaces n = 0.016 (constant)
- Turf n = 0.03 (constant)
- Gravel n = 0.02 (constant)

1-D pipe network. Only major storm sewer systems were included in the model. This included 92 individual pipes with a total length 44,084 feet, ranging in size from 24" to 10' equivalent diameter. All pipes were assumed to be concrete and were assigned a Manning's n roughness value of 0.013. Data describing these pipes was obtained from the City of Milwaukee GIS database and they are not explicitly documented in this report.

Minor Losses. Minor losses were assigned to the 1D model at structures within storm sewer systems. The following values were used:

- **Entry Loss Coefficients**
  - Storm Sewer:
    - Straight Through = 0.05
    - 45-degree bend = 0.25
    - 90-degree bend = 0.5
- **Exit Loss Coefficient**
  - Storm Sewer:
    - Straight Through = 0.05
    - 45-degree bend = 0.25
    - 90-degree bend = 0.5

1D-2D interface Lines. 1D-2D interface lines were added to the model to ensure that overland flows were captured and routed to storm sewer pipes. These interface lines were added to the model to ensure that in these locations the precise (or rather imprecise) location of an inlet in the model did not unintentionally impact the ability to collect surface flow in the pipe system. It is important to note that for proposed conditions, the use of 1D-2D interface lines implicitly assumes that adequate inlet capacity is available.

Outfall Boundary Condition. A 2D outfall boundary line was added to the entire perimeter of the rain-on-grid model extent. This boundary was divided into three specific areas, two were located in the vicinity of W. Center Street to allow quantification of hydrographs where overflows to Wauwatosa would occur, while the third encompassed the remainder of the watershed perimeter to simply prevent the model from simulating flooding that would otherwise have been the result of an implied vertical wall that is automatically imposed around the perimeter of the 2D model area. The presence of this wall couple potentially force flows to follow improper flow paths, potentially affecting quantification of overflows to Wauwatosa.

The XP-SWMM model assumed a free outfall to the river, for all storm events simulated and for all scenarios evaluated. This condition was applied for both the 1-D and 2-D outfalls.

5 Hydrologic/Hydraulic Model Findings

5.1 Potential Impacts to Structures and Roads

The outputs from the detailed models used in this study were exported into GIS (Geographic Information Systems) to more easily visualize the flood extents. Flood extents will, of course, vary throughout the duration of the selected design storm event. However, one method for interpreting model results is to visualize the *maximum inundation depth* within the design storm. Note that it does not account for *how long* that maximum depth was maintained (it could be that depth for just a few seconds), but it does provide a uniform metric for interpreting model outputs.

To estimate the impacts on structures within the watershed, the maximum inundation depth outputs from the PCSWMM model were compared against digitized building footprints. Each building footprint was buffered by 1-ft (to account for digitization errors) and then intersected with the maximum inundation raster. Buffered-structures that touched 6" of maximum inundation depth were flagged as potentially at risk for flooding. This tool is a good way to quickly visualize flood risks to buildings, but it does have limitations:

- No information was available to determine the use of the structure (e.g. garage, single-family home, commercial property, etc.). All structures are therefore treated equally.
- The building footprints do not have any information about the lowest opening for the structure. Therefore, a survey is required to understand the level of risk to flooding, based on modeling outputs. Buildings that are elevated and do not have low window or door openings will have reduced risk. Survey was not included as part of this project.
- This methodology does not account for the duration of the maximum water depth at a specific location. High water levels will likely do more damage to properties if the levels remain high for a long period of time.
- The analysis was only completed within the PCSWMM study area as shown in **Figure 7.**
- Finally, the level of detail in the modeling (as described in **Section 4.4**) will not account for any small, localized drainage near homes (e.g. a swale, directing flows to backyards). Residents might have implemented local floodproofing measures that are not accounted for in this large-scale model.

To estimate the impacts on roads, a GIS dataset of the road centerlines within the PCSWMM study area was broken into 100-ft segments. The road segments were intersected with the maximum inundation depth, to calculate the average maximum inundation depth for that road segment. Any road segment with an average of 6" or more of water was flagged as potentially impacted. Keeping roads clear of water during a flood event is often referenced when considering emergency vehicle access (e.g. fire trucks, ambulances, etc.). It is recommended that the City consult with local authorities to determine the maximum clearance of the City's emergency vehicles when referring to any mapping products as part of this report.

Finally, this project was intended to reduce the flood risk along the *main channel* of the Schoonmaker Creek (and the portions of the historic creek that are now contained within a pipe network). There are additional storm system improvements, localized grading or property improvements that can also be implemented to reduce flood risk for structures impacted by flooding further away from the main trunkline of the watershed. Recommending these improvements is outside of the scope of this study, but the City may pursue these improvements in future as needed.

5.2 Existing Conditions

Figures 12 through **16** present the maximum flood inundation depths for existing conditions under 1-yr 24-hr conditions through 100-yr 24-hr conditions. **Figure 17** shows the extents of roads and buildings that might flood under 100-yr conditions. An estimated 110 buildings and 4.6 miles of street within Wauwatosa could be flooded by more than six inches under 100-yr 24-hour conditions. *Refer to **Section 5.1** for more details on potentially impacted structures and roads*.

5.3 Conceptual Improvements North of W. Lloyd St

As previously indicated, and supported by the results shown in **Figure 16**, the City of Wauwatosa reports that Schoonmaker Creek watershed is subject to frequent and widespread flooding. Most (but not all) of the flooding in the watershed occurs upstream from W Lloyd Street; however, this study was completed to primarily evaluate two selected options which will provide additional conveyance of stormwater flows for areas south of Lloyd Street. These improvements pre-supposed that systemic improvements to the drainage system serving areas north of W Lloyd Street would be installed and would connect to either of these alternatives. Evaluation of the systemic improvements north of W Lloyd Street were not specifically part of the scope of this study; however, some conceptual evaluations were necessary to understand the ramifications of upstream improvements on the two options evaluated by this study.

Through a trial-and-error process, existing storm pipes along the existing trunk storm sewer system north of W. Lloyd Street had their capacities increased until flooding conditions in the upper watershed were substantially reduced. This was a qualitative assessment based on the reduction in the number of buildings flooded and the occurrences of roadway flooding outside the rights-of-way under 100-yr 24-hr rainfall conditions. When existing pipes along the trunk line had their capacities increased by a factor of four (pipes in the model were assigned a barrel multiplier or 4) it was felt that adequate reduction in flooding as depicted by modeling had been achieved. **Figure 11** identifies the existing pipes that were increased in capacity in this manner (conceptual trunk line improvements). Also indicated on **Figure 11** are eleven (11) locations where flow comparisons have been made.

Table 5-1 below presents a summary of peak discharge at each indicated location. Note that values for locations 1 through 6 represent the summation of surface flows across the entire indicated cross-section. Flows are from north to south. Locations 7 and 8 present cumulative flows in the creek at these locations.

Table 5-1. Existing conditions & with improvements north of W Lloyd St. Modeled peak discharge rate at select locations. *Peak discharge reported for existing conditions and with conceptual trunkline improvements north of Lloyd St. The location numbers correlate to the IDs shown in **Figure 11** in the main report. Note this table does not include any improvements south of W Lloyd Street.*

Location		Condition	Peak Discharge Rate						
			1-yr 24-hr	2-yr 24-hr	5-yr 24-hr	10-yr 24-hr	25-yr 24-hr	50-yr 24-hr	100-yr 24-hr
1	**Clarke St**	Existing	12	37	118	200	318	423	545
		Improved N/Lloyd	12	36	113	199	317	422	549
2	**Wright St**	Existing	1	15	115	217	404	573	725
		Improved N/Lloyd	1	6	51	101	186	269	386
3	**Meinecke Ave**	Existing	0	3	126	277	542	759	1054
		Improved N/Lloyd	0	1	14	44	122	199	289
4	**North Ave**	Existing	0	1	21	224	511	819	1157
		Improved N/Lloyd	0	0	20	44	91	142	212
5	**Garfield Ave**	Existing	0	0	4	47	482	872	1267
		Improved N/Lloyd	0	0	3	13	52	89	150
6	**Lloyd St**	Existing	3	7	24	71	514	927	1422
		Improved N/Lloyd	3	7	12	25	88	159	252
7	**Schoonmaker Creek Downstream of W. Lloyd St**	Existing	421	446	484	537	1007	1446	1838
		Improved N/Lloyd	442	524	658	803	1125	1384	1576
8	**Schoonmaker Creek Downstream of Revere Ave**	Existing	552	598	654	705	1153	1602	2173
		Improved N/Lloyd	538	653	781	924	1279	1673	1908

While the data shows that flows under improved conditions under 10-yr and larger events for locations 1 and 2 are largely unchanged, this is due to the limited nature of the conceptual improvements evaluated in this study. When improvements north of W Lloyd St (in the upper watershed) are actually designed, these flows are expected to be substantially reduced. Cumulative flows for areas 3 through 6 are substantially reduced.

Not surprisingly flows at locations 7 and 8 show trending increases in flows in Schoonmaker Creek. While not reported in this table, these increases are observed along the entire length of the open channel portion of Schoonmaker Creek. Surprisingly, given the reductions in flows in the upper portion of the watershed, the increases in flow in the creek are less than may have been expected, especially under 100-yr conditions where peak flows in the creek are predicted to slightly decrease. This is due in large part to the timing of the delivery of peak flows to the creek under existing and improved conditions. Regardless of magnitude, increases in flows to Schoonmaker Creek are not intended and will be prevented though the implementation of either the tunnel or improved storm sewer options.

This report does not include maps of flood inundation for this scenario as it is entirely hypothetical and intended to support the evaluation of the tunnel and improved storm sewer options.

5.4 Tunnel (Option A) and Storm Sewer (Option B) Improved Conditions

Figures 18 through 22 present flood inundation extents for improved conditions inclusive of the conceptual improvements north of W. Lloyd Street and construction of a new 10-ft diameter storm sewer tunnel from W. Lloyd Street to the Menomonee River (Option A). Figures depict flooding extents for the 1-yr 24-hr conditions through 100-yr 24-hr condition. **Figure 23** shows the extents of roads and buildings flooded under 100-yr conditions. Flooding is substantially reduced; now only 5 structures and 2.3 miles of street within Wauwatosa are expected to be flooded by more than six inches under 100-yr 24-hour conditions. *Refer to **Section 5.1** for more details on potentially impacted structures and roads. Any remaining structures that could be impacted by flooding will be addressed in the final design phase.*

Figures 24 through 28 present 1-yr through 100-yr flood inundation extents for improved conditions throughout the watershed inclusive of the conceptual improvements north of W. Lloyd Street and construction of a new large box storm under Martha Washington Drive from W. Lloyd Street to the Menomonee River (**Option B**). From W. Lloyd Street to Milwaukee Avenue the storm sewer has been evaluated as a 6-ft x 12-ft RCP box. Downstream from Milwaukee Avenue to just south of State Street the storm sewer has been evaluated as a 6-ft x 16-ft RCP box.

Figure 29 shows the extents of roads and buildings flooded under 100-yr conditions. Flooding is also substantially reduced for this option. Only 3 buildings and 1.9 miles of street within Wauwatosa are expected to be flooded by more than six inches under 100-yr 24-hour conditions. *Refer to **Section 5.1** for more details on potentially impacted structures and roads. Any remaining structures that could be impacted by flooding will be addressed in the final design phase.*

Regardless of the selected option, flows directed to the open channel portion of Schoonmaker Creek will be reduced by 35% or more depending on the specific location and storm event. **Table 5-2** below presents a summary of peak discharge at each indicated location.

Table 5-2. Proposed conditions. Modeled peak discharge rates at select locations.

Peak discharge reported for existing and proposed conditions. Note both Option A and option B were modeled with conceptual trunkline improvements north of W Lloyd St. The location numbers correlate to the IDs shown in Figure 11 in the main report.

Location		Condition	Peak Discharge Rate (cfs)						
			1-yr 24-hr	2-yr 24-hr	5-yr 24-hr	10-yr 24-hr	25-yr 24-hr	50-yr 24-hr	100-yr 24-hr
1	**Clarke St**	Existing	12	37	118	200	318	423	545
		Option A	12	36	113	205	317	422	550
		Option B	12	36	112	200	314	419	554
2	**Wright St**	Existing	1	15	115	217	404	573	725
		Option A	1	6	49	99	183	270	390
		Option B	1	6	48	104	188	275	396
3	**Meinecke Ave**	Existing	0	3	126	277	542	759	1054
		Option A	0	1	14	44	120	204	304
		Option B	0	1	15	45	120	209	292
4	**North Ave**	Existing	0	1	21	224	511	819	1157
		Option A	0	0	20	44	89	145	213
		Option B	0	0	20	44	90	141	214
5	**Garfield Ave**	Existing	0	0	4	47	482	872	1267
		Option A	0	0	3	13	52	91	145
		Option B	0	0	3	13	50	93	147
6	**Lloyd St**	Existing	3	7	24	71	514	927	1422
		Option A	3	7	12	24	76	145	223
		Option B	3	7	12	24	76	140	225
7	**Schoonmaker Creek Downstream of W. Lloyd St**	Existing	421	446	484	537	1007	1446	1838
		Option A	131	148	172	191	218	263	326
		Option B	124	152	198	237	296	426	628
8	**Schoonmaker Creek Downstream of Revere Ave**	Existing	552	598	654	705	1153	1602	2173
		Option A	235	261	301	343	425	503	602
		Option B	130	159	205	246	311	460	675

Location		Condition	Peak Discharge Rate (cfs)						
			1-yr 24-hr	2-yr 24-hr	5-yr 24-hr	10-yr 24-hr	25-yr 24-hr	50-yr 24-hr	100-yr 24-hr
9	**Schoonmaker Creek Upstream of Washington Cir**	Existing	688	746	807	865	1279	1744	2146
		Option A	237	263	322	446	578	666	769
		Option B	131	159	206	243	353	550	642
10	**Schoonmaker Creek Upstream of Upper Pkwy N.**	Existing	527	599	684	756	1273	1704	2281
		Option A	269	300	358	414	503	612	743
		Option B	148	181	239	287	364	448	549
11	**Schoonmaker Creek Upstream of W. Washington Blvd**	Existing	536	616	738	832	1223	1644	2382
		Option A	283	316	378	442	536	666	818
		Option B	154	186	245	295	382	486	806
12	**Schoonmaker Creek Upstream of Milwaukee Avenue**	Existing	650	860	975	1087	1561	2081	2645
		Option A	311	350	433	695	860	950	1174
		Option B	156	189	250	304	506	1023	1402
13	**Martha Washington Dr**	Existing	2	5	78	195	735	1257	1880
		Option A	2	3	5	11	63	138	435
		Option B	1	1	2	3	6	10	40
14	**Martin Dr**	Existing	0	76	190	310	800	1500	2200
		Option A	1	2	7	70	180	260	600
		Option B	0	0	0	1	28	151	338
15	**State Street**	Existing	0	0	0	4	247	685	1317
		Option A	0	0	0	0	0	2	36
		Option B	0	0	0	0	0	4	9

- Data within rows 1-6, 13, 14, 15 report cumulative surface flows at these locations across the cross-section line depicted on Figure 11 (flows in 1D storm sewer pipes not included)
- Data within rows 7, 8, 9, 10, 11, 12 report total flows in the open channel portion of Schoonmaker Creek (sum of 1D and 2D layers)
- Data within row 14 is approximate based on a visual interpretation of model output. The 2D layer of the PC-SWMM model exhibited instability in this locations for storms 10-yr severity and larger.

6 Desktop Analysis

This project is primarily driven by the need to improve storm water system capacity *south* of W Lloyd St. However, there are still stormwater capacity concerns *north* of W Lloyd St and other utilities in this area (sanitary and potable water) are in need of repairs/upsizing. Therefore, a desktop analysis of the area *north* of W Lloyd St was completed to have a comprehensive understanding of all the utilities improvements in the project limits.

The desktop analysis covered a large area, and therefore was broken into street segments, roughly on a block-by-block basis. A large table, showing the approximate length of utilities to be replaced as well as associated costs with each block segment is included in the Appendix. To help the reader understand this table, a summary of the desktop analysis and methodology used for the evaluation is provided in this chapter. Small screen captures of the large format table are included for reference; however the complete table in the appendix should be referenced when considering improvements north of W Lloyd St.

6.1 Extents

The general extents of the desktop analysis were defined by the following. Refer to the attached table and mapping located in the Appendix and Figures for specific locations evaluated.

- South – West Lloyd Street
- North – West Center Street
- West – North 76th Street
- East – North 61st Street

6.2 Methodology

Improvements to the sanitary sewer are based on the findings in the 2011 study titled *'Investigation and Analysis of Sanitary Sewersheds WA4001, WA4004, WA4035'* by Brown and Caldwell. It should be noted that the sanitary sewer upsizing included in the 2011 study included recommendations for MMSD MIS sewer upsizing which affected the recommended upsizing for City sanitary and sewer. Water main improvements are based on a preliminary design improvement plan provided by the City of Wauwatosa.

Although not originally intended to be completed with the desktop analysis, MSA completed limited hydrologic/hydraulic modeling within the desktop analysis extents to determine preliminary upsizing of the storm sewer trunkline extending north from the extents of the Martha Washington Drive improvements. Based on trunk line improvements, the City directed MSA to include storm sewer improvements for branch lines with assumptions noted below.

Below is a summary of the desktop analysis upsizing overview as detailed in the spreadsheet included in Appendix. These calculations were used as a basis to the preliminary cost estimates provided later in the report.

The studies identified above were used as a basis for selecting project upsizing whether that would involve water, sanitary or storm sewer. Sanitary sewer project identified in the B&C study, water main identified the City's preliminary design or storm sewer identified by MSA's hydrology/hydraulic modeling are identified in **green** within the table. For any utility upgrades identified as described above, remaining utilities within those street corridors were replaced or upsized and identified as **orange** in the table. Upsizing all utilities are based on the following criteria:

6.3 Storm Sewer

- Storm sewer identified in **green** is based on preliminary hydraulic analysis completed by MSA.
- Storm sewer upsizing in **orange** was not based on hydraulic modeling however based on direction from the City for upsizing additional storm sewer and appurtenances
- Current storm sewers were upsized by a factor of 2.5 x existing pipe capacity (not accounting for pipe slopes)
- Existing storm inlets are upsized to double inlets and the number of double inlets are based on a factor of 4 x the number of existing inlets
- Stormwater improvements north of Lloyd used for the cost estimate are shown in **Figure 30**.

			Existing/Proposed																	
			City Sanitary Sewer				Potable Water								Storm Sewer					
Street Name	Start of Project	End of Project	Type	Length	MH	Laterals	Current Diam	Planned Upsized Diam	Type	Length	Hydrants	Valves	Curb Stops	Laterals	Current Diam	Planned Upsized Diam	Main Type	Main Length	MH	Inlets
W Garfield Ave	N 64th St	N 65th St	PVC	234.7	2	2	6"	8"	Not Listed	379.7	0	2	3	3	24"	36"	Clay	325	2	2
															24"	36"	Conc	26.2	1	0
W Garfield Ave	N 65th St	N 66th St	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24"		Conc	116	2	4
															24"	144" x 72"	RCP	376.3	2	0
W Garfield Ave	N 66th St	N 67th St	Clay	231	4	2	6"	8"	CI	287.79	0	2	2	2	54"	144" x 72"	RCP Main	390	0	4
			PVC	26.3	2	0									66"		Conc Main	200	0	0
W North Ave	N 61st St	N 62nd St	Clay	300.4	3	1	16"	16"	MKE cnty Main	300	0	0	1	1 (NC)	21"	30"	RCP Main	296.5	3	2
W North Ave	N 62nd St	N 63rd St	Clay	299.4	2	5	12"	16"	DI	326.09	0	1	6	6	21"	30"	RCP Main	299	4	2
							16"		MKE cnty Main	300	0	0	0	0						

6.4 Water Main

- Water main identified in **green** is based on the preliminary water main improvements prepared by the City of Wauwatosa.
- Water main upsizing in **orange** was based on upsizing water main less than 8" in diameter to a minimum of 8" diameter

- Water main identified within the table with a **red** dashed line indicates that due to planned large diameter storm sewer within the road corridor, dual water mains will be required to avoid lateral conflicts
- Water improvements north of Lloyd used for the cost estimate are shown in **Figure 31**.

Street Name	Start of Project	End of Project	City Sanitary Sewer Type	Length	MH	Laterals
N 66th St	W North Ave	W Garfield Ave	Clay	416.8	2	17
			PVC	203.9	2	8
N 65th St	W Wright St	W Meinecke Ave	PVC	663.2	2	30
N 65th St	W Meinecke Ave	W North Ave	PVC	331	1	14
			PVC	334.3	1	9
N 65th St	W North Ave	W Garfield Ave	Clay	618.3	4	25
N 65th St	W Garfield Ave	W Lloyd Ave	Clay	735.5	4	29
N 64th St	W Clarke St	W Wright St	PVC	630.1	7	20
			Clay	159.1	1	6
N 64th St	W Wright St	W Meinecke Ave	Clay	663.3	3	30

Street Name	Start of Project	End of Project	Potable Water Current Diam	Planned Upsized Diam	Type	Length	Hydrants	Valves	Curb Stops	Laterals
N 66th St	W North Ave	W Garfield Ave	6"	8"	Main	631.5	3	5	24	24
N 65th St	W Wright St	W Meinecke Ave	6"	8"	Main	658.87	2	3	30	30
N 65th St	W Meinecke Ave	W North Ave	6"	8"	Main	640.44	2	5	24	24
N 65th St	W North Ave	W Garfield Ave	6"	8"	Main	645.58	2	5	24	24
N 65th St	W Garfield Ave	W Lloyd Ave	6"	8"	Main	721.34	2	3	28	28
N 64th St	W Clarke St	W Wright St	6"	24"	CI Main	603.36	0	1	25	25
			8"		DI Main	50	2	3	1	1
			16"		CI Main	653.01	0	3	1	1
N 64th St	W Wright St	W Meinecke Ave	6"		CI Main	669.77	2		30	30
			12"	24"	Monocast Main	670	0	1	0	0

Street Name	Start of Project	End of Project	Storm Sewer Current Diam	Planned Upsized Diam	Main Type	Main Length	MH	Inlets
N 66th St	W North Ave	W Garfield Ave	6" [partly obscured]	54"	RCP Main	638.4	4	3
N 65th St	W Wright St	W Meinecke Ave	4" [partly obscured]	36"	RCP Main	596	3	4
N 65th St	W Meinecke Ave	W North Ave	4" [partly obscured]	36"	RCP Main	470.6	2	4
			0" [partly obscured]	48"	RCP Main	139	1	0
N 65th St	W North Ave	W Garfield Ave	6" [partly obscured]	54"	RCP Main	642.1	6	2
N 65th St	W Garfield Ave	W Lloyd Ave	6" [partly obscured]	144" x 72"	RCP Main	680	4	2
N 64th St	W Clarke St	W Wright St	2" [partly obscured]	18"	RCP Main	228.9	2	4
N 64th St	W Wright St	W Meinecke Ave						3

6.5 Sanitary Sewer

- Sanitary sewer main identified in **green** is based on the findings from the 2011 Brown and Caldwell Study.
- Sanitary sewer main identified within the table with a **red** dashed line indicates that due to planned large diameter storm sewer within the road corridor, dual sanitary sewer will be required to avoid lateral conflicts.
- Sanitary improvements north of Lloyd used for the cost estimate are shown in **Figure 32**.

Street Name	Start of Project	End of Project	City Sanitary Sewer Current Diam	Planned Upsized Diam	Type	Length	MH	Laterals
N 66th St	W North Ave	W Garfield Ave	8"	8"	Clay	416.8	2	17
			8"	8"	PVC	203.9	2	8
N 65th St	W Wright St	W Meinecke Ave	10"	12"	PVC	663.2	2	30
N 65th St	W Meinecke Ave	W North Ave	10"	12"	PVC	331	1	14
			12"	12"	PVC	334.3	1	9
N 65th St	W North Ave	W Garfield Ave	8"	10"	Clay	618.3	4	25
N 65th St	W Garfield Ave	W Lloyd Ave	8"	10"	Clay	735.5	4	29
N 64th St	W Clarke St	W Wright St	8"	8"	PVC	630.1	7	20
			8"	8"	Clay	159.1	1	6
N 64th St	W Wright St	W Meinecke Ave	8"	10"	Clay	663.3	3	30

6.6 Street Improvements

- Street corridor values were based not based on surveyed or GIS data however were based on WISLR data provided by WDOT.
  - Street lengths and pavement widths based on WISLR data (pavement widths assume widths of 30" curb and gutter)

  - Curb and gutter lengths are not based on measured lengths and were calculated by doubling the street lengths (curb and gutter on 2 sides of street)
  - Sidewalk areas are not based on measured areas and were calculated using street lengths and an assumed width of 5' average per sidewalk
  - Existing street light quantities are based on City of Wauwatosa GIS mapped locations
- **Figure 33** shows all the proposed improvement areas, indicating which utility would drive the street reconstruction effort.

Street Name	Start of Project	End of Project	Streets				
			Section Length (ft)	Pavement Width (ft)	C&G (LF)	Sidewalk (sf)	Street Lights
N 64th St	W Wright St	W Meinecke Ave	528	20	1056	5280	3
N 64th St	W Meinecke Ave	W North Ave	581	20	1162	5810	4
N 64th St	W North Ave	W Garfield Ave	686	20	1372	6860	4
N 64th St	W Garfield Ave	W Lloyd Ave	739	20	1478	7390	3
N 63rd St	W Meinecke Ave	W North Ave	686	20	1372	6860	4
N 63rd St	W North Ave	W Garfield Ave	686	20	1372	6860	4

7 Cost Opinions

Cost opinions were completed for Options A & B, inclusive of the Desktop Analysis north of W. Lloyd Street. The following tables 7-1 through 7-4 summarize the overall costs of individual options as well as overall project costs. Full details can be found in the Appendix. The following assumptions were used in cost estimating

Sanitary Sewer: Costs include upsized City sewers and structures, upsized MIS segments, and storage facilities from the 2011 Brown and Caldwell study, new laterals to the ROW for properties along a new main, and second parallel mains if needed to accommodate larger storm sewers (sewer service from either side of large diameter storm sewers).

Water Main: Costs include upsized City mains from the City's Water Improvements (provided by the City), new services to the ROW for properties along a new main, new hydrants and valves, and second mains along a block if needed to accommodate larger storm sewers.

Storm Sewer: Costs include upsized City sewers and structures from hydrologic and hydraulic modeling by MSA, new storm connections for properties along any new main, foundation drain disconnect and sump pump allowance for properties along any new storm sewer.

Street, Curb, Sidewalks: Costs are based on the anticipated impact of the proposed improvements on a block-by-block basis. Costs assume full replacement of all improvements including curb and sidewalk within the right-of-way rather than attempting to identify spot repairs.

Street Lighting, Communications, and Street Trees: Costs are based on 1:1 replacement of poles and wiring on all blocks where new mainline sanitary, storm, or water main is installed. City street tree impacts were replaced on 1:1 basis on improvements proposed in the terrace for any of the utilities or anticipated impact from construction operations.

The following Table 7-1 represents the cost opinion of Option A Tunnel. Additionally included is the cost of reconstructing the Martha Washington Drive corridor including water and sanitary sewer to make a comparable analysis to Option B. A detailed breakdown of costs can be found in **Appendix E**.

Table 7-1. Option A: Tunnel Preliminary Estimate of Costs

Note that this cost estimate includes the reconstruction of the Martha Washington corridor, included within Option B

ITEM DESCRIPTION	TOTAL PRICE
Tunnel Alignment 1	$48,500,166
SUBTOTAL	**$48,500,166**
West Lloyd St (66th St to 65th St)	$1,158,183
Martha Washington Dr (Revere Ave to Washington Circle)	$1,094,833
Martha Washington Dr (Washington Circle to Upper Parkway N)	$643,328
Martha Washington Dr (Upper Parkway N to W Washington Blvd)	$1,977,298
Martha Washington Dr (W Washington Blvd to Washington Cir)	$1,927,719
Martha Washington Dr (Washington Cir to Milwaukee Ave)	$889,076
Martha Washington Dr (Milwaukee Ave to Martin Dr)	$3,736,105
Martin Ave (62nd St to 60th St)	$1,283,096
60th Street (Martin Ave to State Street)	$1,140,387
West State Street	$1,258,793
SUBTOTAL	**$15,110,000**
OVERALL TOTAL (TUNNEL & MARTHA WASHINGTON)	**$63,620,000**

The following Table 7-2 represents the cost opinion of Option B Storm Sewer including water, storm and sanitary sewer. A detailed breakdown of costs can be found in **Appendix F**.

Table 7-2. Option B: Storm Sewer within Martha Washington Blvd Preliminary Estimate of Costs

ITEM DESCRIPTION	TOTAL PRICE
West Lloyd St (66th St to 65th St)	$2,448,962
Martha Washington Dr (Revere Ave to Washington Circle)	$2,507,636
Martha Washington Dr (Washington Circle to Upper Parkway N)	$1,430,426
Martha Washington Dr (Upper Parkway N to W Washington Blvd)	$4,622,092
Martha Washington Dr (W Washington Blvd to Washington Cir)	$4,298,918
Martha Washington Dr (Washington Cir to Milwaukee Ave)	$1,826,833
Martha Washington Dr (Milwaukee Ave to Martin Dr)	$9,252,480
Martin Ave (62nd St to 60th St)	$2,760,024
60th Street (Martin Ave to State Street)	$5,951,261
West State Street	$3,750,346
TOTAL	**$38,850,000**

The following Table 7-3 represents the cost opinion of the Desktop Analysis north of W Lloyd Street including water, sanitary and sewer upsizing. Due to the preliminary level of analysis, a contingency range of 20% to 40% was used for estimating purposes. A detailed breakdown of costs can be found in **Appendix G**.

Table 7-3. Desktop Analysis North of W. Lloyd St Preliminary Estimate of Costs

ITEM DESCRIPTION	TOTAL PRICE
Water Main	$14,490,735
Storm Sewer	$30,334,500
Sanitary Sewer	$15,425,325
Street & Miscellaneous	$27,101,314
SUBTOTAL	**$87,351,874**
Contingency (20-40%)	**$17,470,375 to $34,490,750**
Engineering (10%)	**$10,482,225 to $12,229,262**
TOTAL	**$115,000,000 to 135,000,000**

A summary was generated for each option to provide an overall cost estimate of each option including the desktop analysis to provide an overall project budget based on 2024 unit prices. Additionally, Option B Storm Sewer was further broken down by utility to provide an estimate of funding requirements for the City.

Table 7-4. Overall Cost Comparison of Option A and Option B, including improvements north of Lloyd Street from Desktop Analysis
Costs are separated by utility type for Option B.

Option A: Tunnel, Desktop Analysis, and Martha Washington corridor to State St	**$180,000,000 to $200,000,000**
Option B: Storm Sewer and Desktop Analysis	**$155,000,000 to $175,000,000**
***Option B**: Water*	***$23,000,000 to $26,000,000***
***Option B**: Storm*	***$65,000,000 to $71,000,000***
***Option B**: Sanitary*	***$23,000,000 to $27,000,000***
***Option B**: Street*	***$46,000,000 to $53,000,000***

8 Route Alternatives Matrix

8.1 Matrix Development Methodology

MSA developed a Route Alternatives Matrix that independently compared 26 factors between the Tunnel (**Option A**) and the Storm Sewer (**Option B**), as shown in **Table 8-1**. Each factor was evaluated for both options and scored with a value of -1, 0 or 1 and then assigned a weight between 1 and 5 depending on the significance or insignificance of the factor on the impact to the project. Overall scores were generated for each option to determine a value with the high score considered the favorable option based on these scoring criteria and weighted values. This matrix is a tool for the City of Wauwatosa to use in decision making for evaluating a path forward. Below is a summary of the scoring criteria, factors and overall results. The complete Route Alternatives Matrix along with justification and explanations used for scoring of each option can be found in the **Appendix I**. Below is a summary of the scoring criteria.

LEGEND	
WEIGHT SYSTEM ASSIGED TO FACTORS	
DESCRIPTION	**WEIGHT**
Minimal Significance	**1**
Moderately Low Significance	**2**
Moderate Significance	**3**
Moderately High Significance	**4**
High Significance	**5**
SCORE SYSTEM ASSIGED TO OPTIONS FOR EACH FACTOR	
DESCRIPTION	**SCORE**
Option provides less benefit or introduces more impediments than other option	**-1**
Option does not provide benefit over other option	**0**
Option provides more benefit or introduces less impediments than the other option	**1**
SCORING UNDERSTANDING	
1. Highest total weighted score indicates recommended option **2. A maximum weighted score of 89 indicates one option was more desirable over the other in every category** **3. A minimum weighted score of -89 indicates one option was less desirable compared to the other in every category** **4. A total weighted score of zero indicates that both options are comparatively equal in every category**	
SCORING SUMMARY	
Option A: Tunnel Total Weighted Score = -1 **Option B: Storm Sewer Total Weighted Score = 11** **Weighted Total Scoring results in recommended option being Option B Storm Sewer (11 vs -1)**	

Table 8-1. Factors included in the evaluation of each Option with assigned weights.

#	FACTOR	WEIGHTED VALUE
1	Impacts to residential properties	5
2	Political and community support of project	5
3	Necessity to obtain temporary / permanent easements	5
4	Impacts / coordination with railroad	5
5	Complexity of permitting	5
6	Preliminary cost determination	5
7	Option "solves" the flooding problem for the City	5
8	Does option require city to enter into agreement with property owners for long term liability	5
9	Impacts to commercial/business properties	4
10	Complexity of construction	4
11	Impacts to City infrastructure	4
12	Impacts to MIS/MMSD infrastructure	4
13	Additional long-term improvements needed from City of Milwaukee to address flooding	4
14	Impacts to local traffic during construction	3
15	Number of trees impacted due to construction within "Tree City"	3
16	Option allows for additional concurrent improvements (ie street, sanitary, water, sidewalk, etc.) to be constructed	3
17	Level of city effort required to deliver project	3
18	Duration of project and phasing required	3
19	Potential for state or federal funding availability	3
20	Number of intersections impacted	2
21	Potential for bedrock to impact construction	2
22	Contribution of cost from MMSD	2
23	Property acquisition required for option	2
24	Potential archaeological impacts	1
25	Potential endangered resources impacted	1
26	Potential wetland impacts	1

8.2 Results of Evaluation Matrix

The scoring between **Options A** and **B** is shown below. The overall weighted score could range between -89 and 8995 with minimum and maximum scores indicating that one option was selected over the other in every category. A score of zero would indicate that both options were equal in every category. In the case of this evaluation matrix, the following results of the overall weighted scores were found with the option having the highest weighted score being Option B, the Storm Sewer. As stated earlier, this score is not the defining opinion for the City to consider however is a tool to independently compare the options based on the qualitative criteria evaluated and assigned weights.

Table 8-2. Results of Evaluation Matrix Scoring for Options A and B.

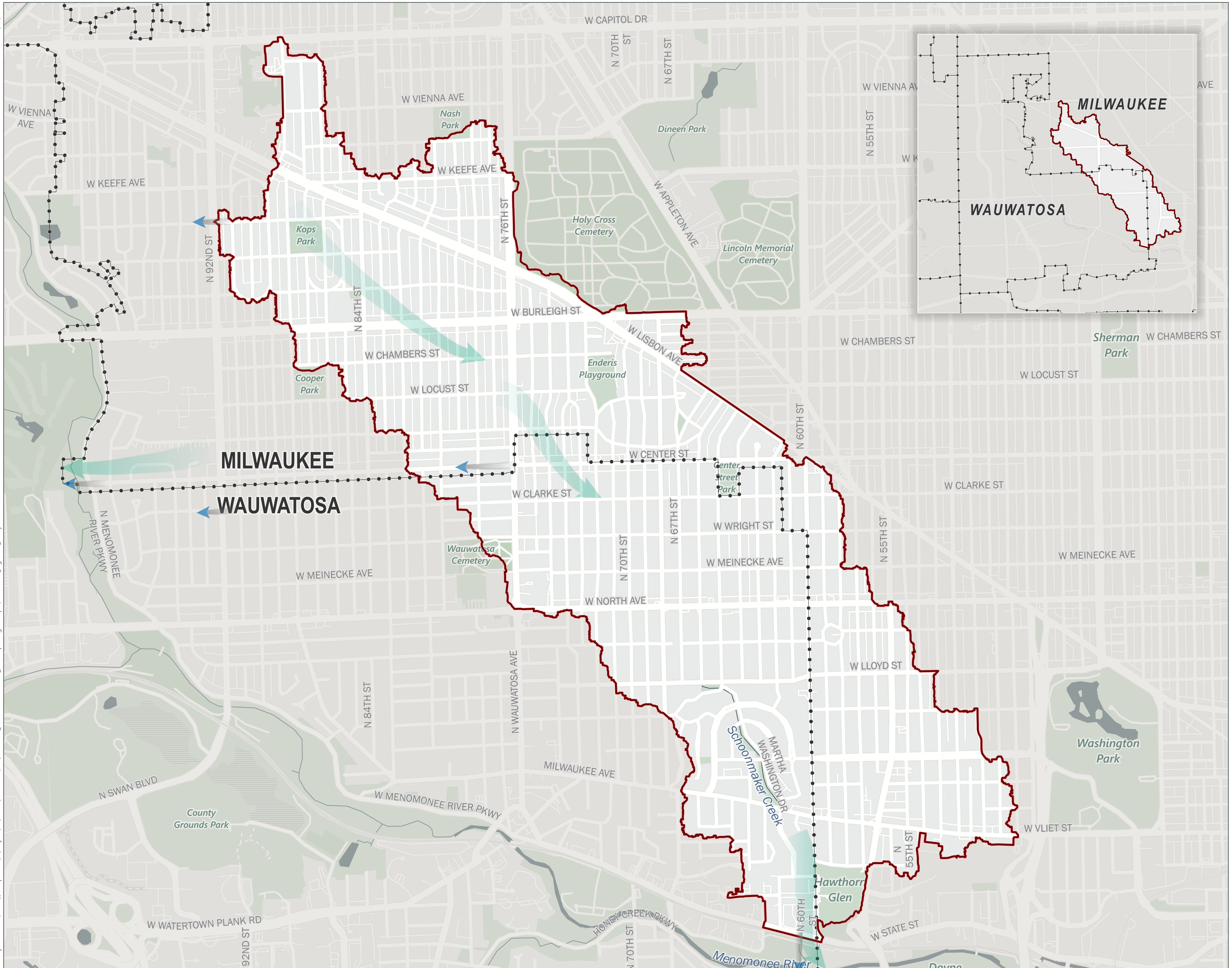
Overall Score	Option A Tunnel	Option B Storm Sewer
-89 to 89	**-1**	**11**

Figures

Study Area

Figure 1

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Study Area

Municipal Boundary

Overland Flow Direction

Piped Flow Direction

Data Sources:
Municipal Boundaries: Milwaukee County
Milwaukee County Land Info, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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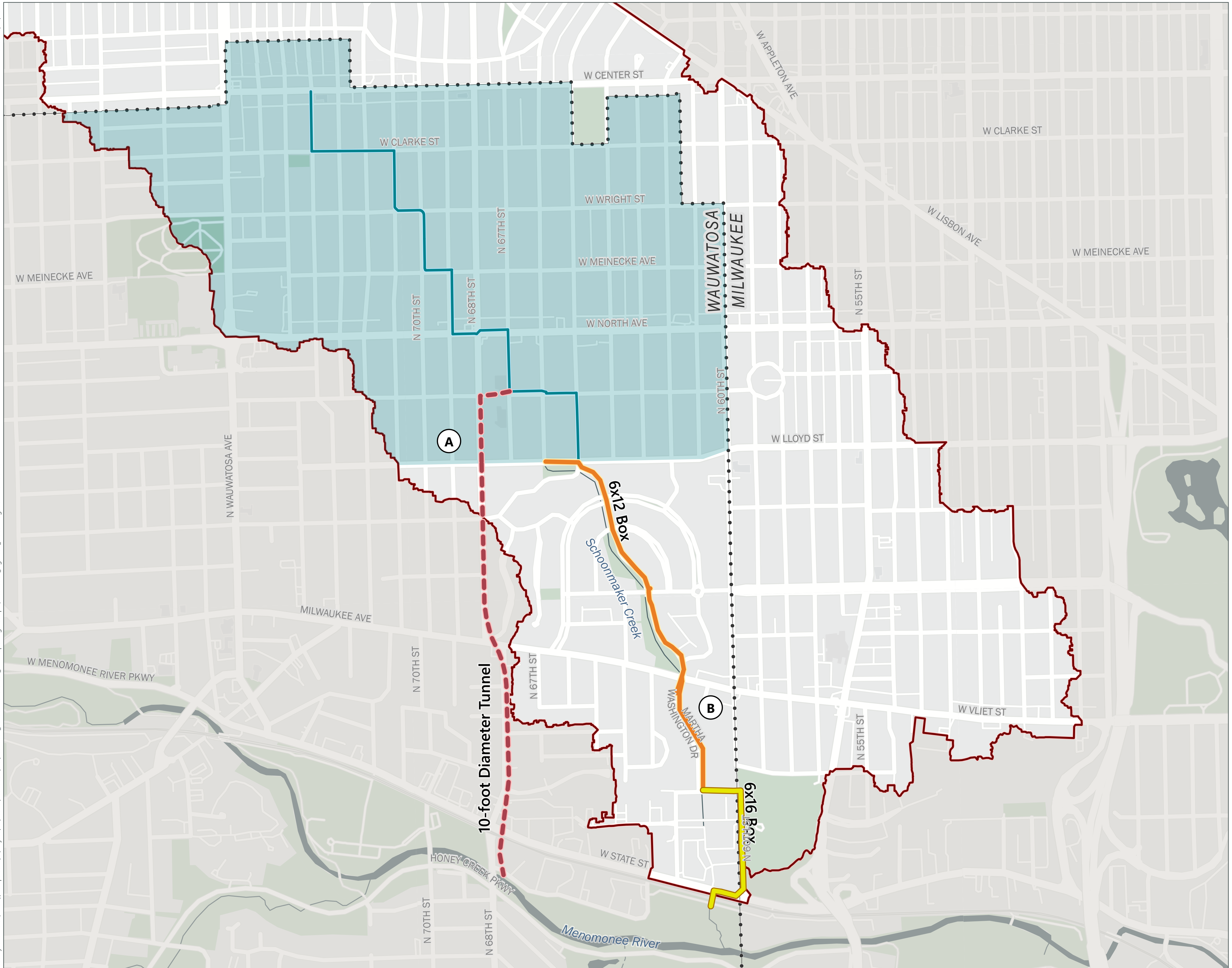
Flood Mitigation Options

Figure 2

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



- Study Area
- Municipal Boundary
- Option A: Deep Tunnel
- Option B: Storm System (6x12 Box)
- Option B: Storm System (6x16 Box)
- Storm System north of Lloyd St

Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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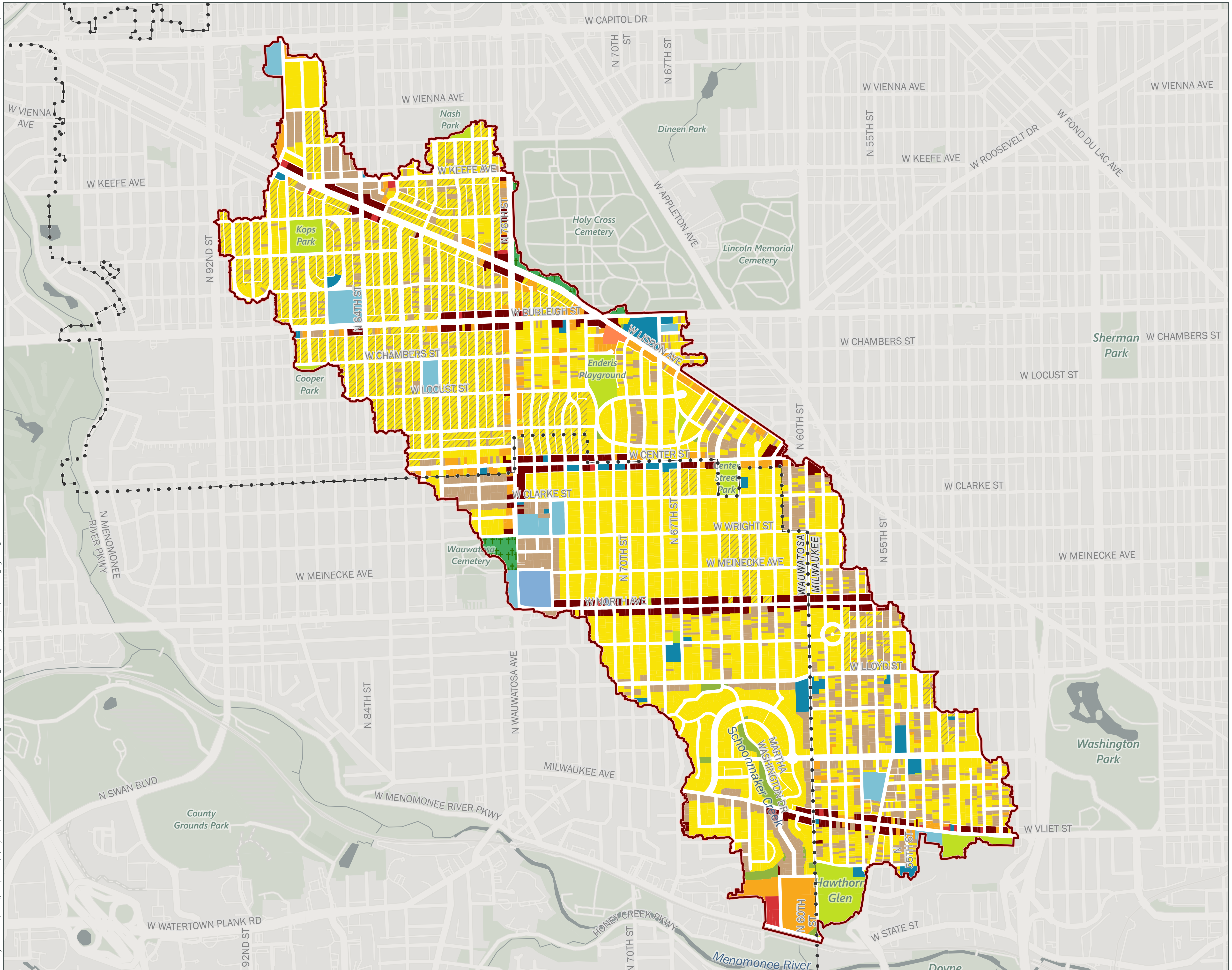
Print Date: 9/28/2024

Land Use

Figure 3

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Study Area

Municipal Boundary

Land Use

- Cemetery
- Commercial, Downtown
- Commercial, Shopping Center
- Commercial, Strip
- Industrial, Light
- Institutional, Misc
- Institutional, School
- Hospital
- Open Space
- Park
- Residential, Suburban
- Residential, High Density without alley
- Residential, High Density with alley
- Residential, Duplex
- Residential, MultiFamily
- Railroad

Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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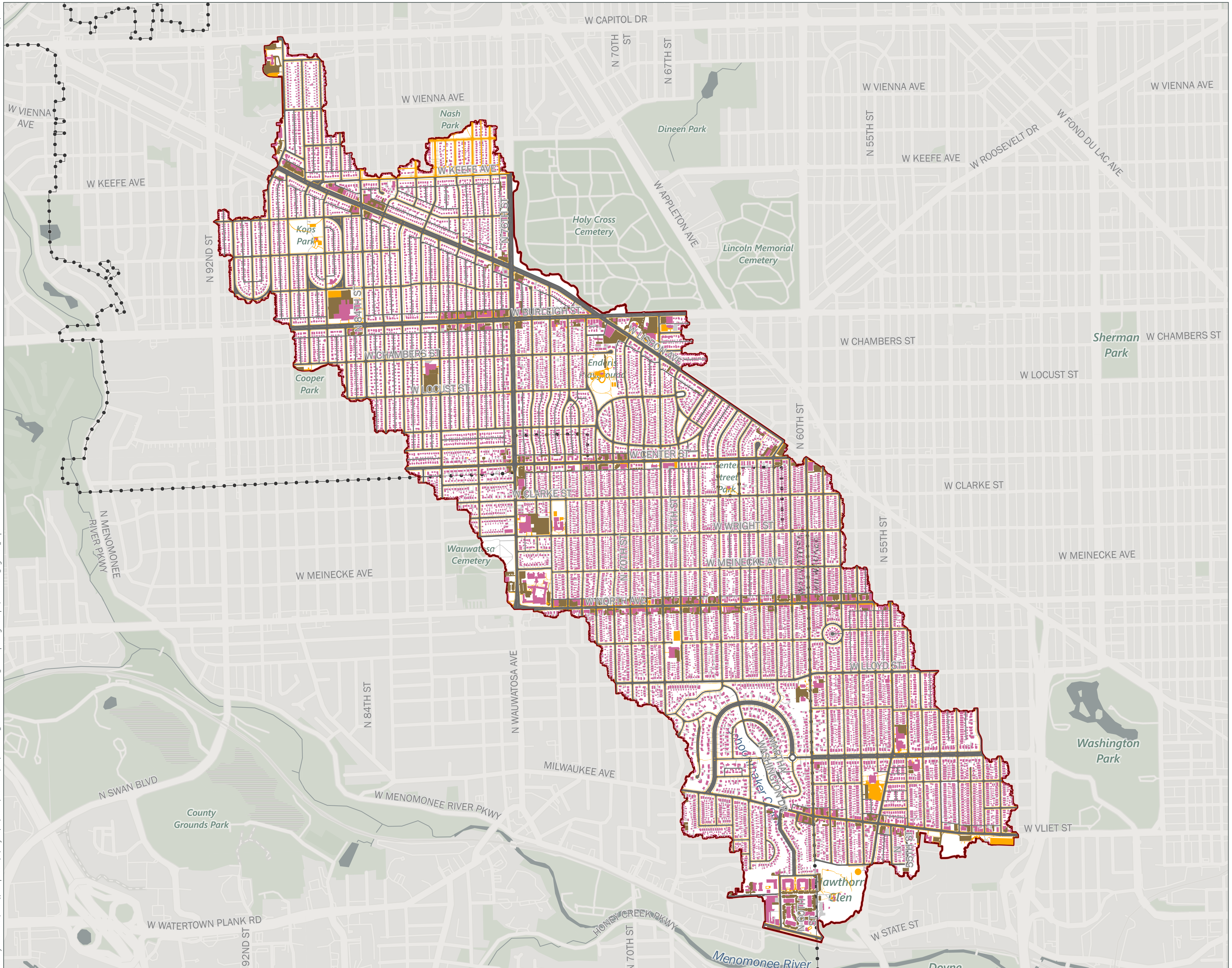

Impervious Area

Figure 4

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

Study Area
Municipal Boundary

Impervious Type

- Street
- Driveway
- Gravel Driveway
- Roof
- Gravel Parking
- Parking
- Sidewalk
- Water

Data Sources:
Municipal Boundaries: Milwaukee County
Impervious Area: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by

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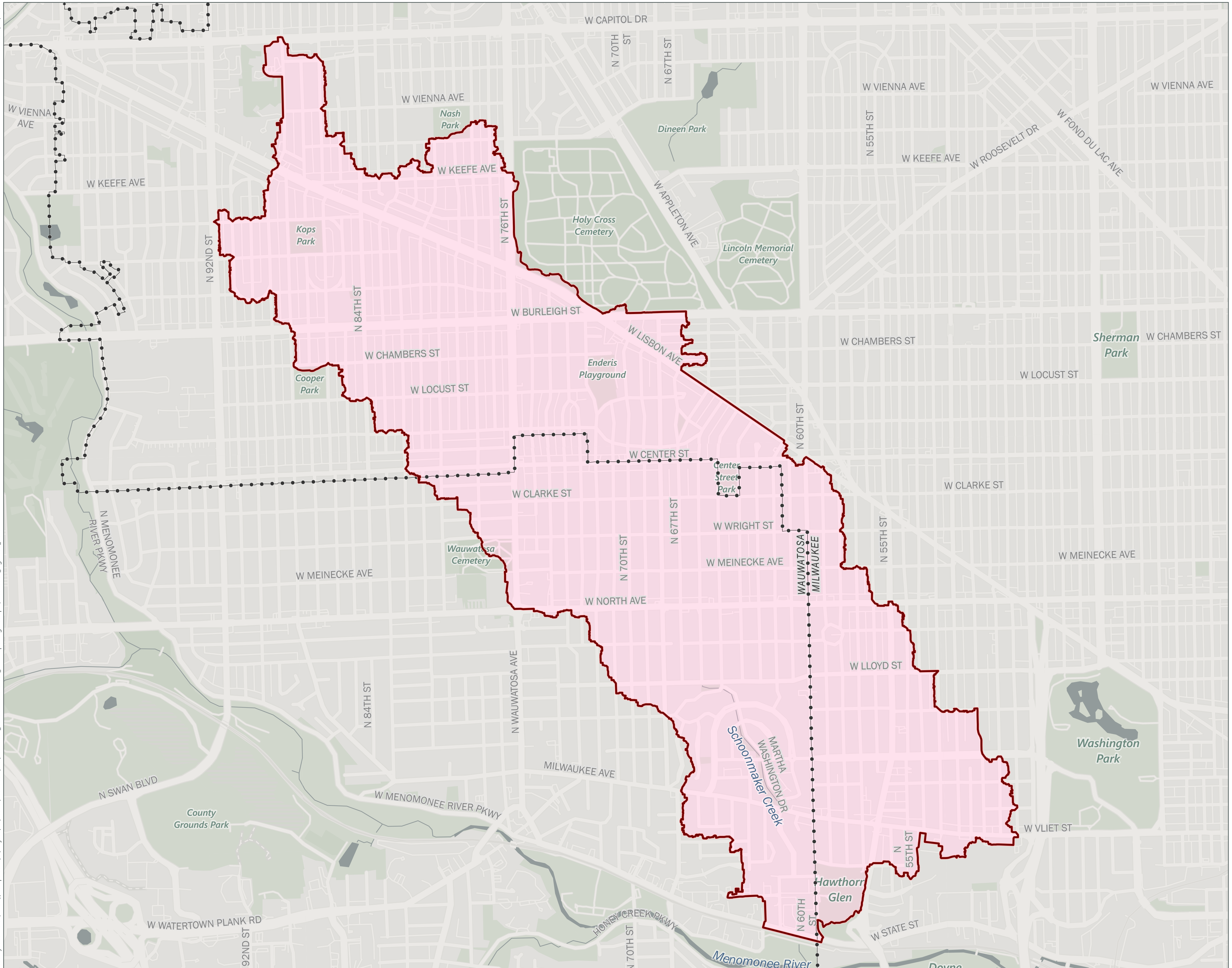
0 850 1,700 Feet

Soils

Figure 5

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Study Area

Municipal Boundary

Hydrologic Soil Group

No Digital Data Available; Modeled as Hydrologic Soil Group C

Data Sources:
Municipal Boundaries: Milwaukee County
Soils: USDA NRCS
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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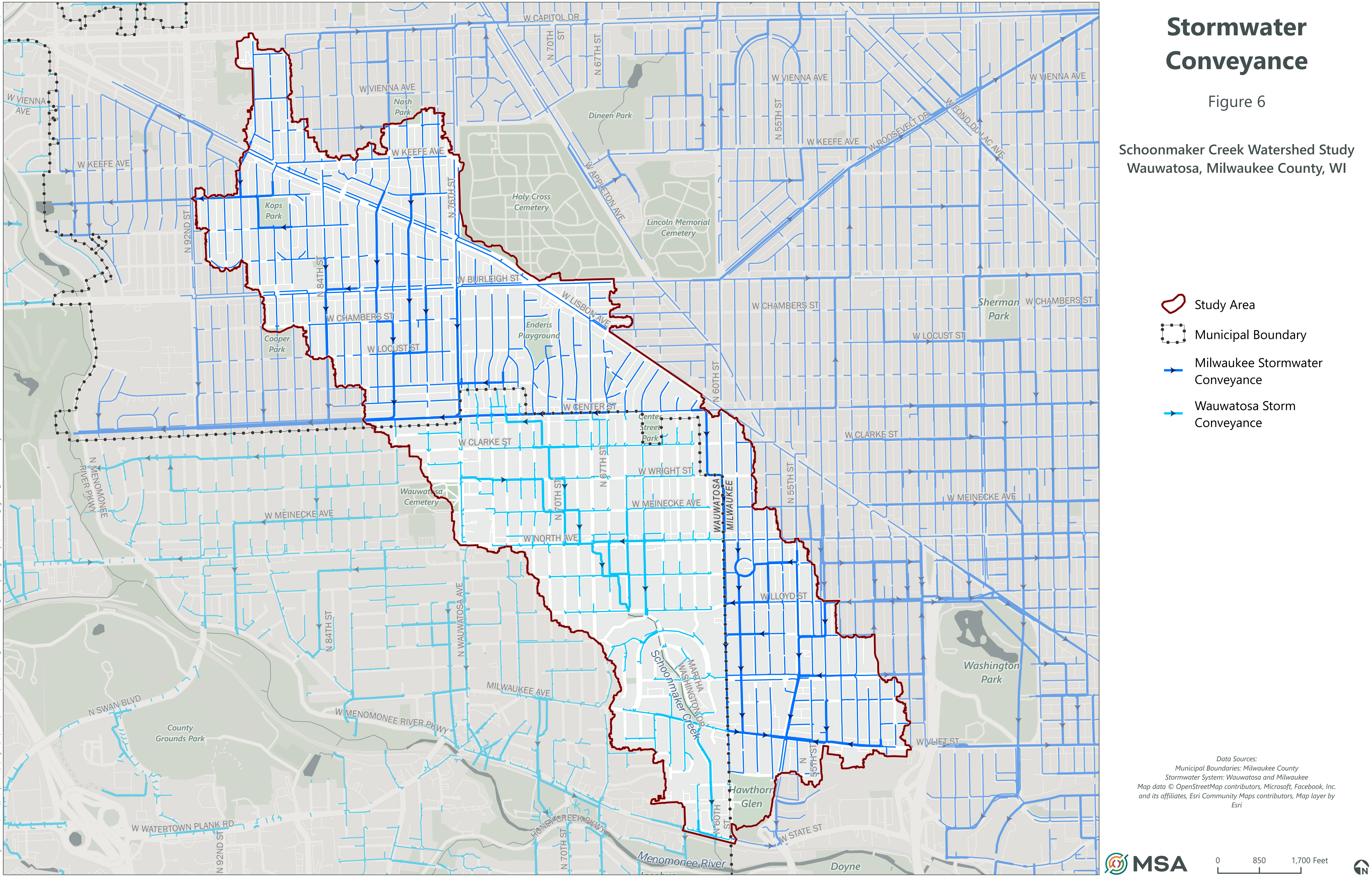
Stormwater Conveyance

Figure 6

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Data Sources:
Municipal Boundaries: Milwaukee County
Stormwater System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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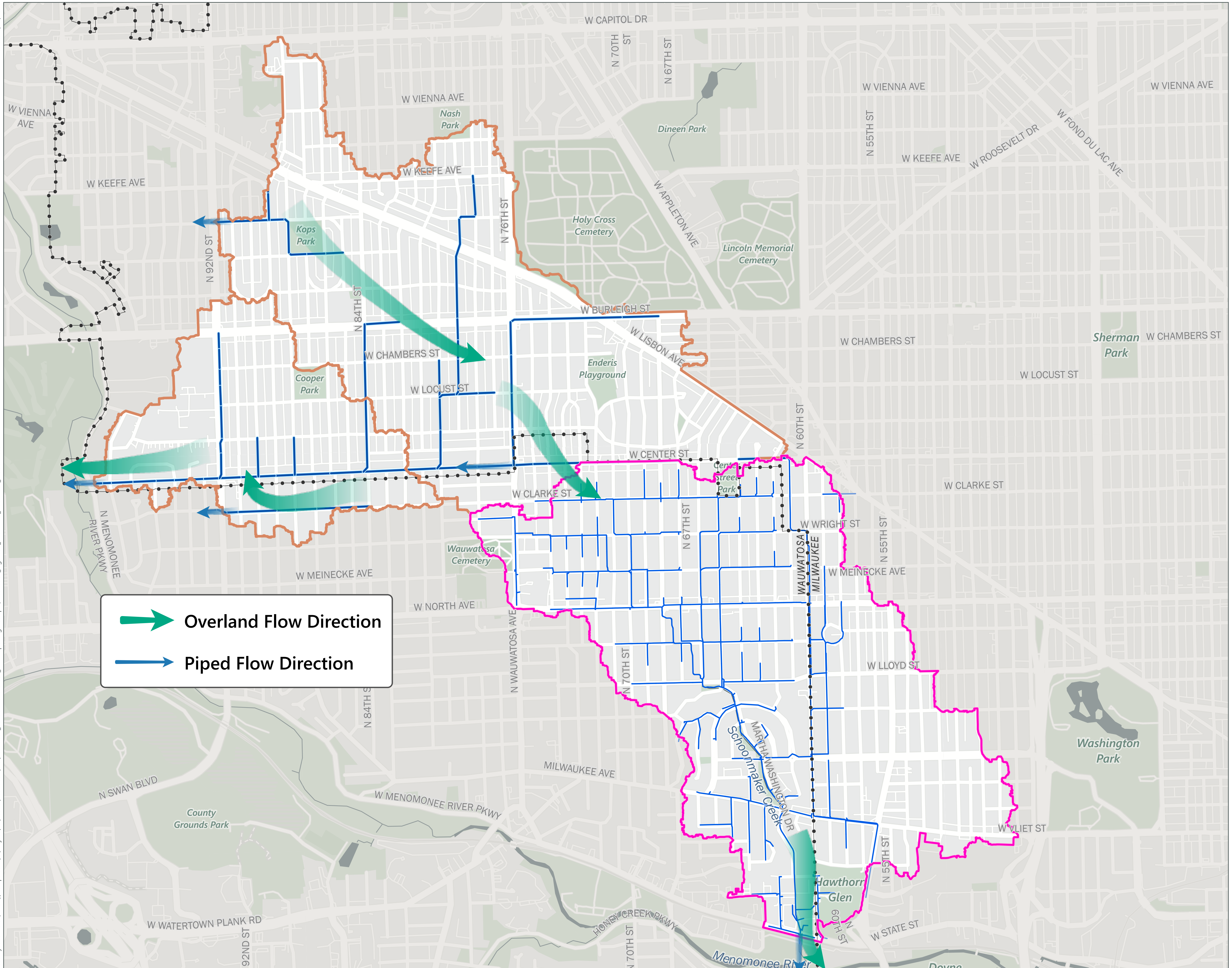

XPSWMM and PCSWMM Model Areas

Figure 7

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- XPSWMM Modeled Links
- PCSWMM Modeled 1D Network Conduit

Data Sources:
Municipal Boundaries: Milwaukee County
Stormwater System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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Print Date: 9/28/2024

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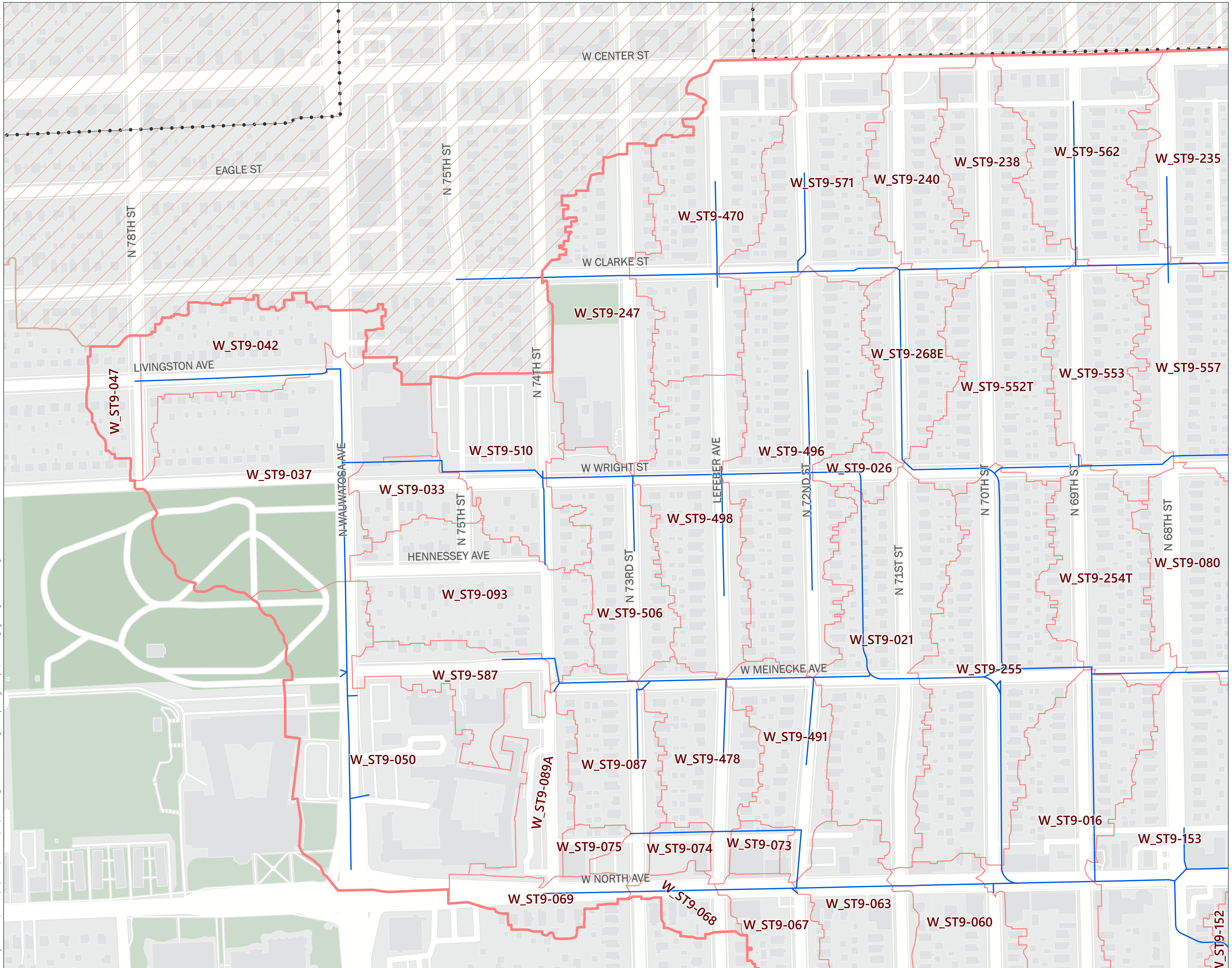
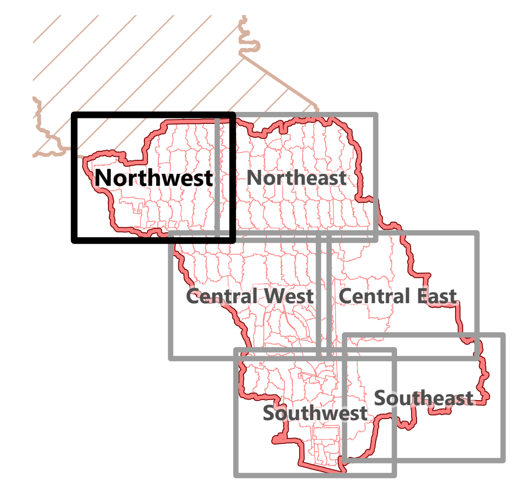


Subwatersheds

Figure 08 - Northwest

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
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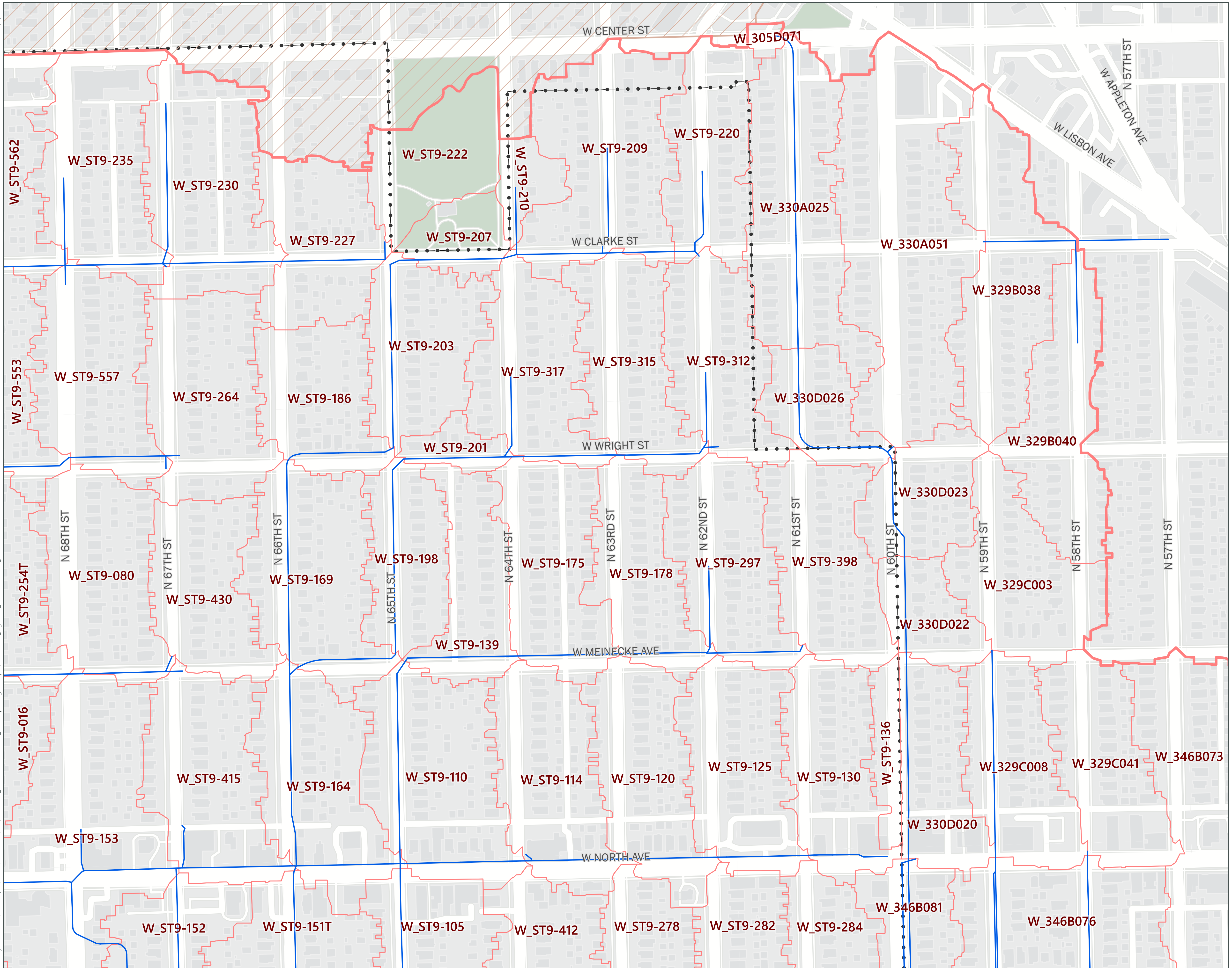
Subwatersheds

Figure 08 - Northeast

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



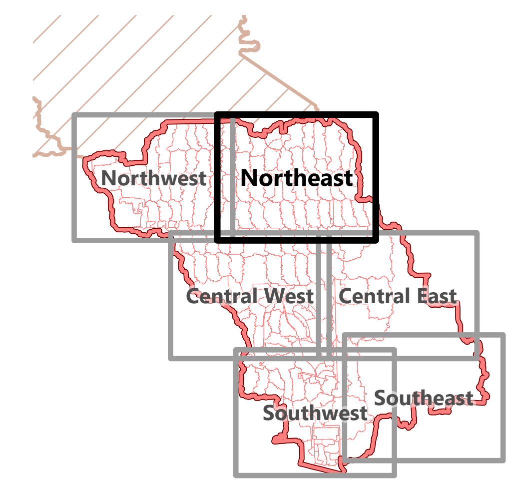
Municipal Boundary

XPSWMM Model Area

PCSWMM Model Area

PCSWMM Subwatersheds

PCSWMM Modeled 1D Network



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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Print Date: 10/9/2024

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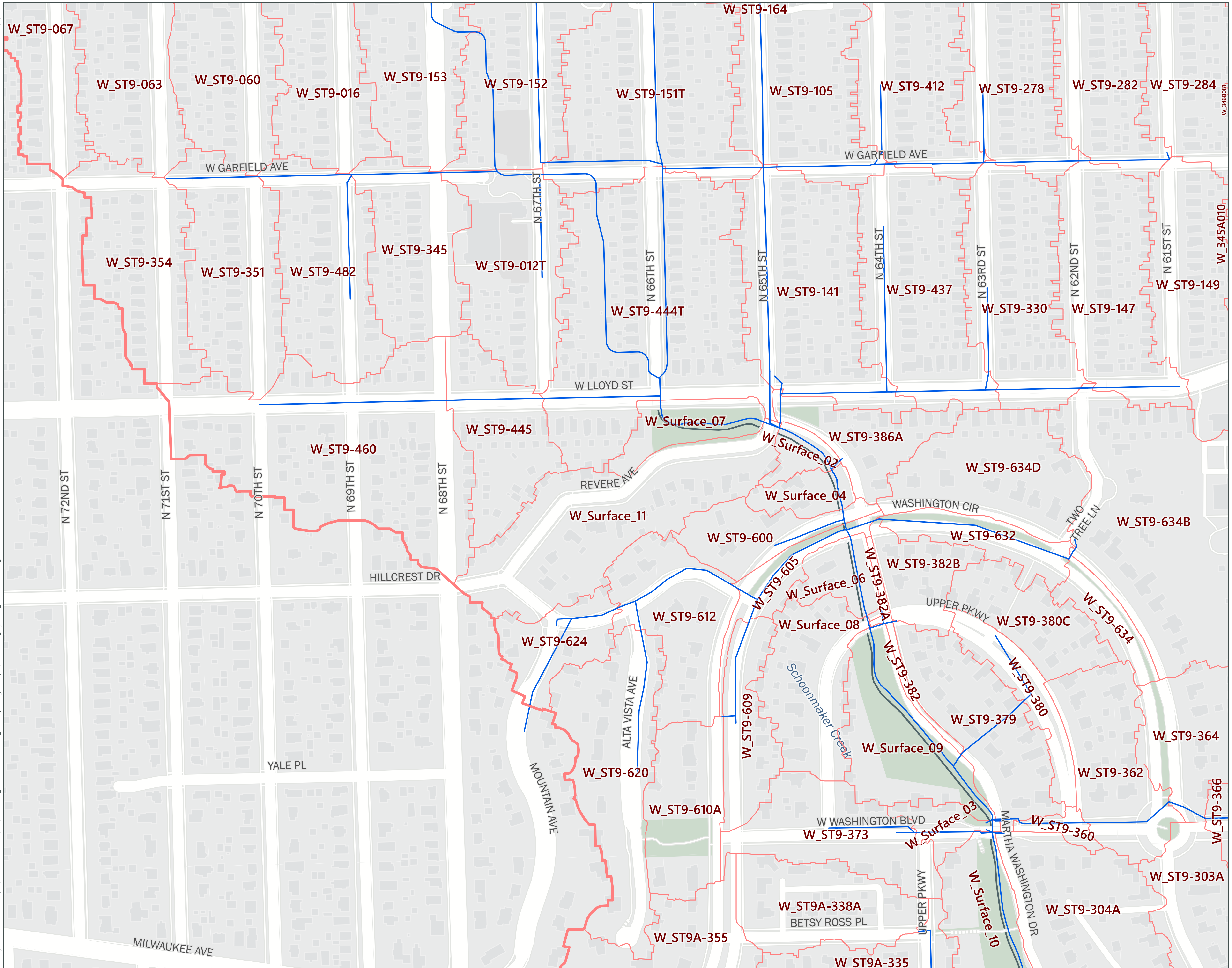
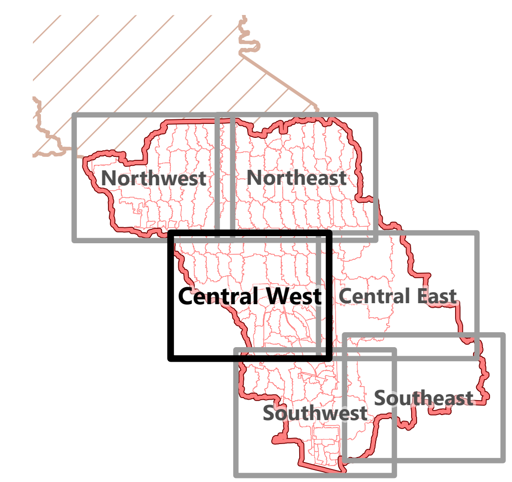
Subwatersheds

Figure 08 - Central West

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
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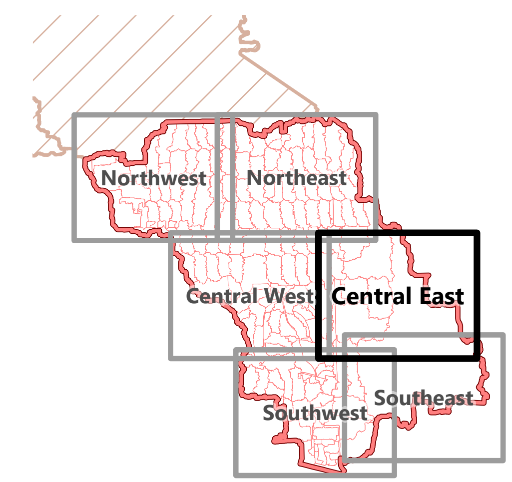
Subwatersheds

Figure 08 - Central East

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
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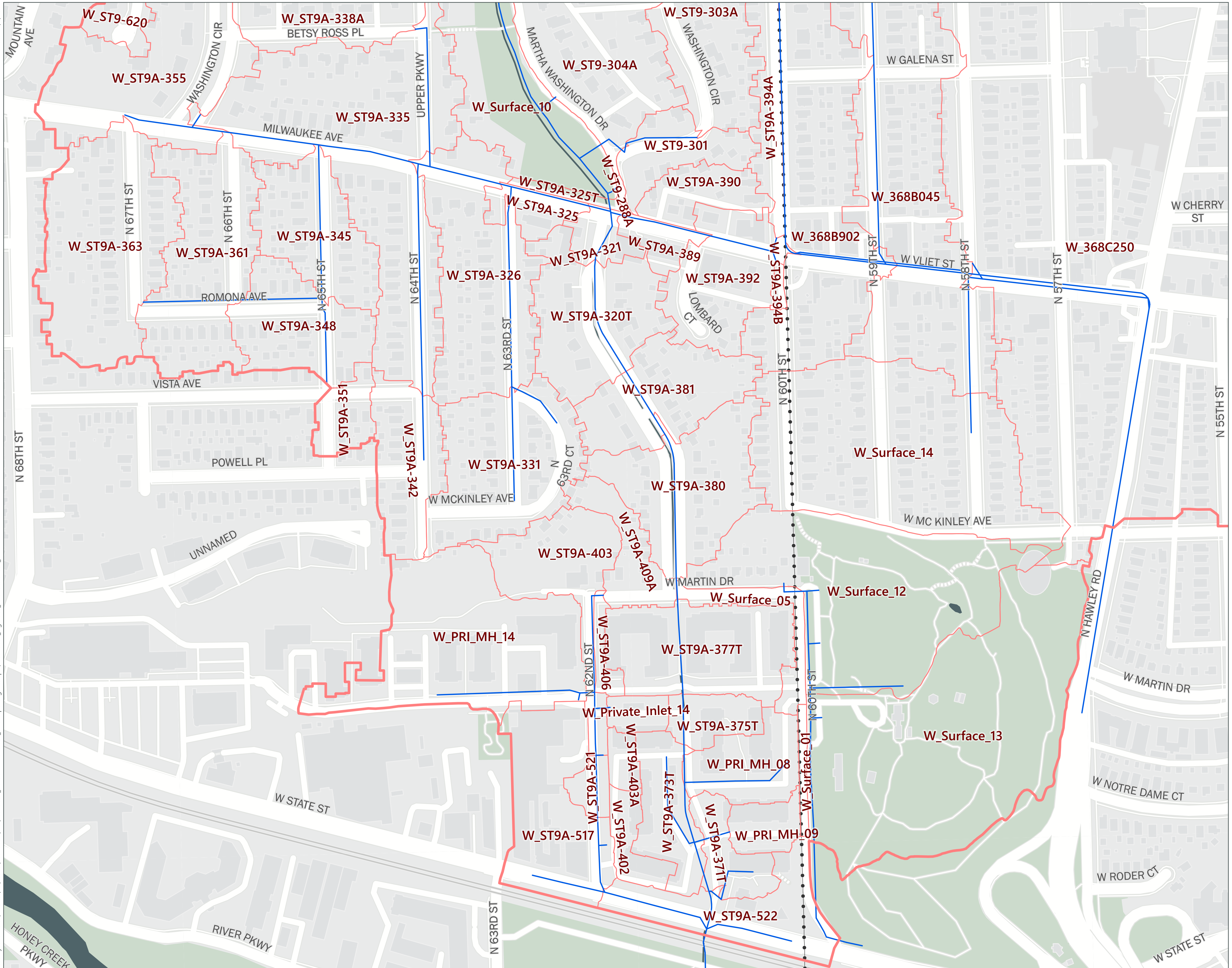
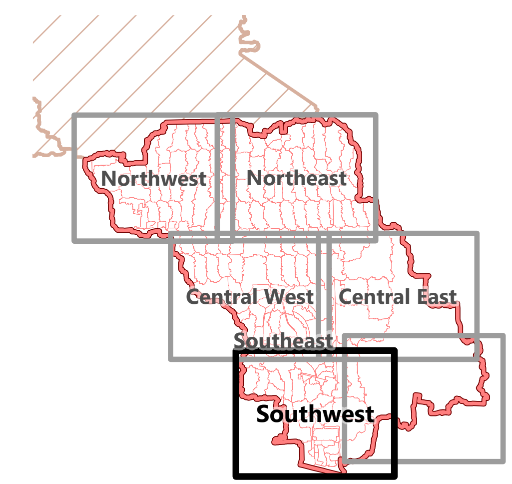
Subwatersheds

Figure 08 - Southwest

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
PCSWMM Subwatersheds
PCSWMM Modeled 1D Network



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
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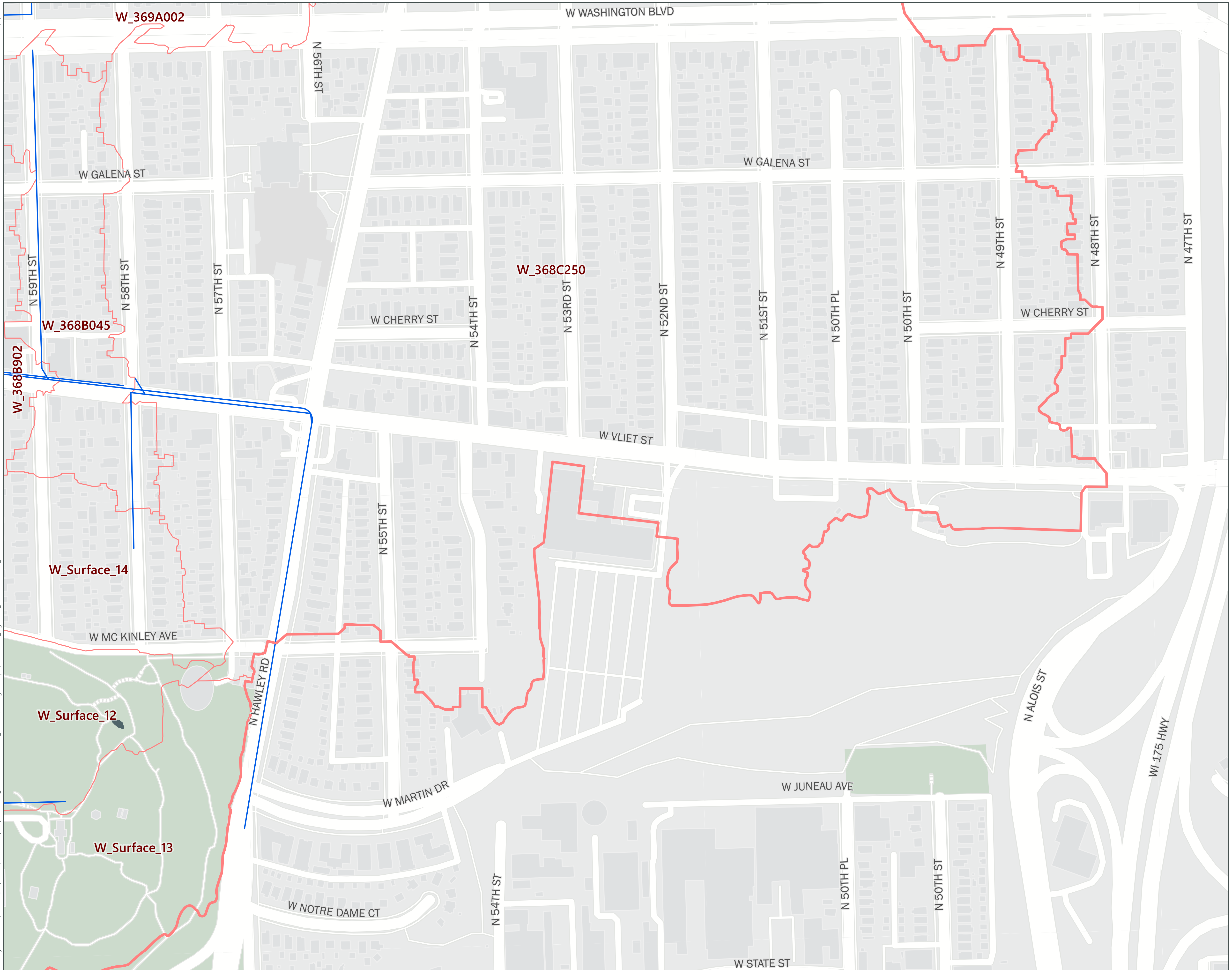
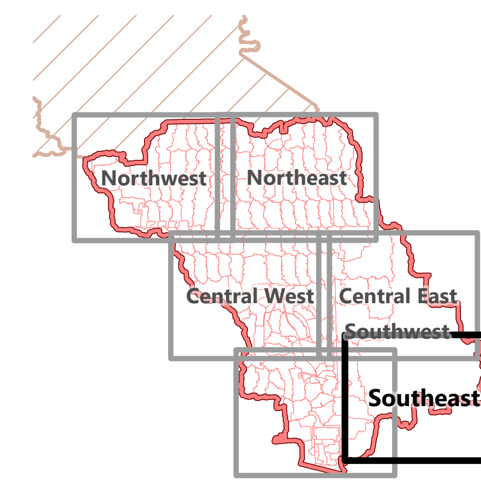
Subwatersheds

Figure 08 - Southeast

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
PCSWMM Subwatersheds
PCSWMM Modeled 1D Network



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
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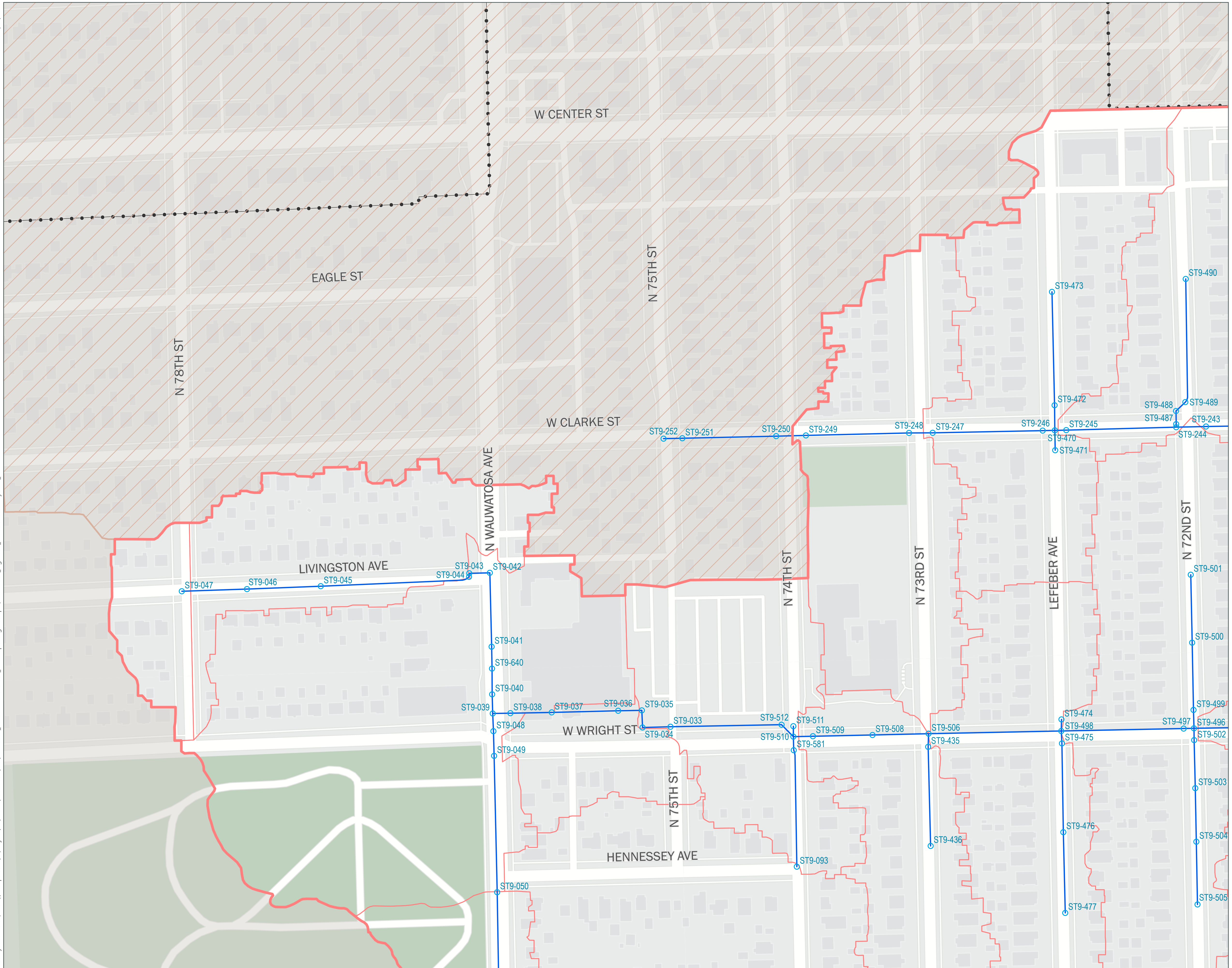
Print Date: 10/9/2024

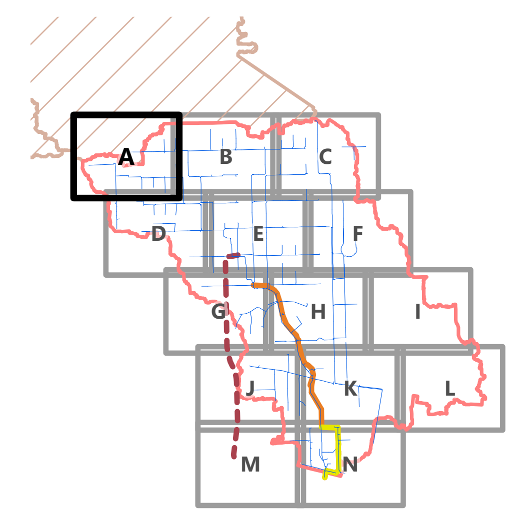
PC-SWMM Modeled 1-D System

Figure 9 - A

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
PCSWMM Subwatersheds
PCSWMM Modeled 1D Network Conduit
PCSWMM Modeled 1D Network Junction
PCSWMM Modeled 1D Network Outfall
Alt A: Deep Tunnel
Alt B: Storm System (6x12 Box)
Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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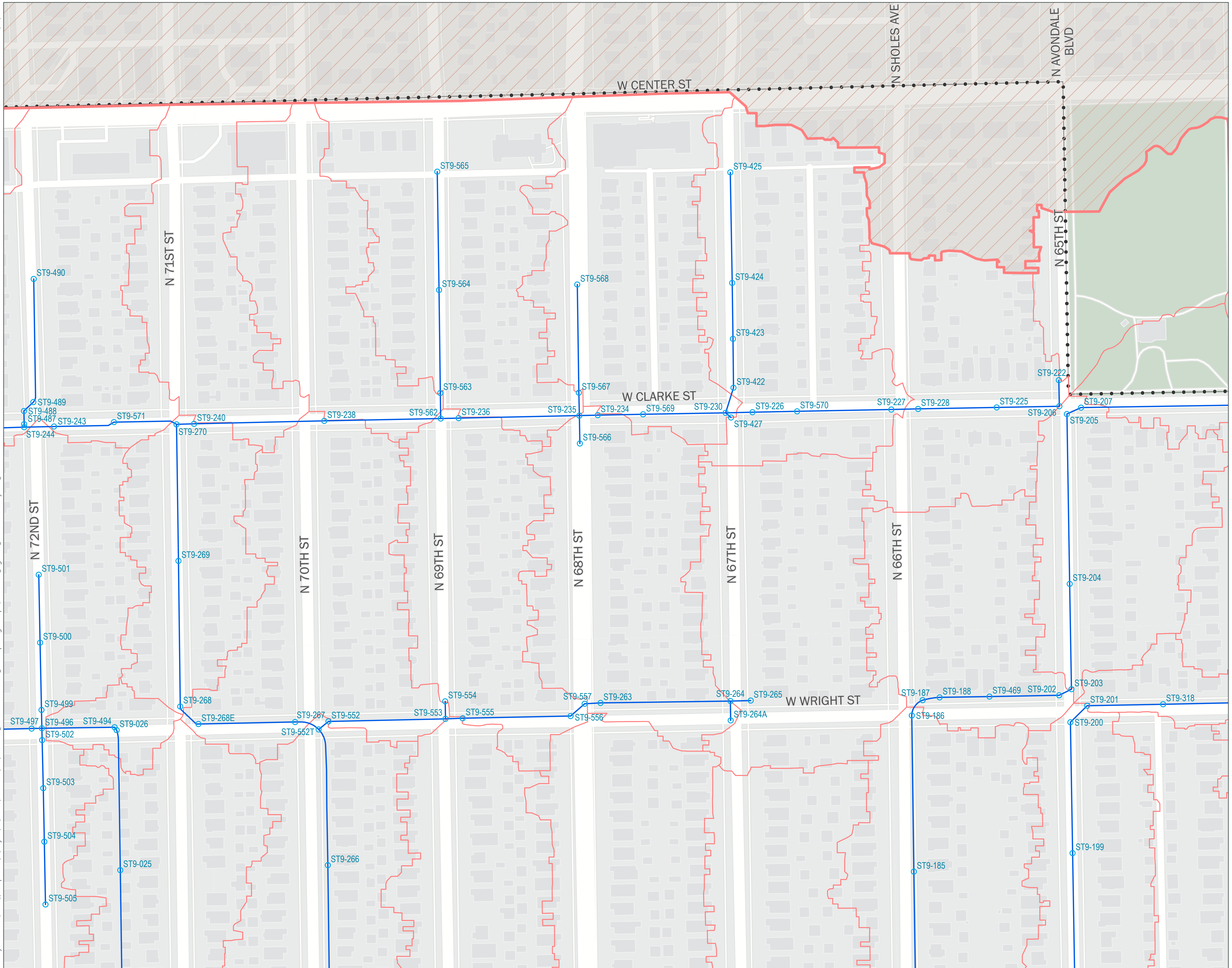
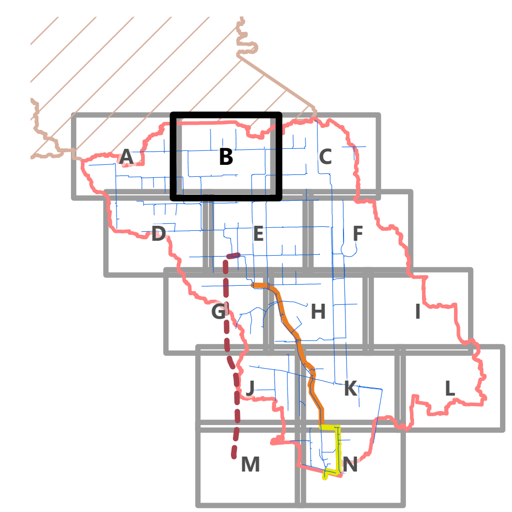


PC-SWMM Modeled 1-D System

Figure 9 - B

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
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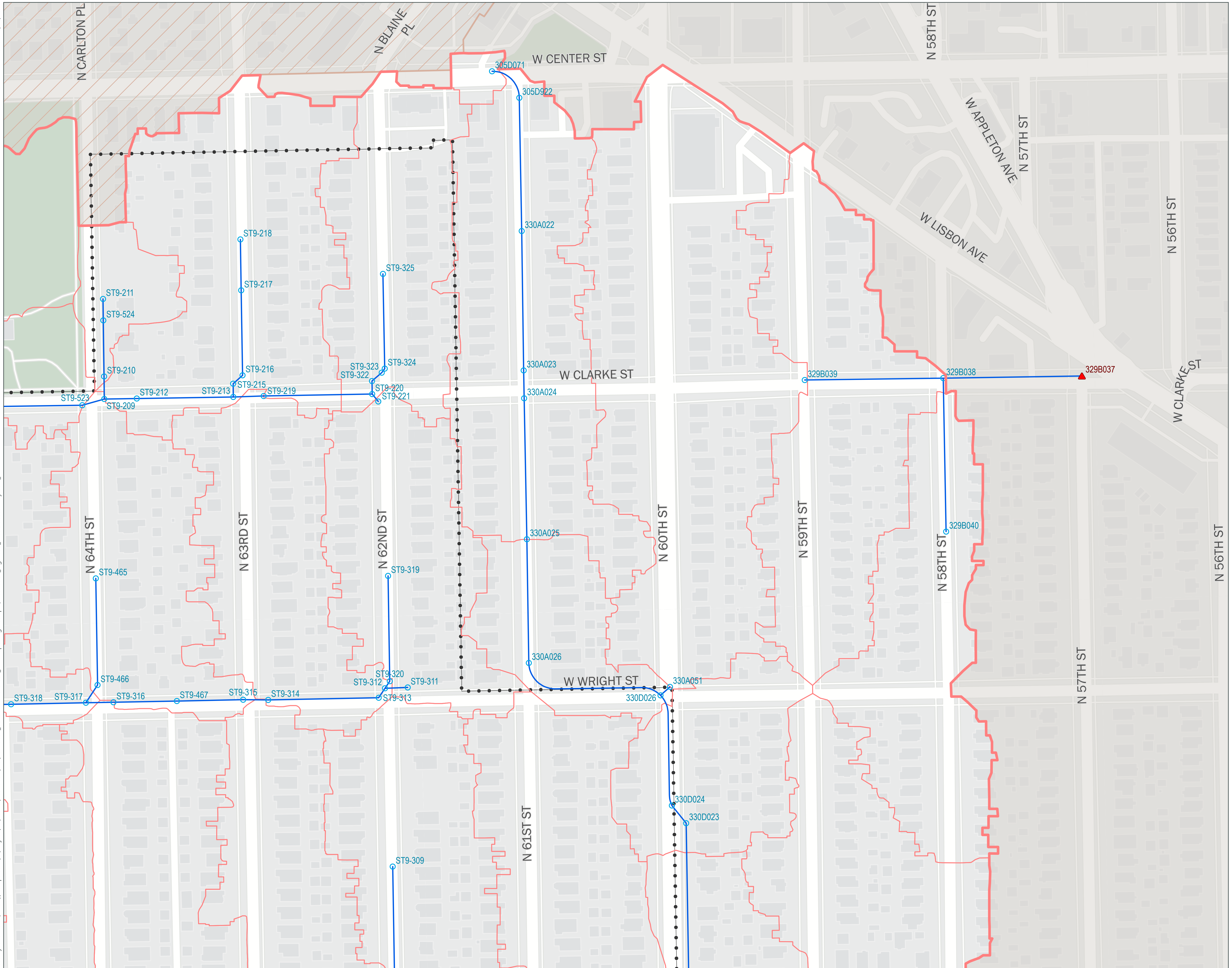
Print Date: 9/30/2024

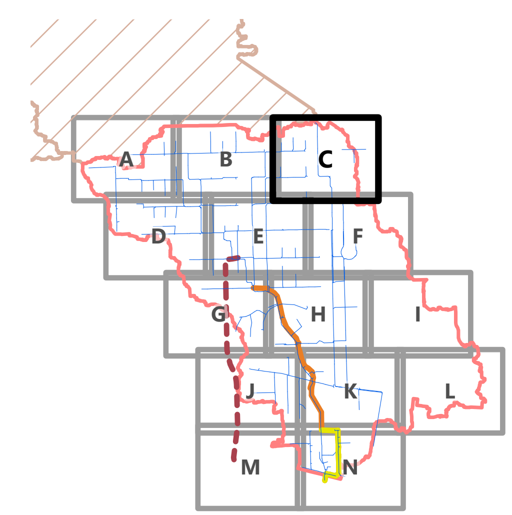


PC-SWMM Modeled 1-D System

Figure 9 - C

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
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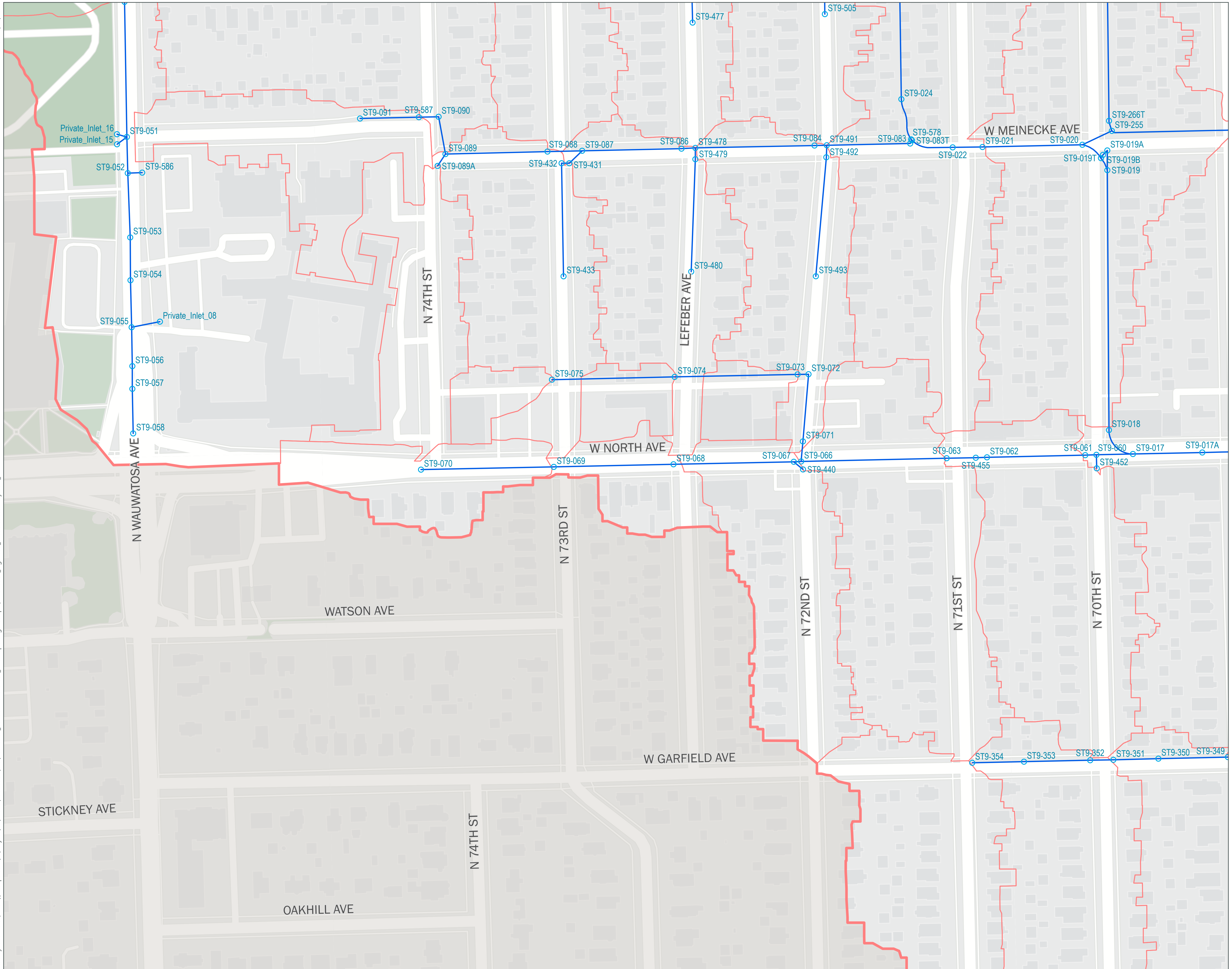
MSA

0 150 300 Feet

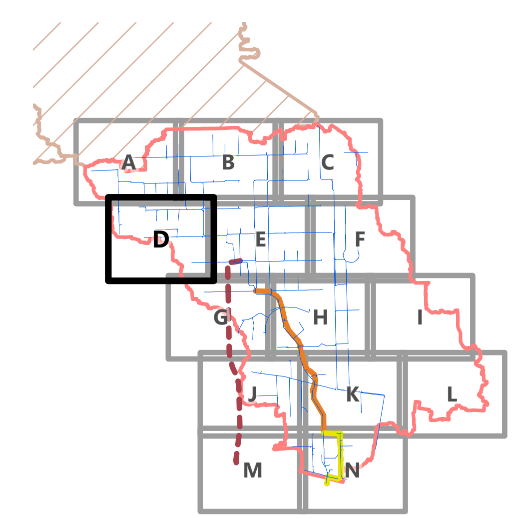


PC-SWMM Modeled 1-D System

Figure 9 - D

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
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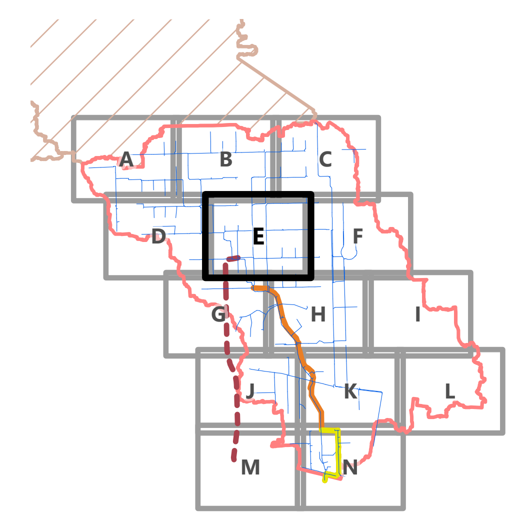
PC-SWMM Modeled 1-D System

Figure 9 - E

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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0 150 300 Feet

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Print Date: 9/30/2024

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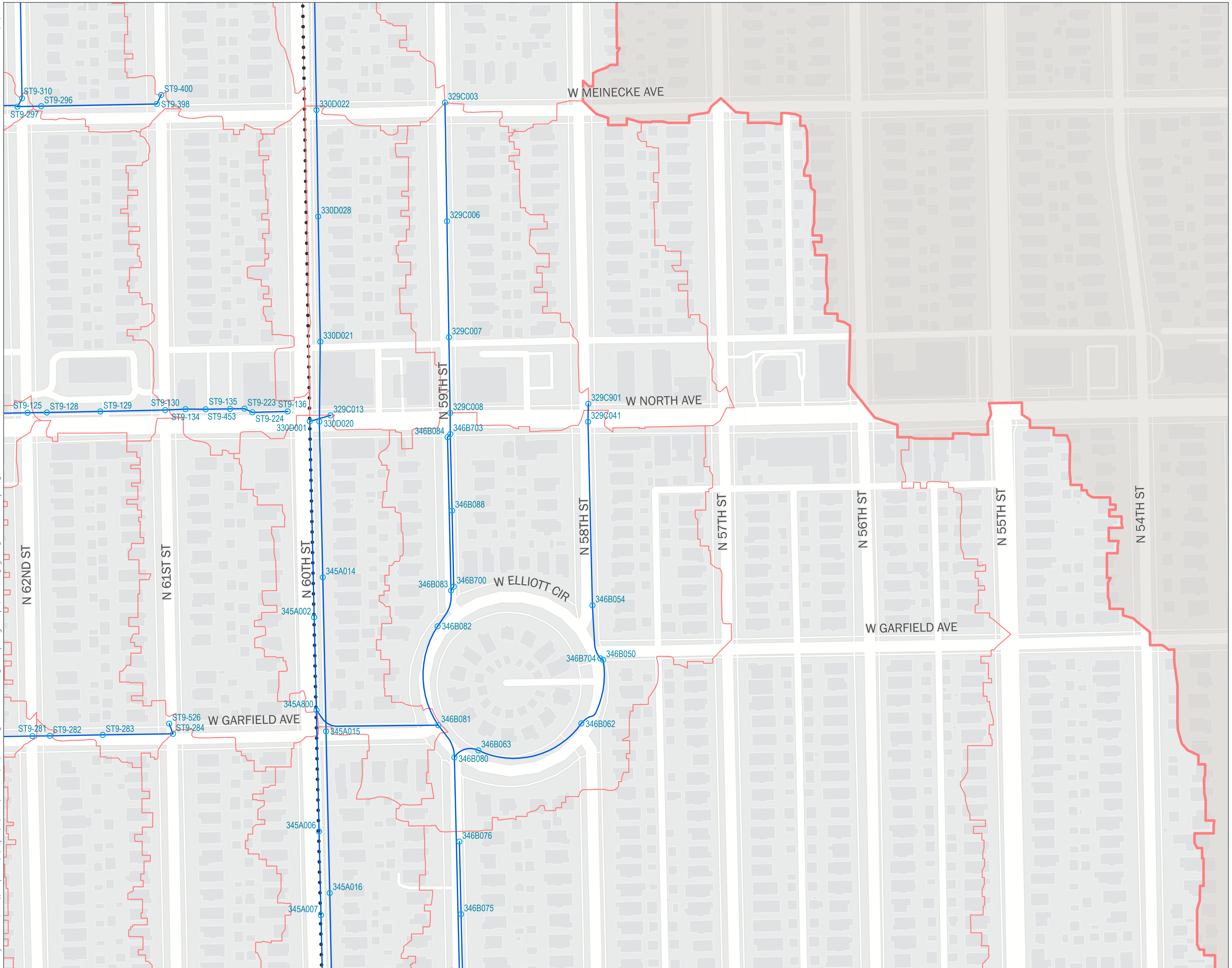
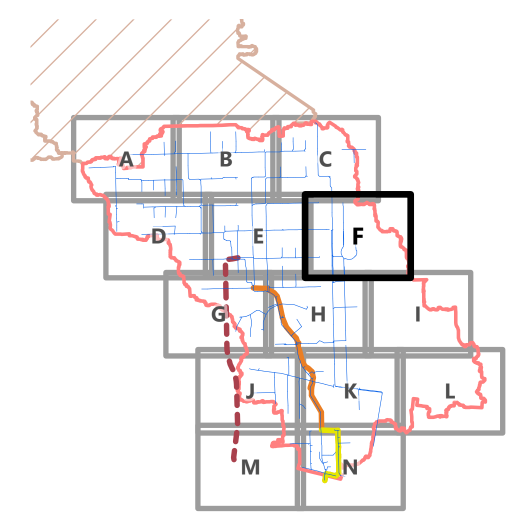


PC-SWMM Modeled 1-D System

Figure 9 - F

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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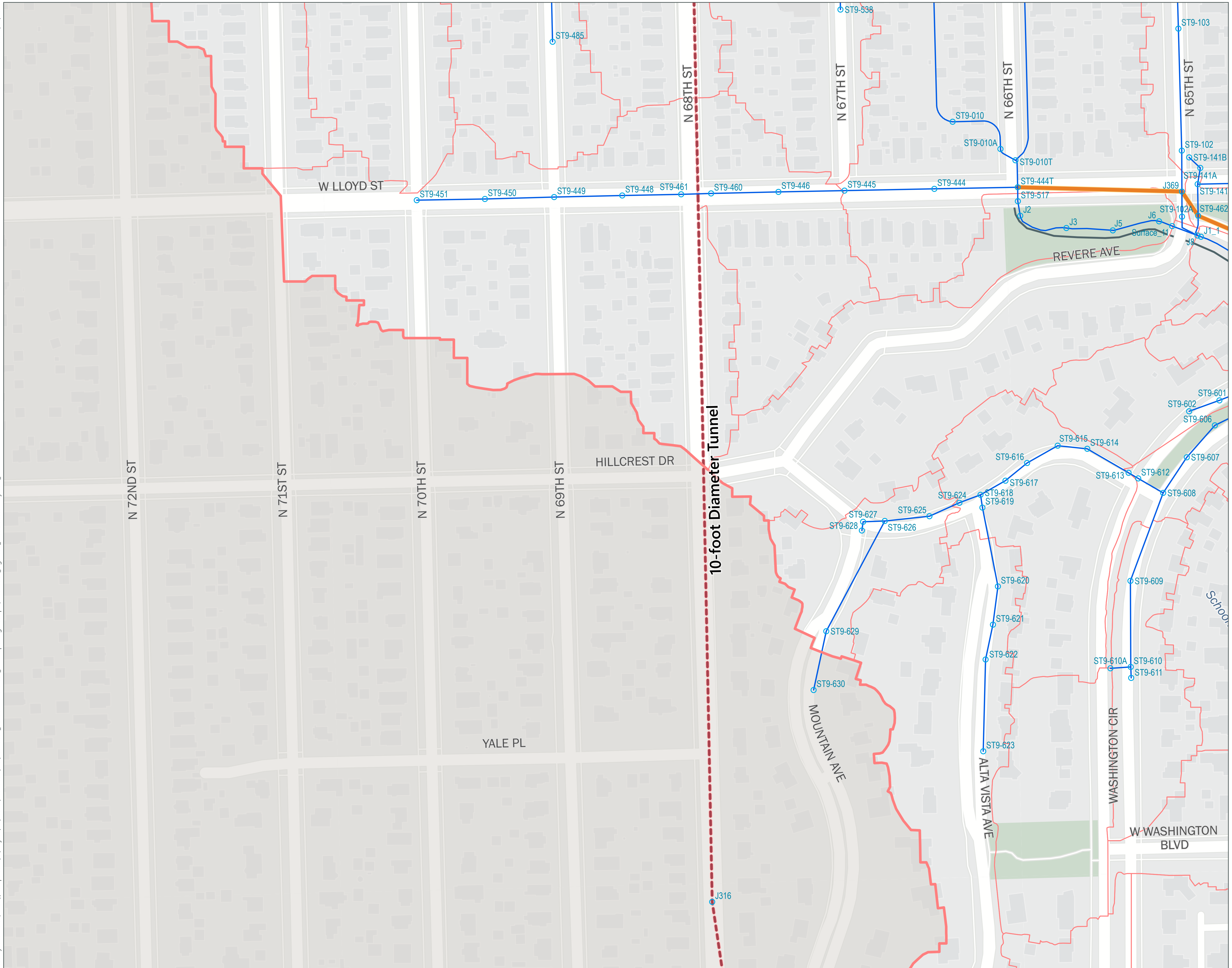
0 150 300 Feet

Print Date: 9/30/2024

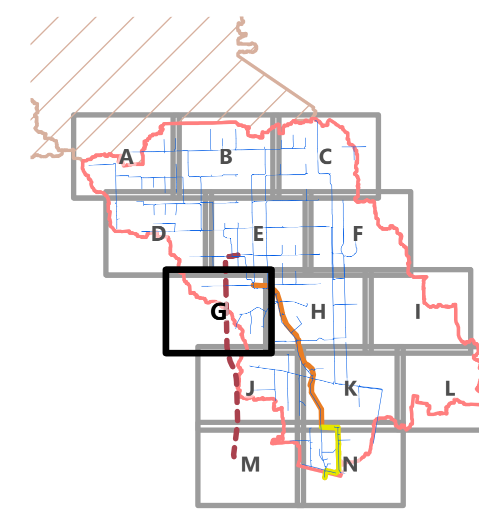


PC-SWMM Modeled 1-D System

Figure 9 - G

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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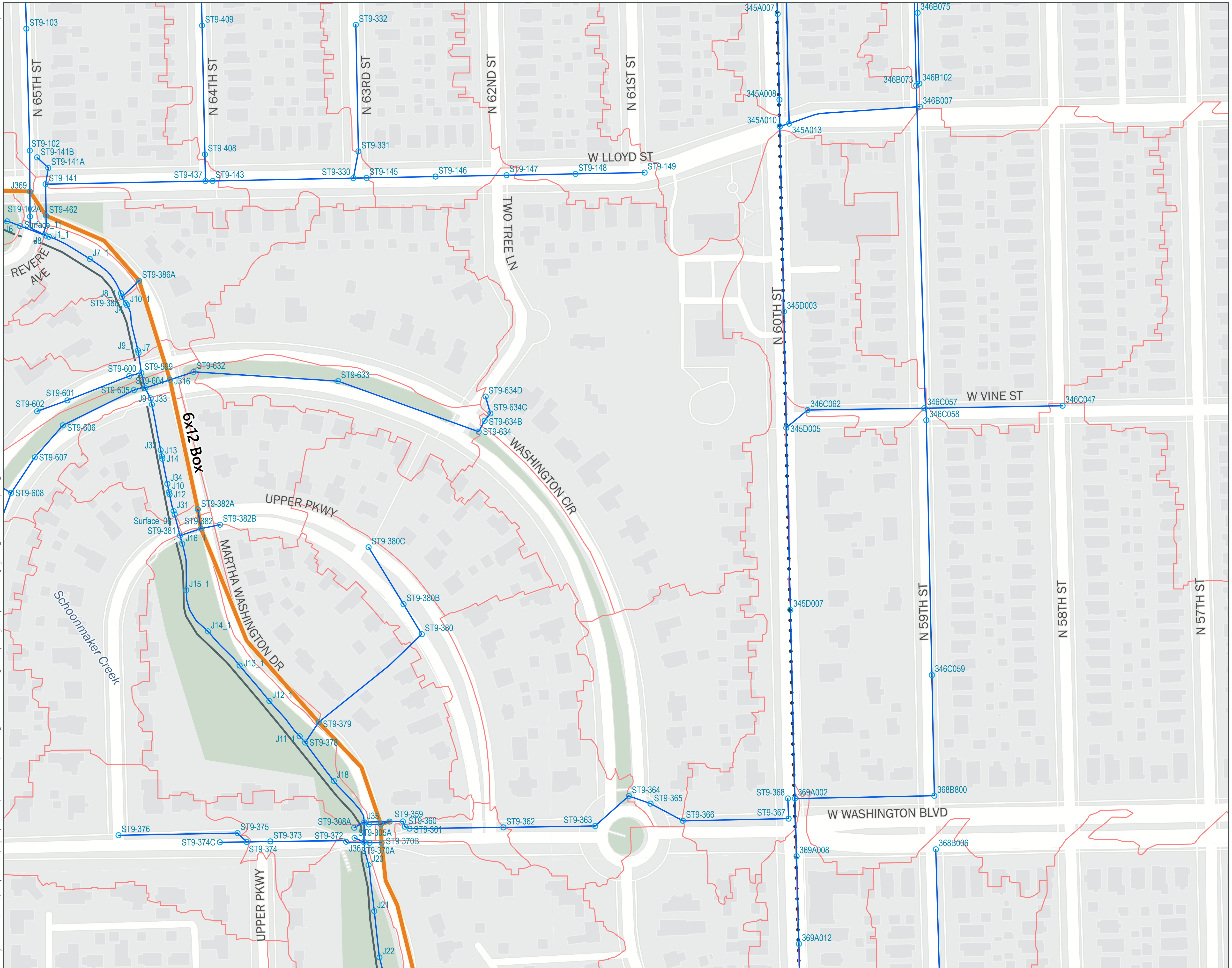
Print Date: 9/30/2024

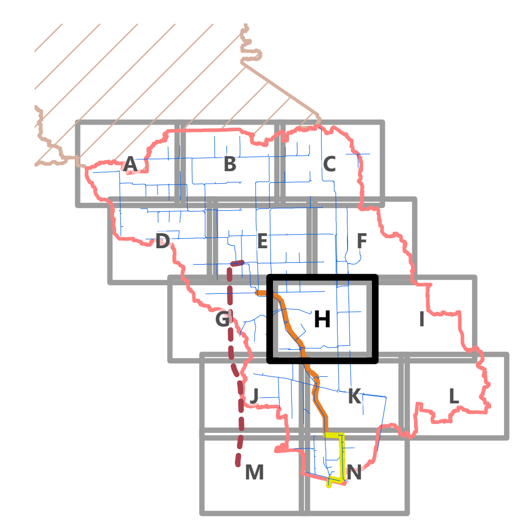


PC-SWMM Modeled 1-D System

Figure 9 - H

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

0 150 300 Feet

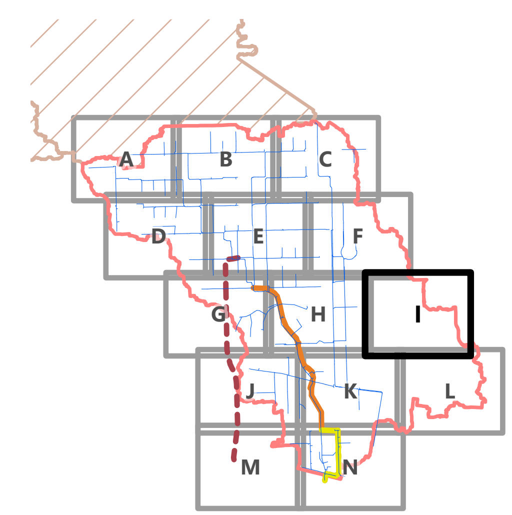
Print Date: 9/30/2024

PC-SWMM Modeled 1-D System

Figure 9 - I

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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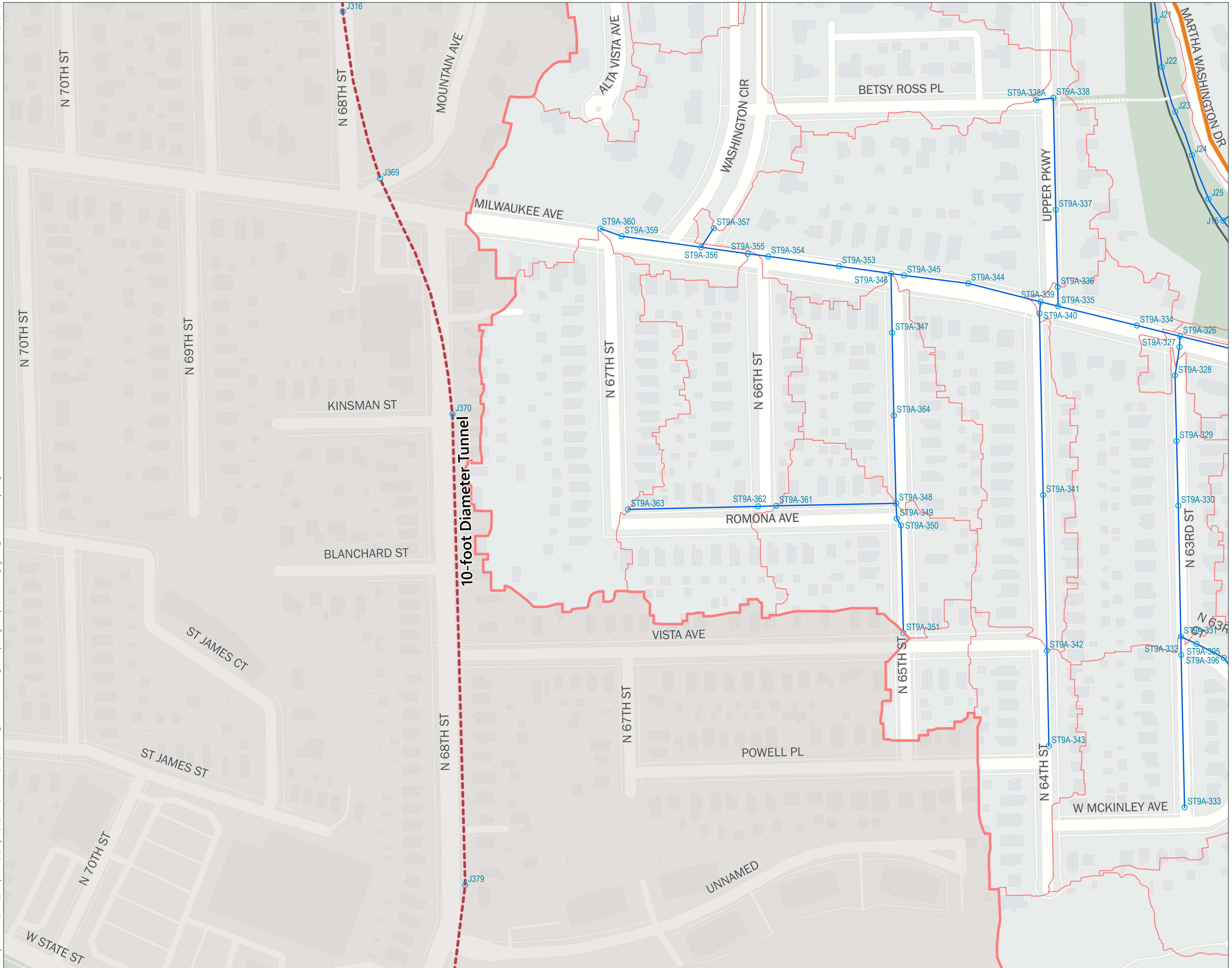
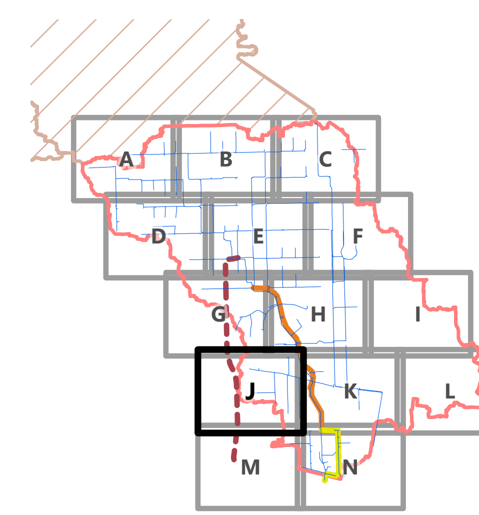
PC-SWMM Modeled 1-D System

Figure 9 - J

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
PCSWMM Subwatersheds
PCSWMM Modeled 1D Network Conduit
PCSWMM Modeled 1D Network Junction
PCSWMM Modeled 1D Network Outfall
Alt A: Deep Tunnel
Alt B: Storm System (6x12 Box)
Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
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0 150 300 Feet

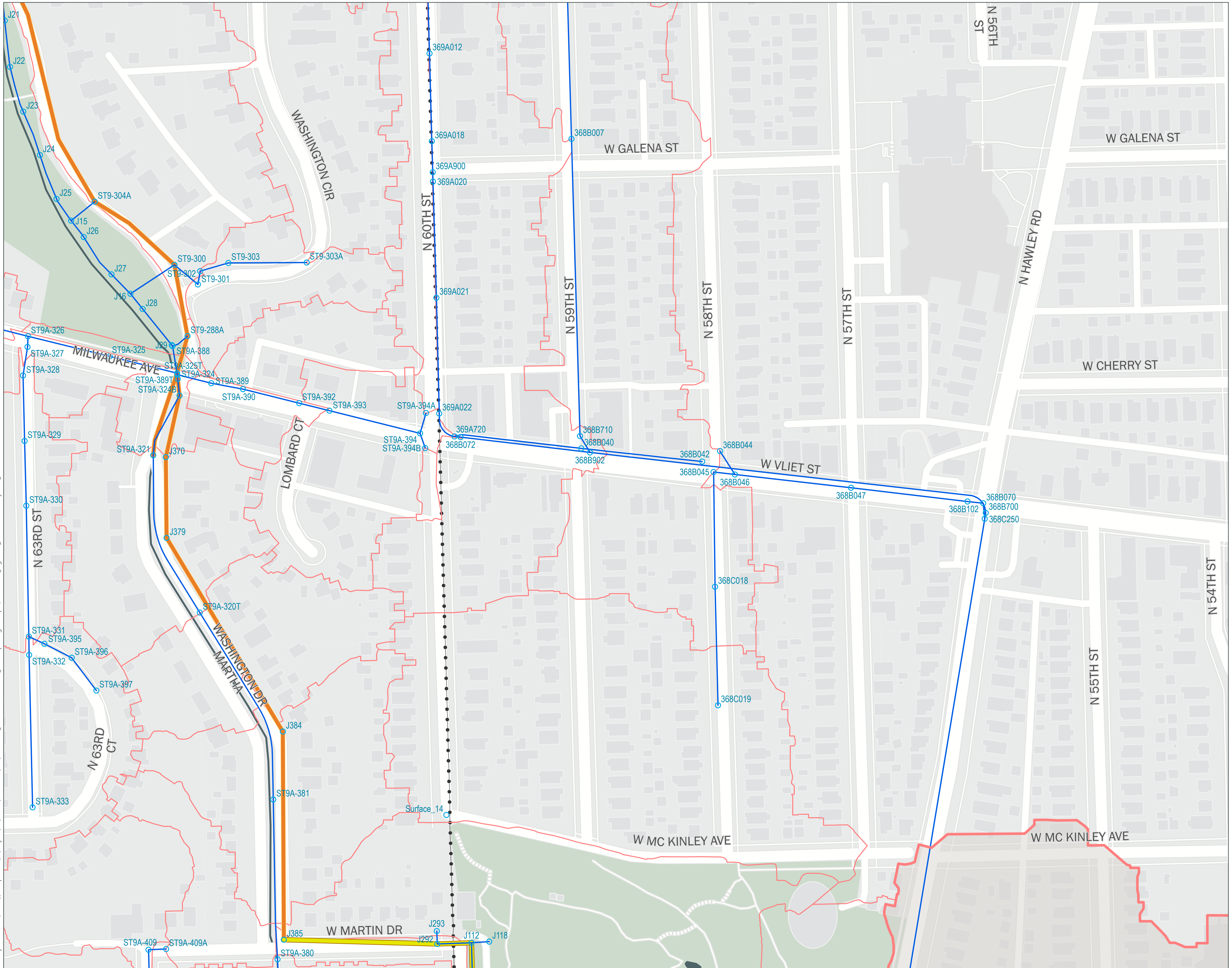
N

Print Date: 9/30/2024

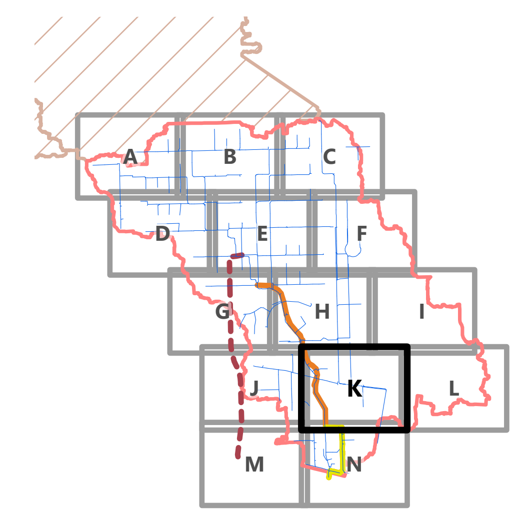
PC-SWMM Modeled 1-D System

Figure 9 - K

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

0 150 300 Feet

N

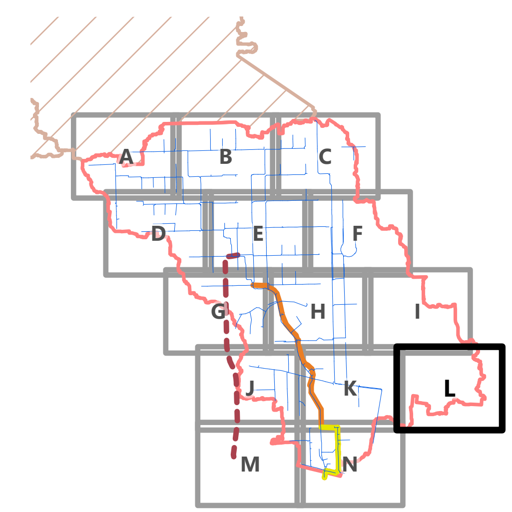
Print Date: 9/30/2024

PC-SWMM Modeled 1-D System

Figure 9 - L

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

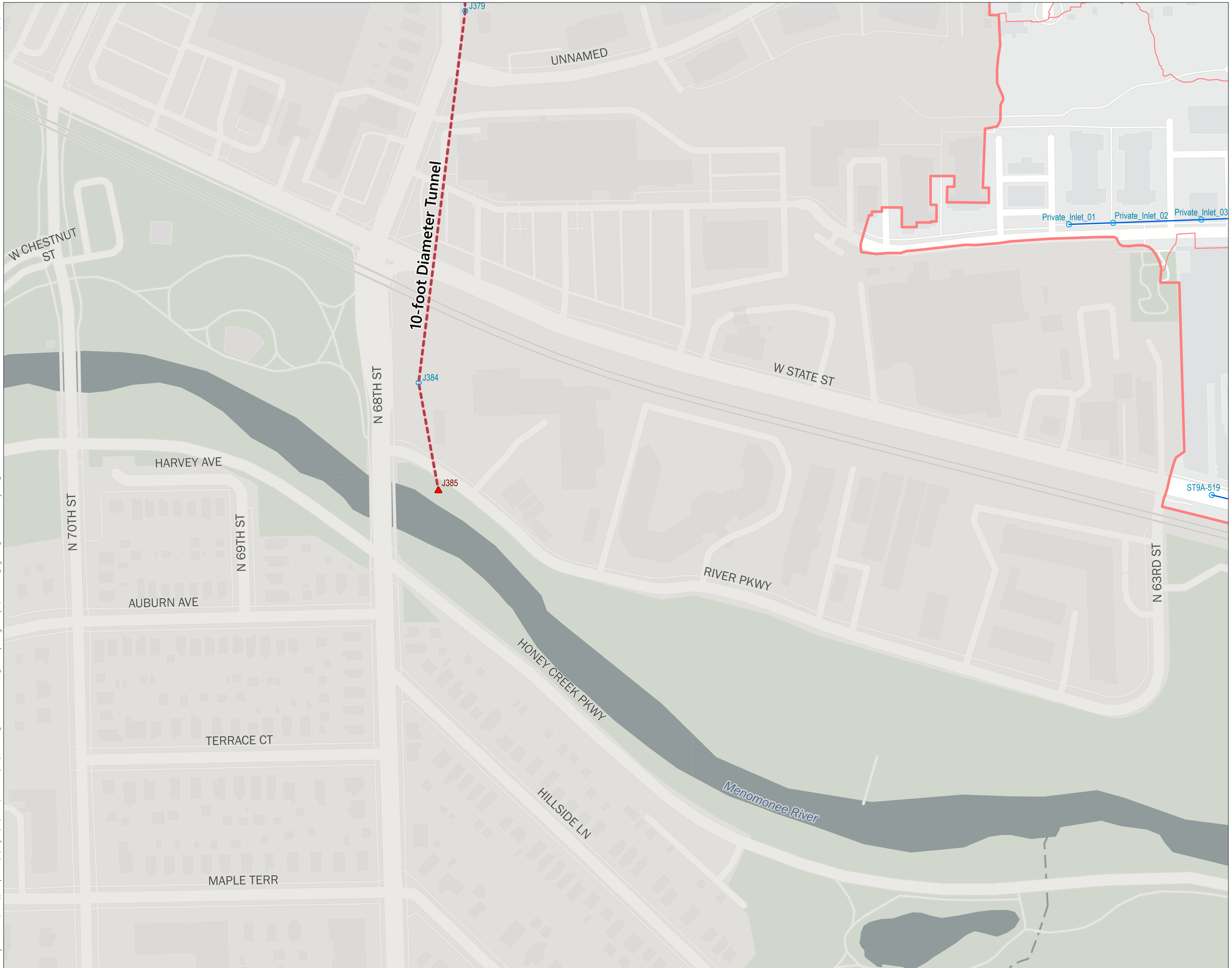
0 150 300 Feet

Print Date: 9/30/2024

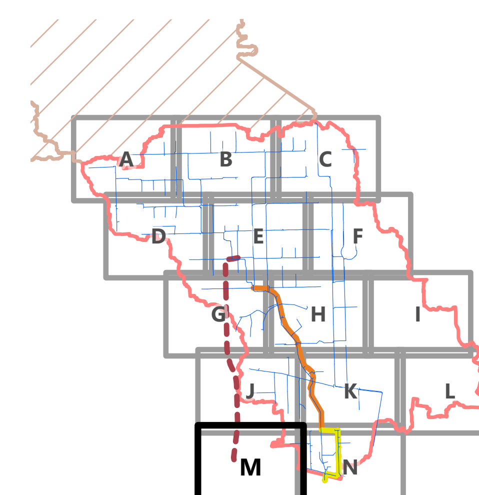
PC-SWMM Modeled 1-D System

Figure 9 - M

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

0 150 300 Feet

N

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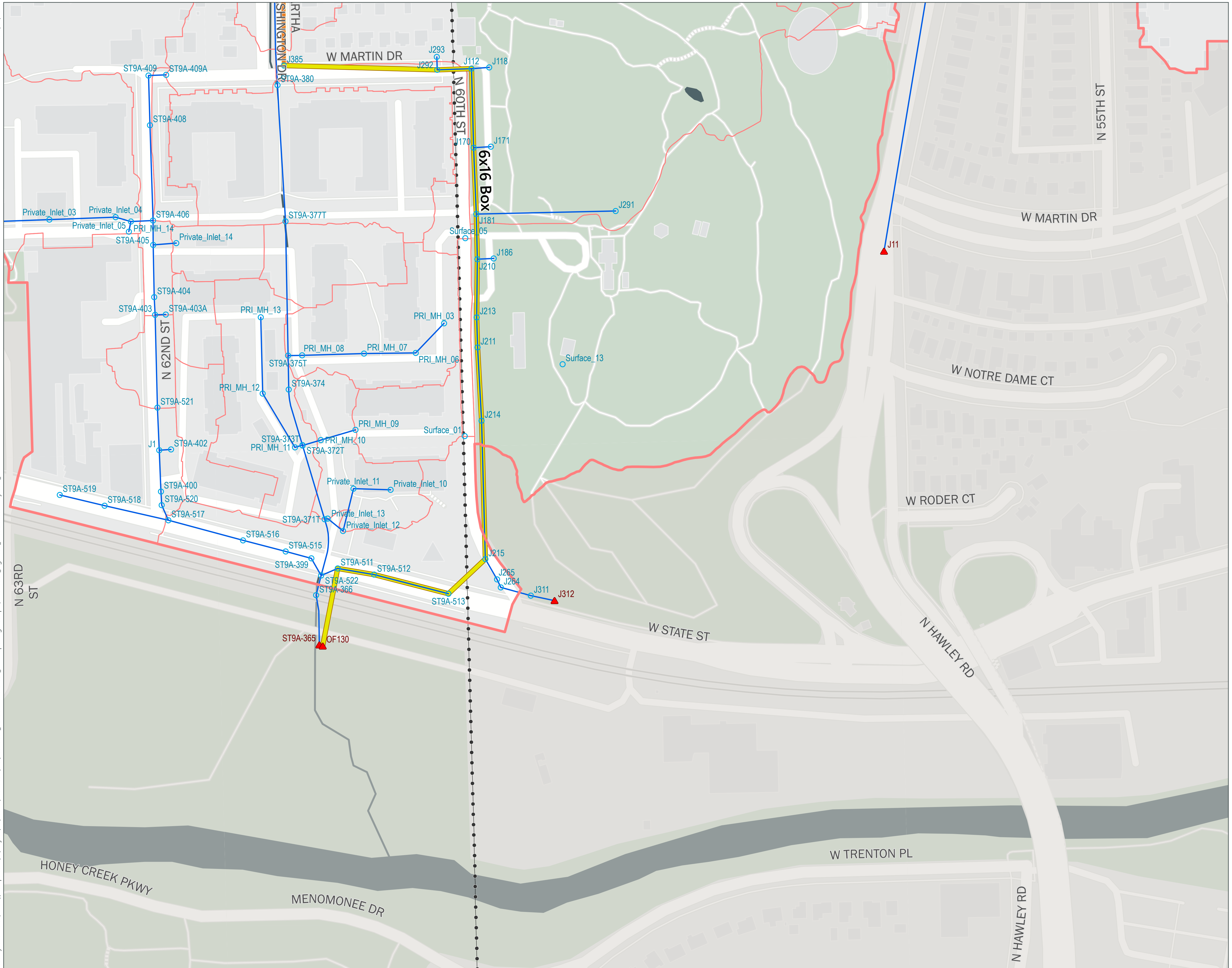
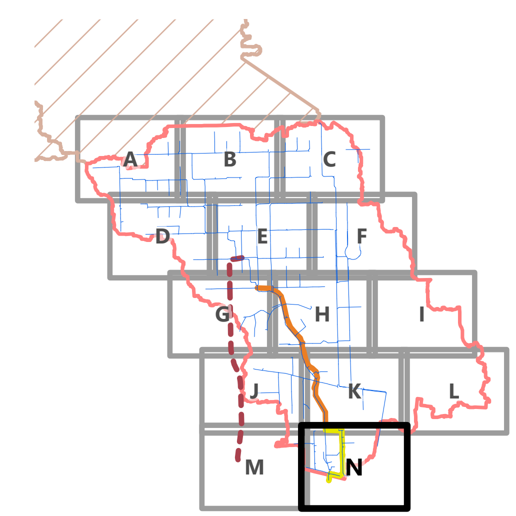


PC-SWMM Modeled 1-D System

Figure 9 - N

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- Municipal Boundary
- XPSWMM Model Area
- PCSWMM Model Area
- PCSWMM Subwatersheds
- PCSWMM Modeled 1D Network Conduit
- PCSWMM Modeled 1D Network Junction
- PCSWMM Modeled 1D Network Outfall
- Alt A: Deep Tunnel
- Alt B: Storm System (6x12 Box)
- Alt B: Storm System (6x16 Box)



Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

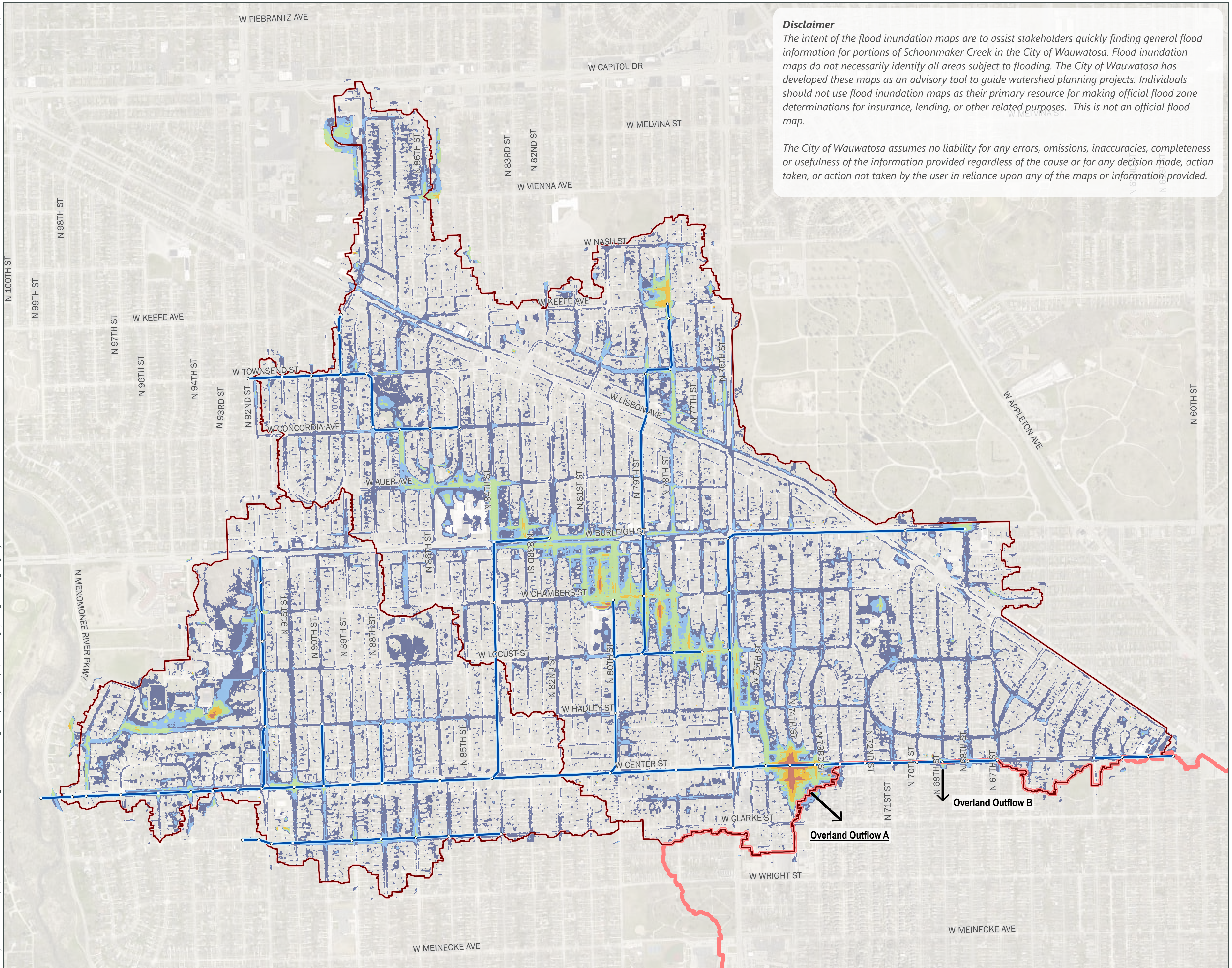
MSA

0 150 300 Feet

XPSWMM Rain on Grid 100-yr 24-hr Event Inundation

Figure 10

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Disclaimer

The intent of the flood inundation maps are to assist stakeholders quickly finding general flood information for portions of Schoonmaker Creek in the City of Wauwatosa. Flood inundation maps do not necessarily identify all areas subject to flooding. The City of Wauwatosa has developed these maps as an advisory tool to guide watershed planning projects. Individuals should not use flood inundation maps as their primary resource for making official flood zone determinations for insurance, lending, or other related purposes. This is not an official flood map.

The City of Wauwatosa assumes no liability for any errors, omissions, inaccuracies, completeness or usefulness of the information provided regardless of the cause or for any decision made, action taken, or action not taken by the user in reliance upon any of the maps or information provided.

- XPSWMM RoG Watershed
- PCSWMM Model Area
- XPSWMM Modeled Links
- XPSWMM Modeled Nodes

Maximum Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3+

Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Basemap: Milwaukee County (2022)
Milwaukee County Land Information Office

MSA

0 0.1 0.2 Miles

N

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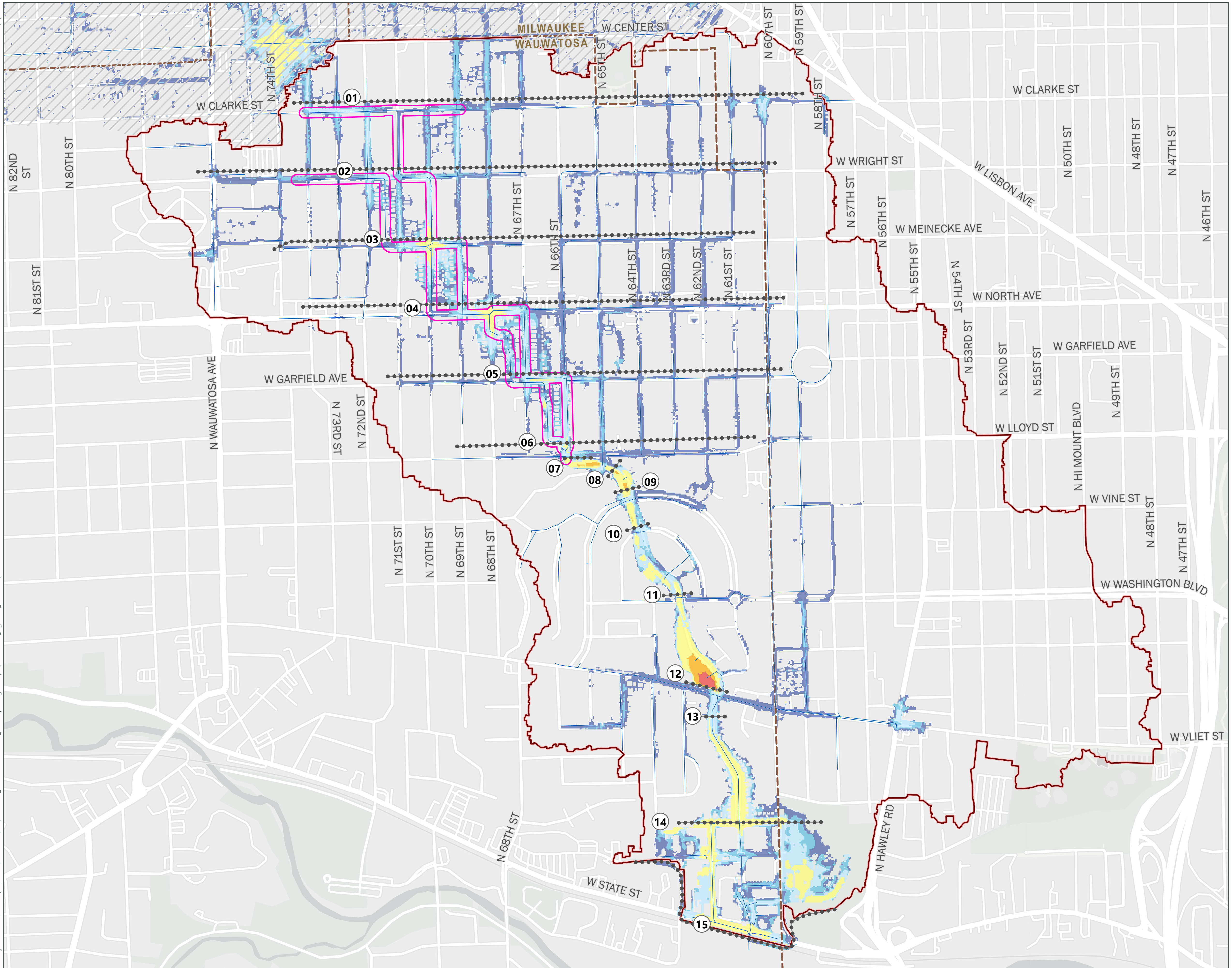


Flow Comparison Cross-Section

Figure 11

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

- PCSWMM Model Area
- Rain on Grid Model Area
- Municipal Boundary
- Modeled Pipe

100-yr 24-hr, Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 7
- 7+
- 01 Flow Estimate Location
- Flow Comparison Location
- Conceptual Trunk Line Improvement

Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa and Milwaukee
Esri Community Maps Contributors, City of Milwaukee, WI, Milwaukee County Land Info, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS

MSA

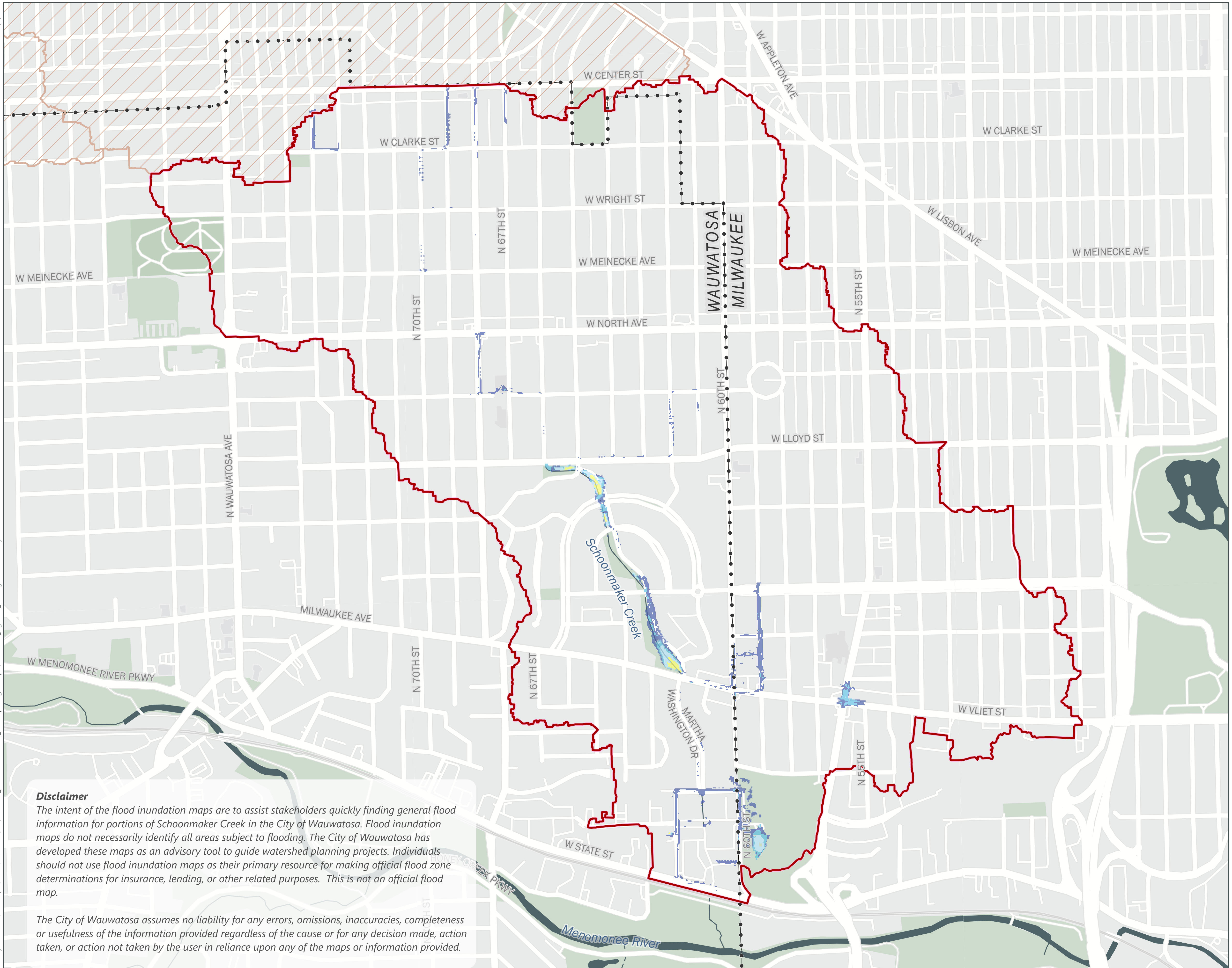
0 450 900 US Feet

Print Date: 10/9/2024

Existing Conditions 1-yr, 24-hr Event

Figure 12

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Disclaimer

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The City of Wauwatosa assumes no liability for any errors, omissions, inaccuracies, completeness or usefulness of the information provided regardless of the cause or for any decision made, action taken, or action not taken by the user in reliance upon any of the maps or information provided.

Municipal Boundary

XPSWMM Model Area

PCSWMM Model Area

Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 7
- 7+

Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

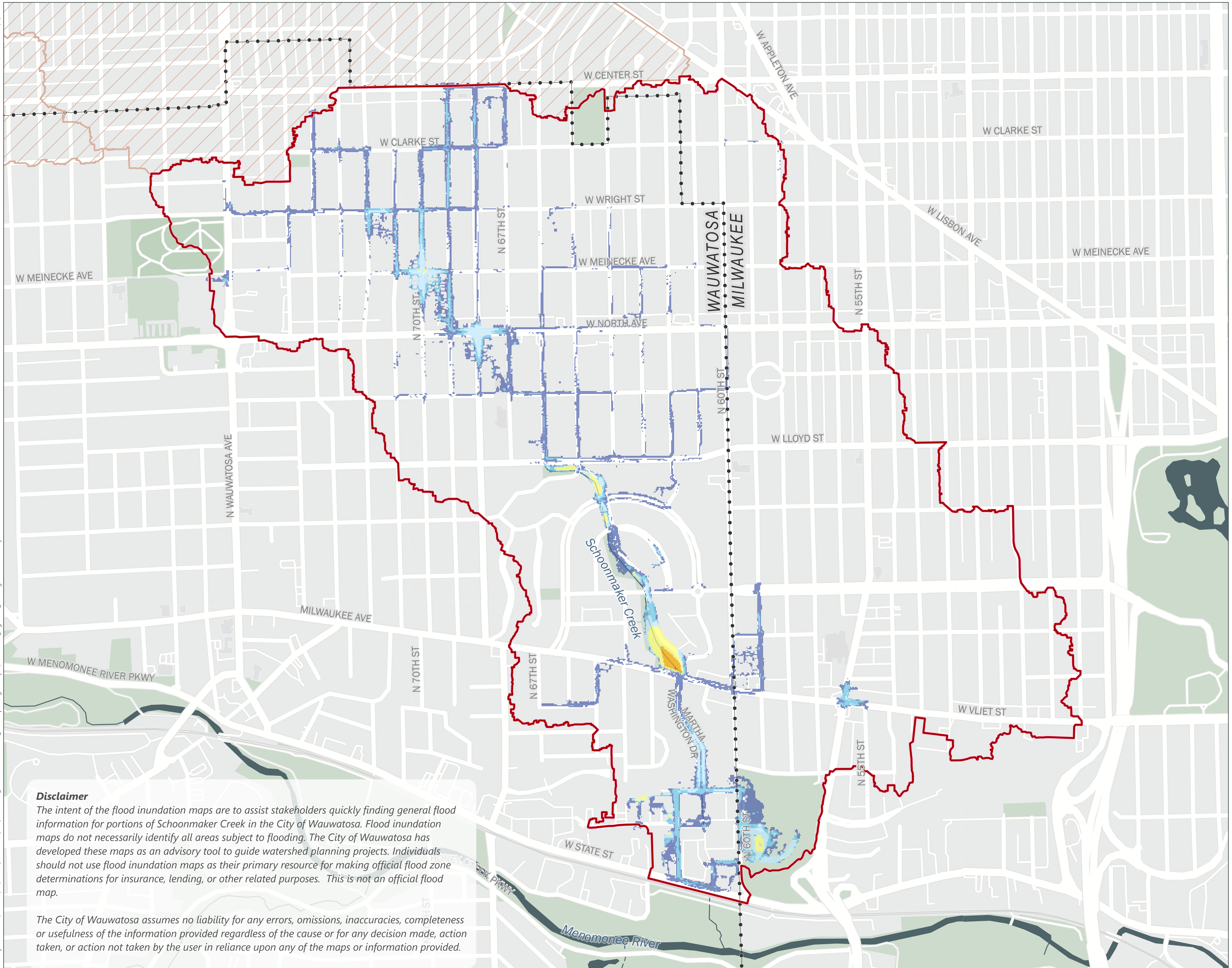
0 500 1,000 Feet

Print Date: 10/9/2024

Existing Conditions 10-yr, 24-hr Event

Figure 13

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary

XPSWMM Model Area

PCSWMM Model Area

Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 7
- 7+

Disclaimer

The intent of the flood inundation maps are to assist stakeholders quickly finding general flood information for portions of Schoonmaker Creek in the City of Wauwatosa. Flood inundation maps do not necessarily identify all areas subject to flooding. The City of Wauwatosa has developed these maps as an advisory tool to guide watershed planning projects. Individuals should not use flood inundation maps as their primary resource for making official flood zone determinations for insurance, lending, or other related purposes. This is not an official flood map.

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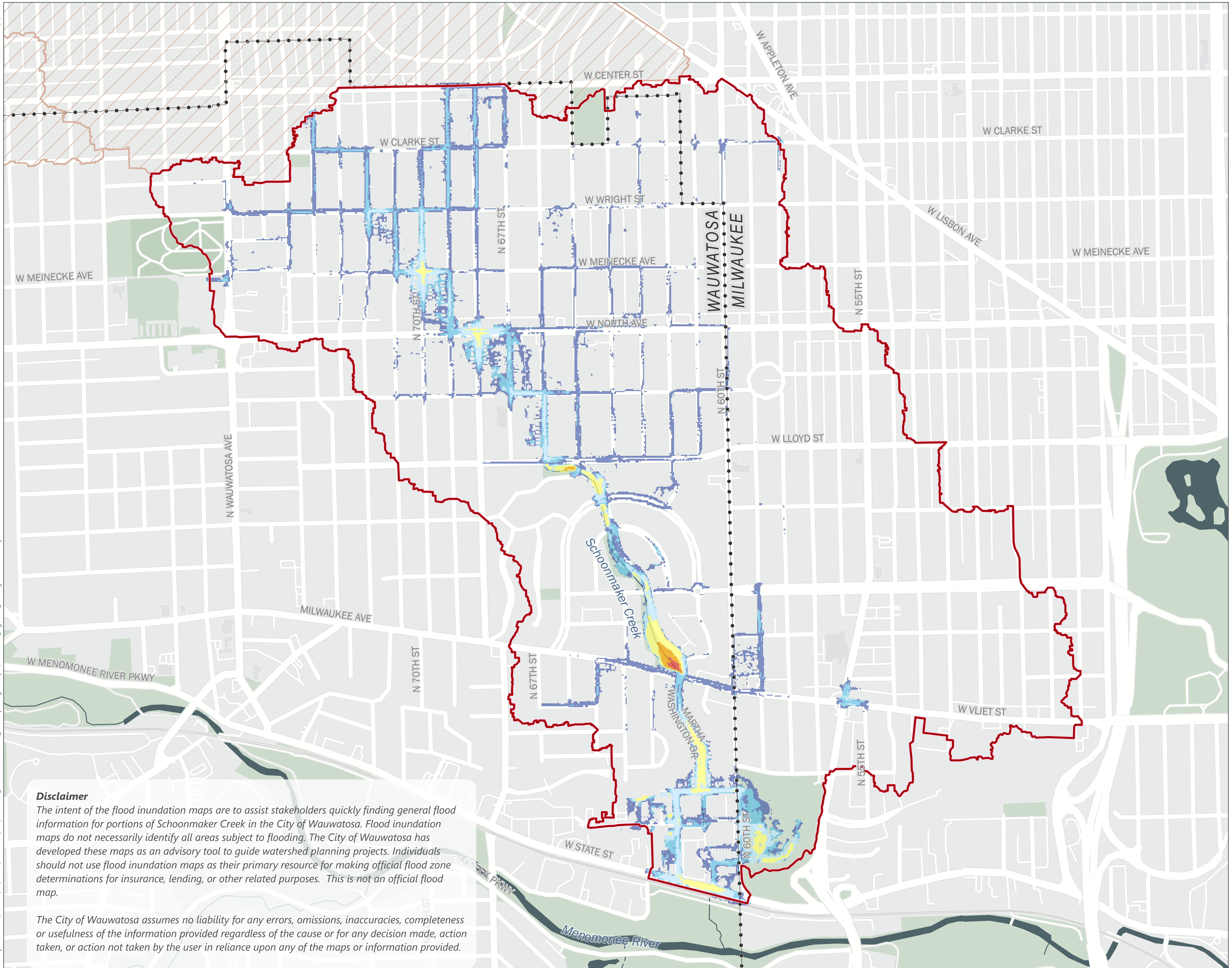
0 500 1,000 Feet

Print Date: 10/9/2024

Existing Conditions 25-yr, 24-hr Event

Figure 13

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary

XPSWMM Model Area

PCSWMM Model Area

Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 7
- 7+

Disclaimer

The intent of the flood inundation maps are to assist stakeholders quickly finding general flood information for portions of Schoonmaker Creek in the City of Wauwatosa. Flood inundation maps do not necessarily identify all areas subject to flooding. The City of Wauwatosa has developed these maps as an advisory tool to guide watershed planning projects. Individuals should not use flood inundation maps as their primary resource for making official flood zone determinations for insurance, lending, or other related purposes. This is not an official flood map.

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Data Sources:
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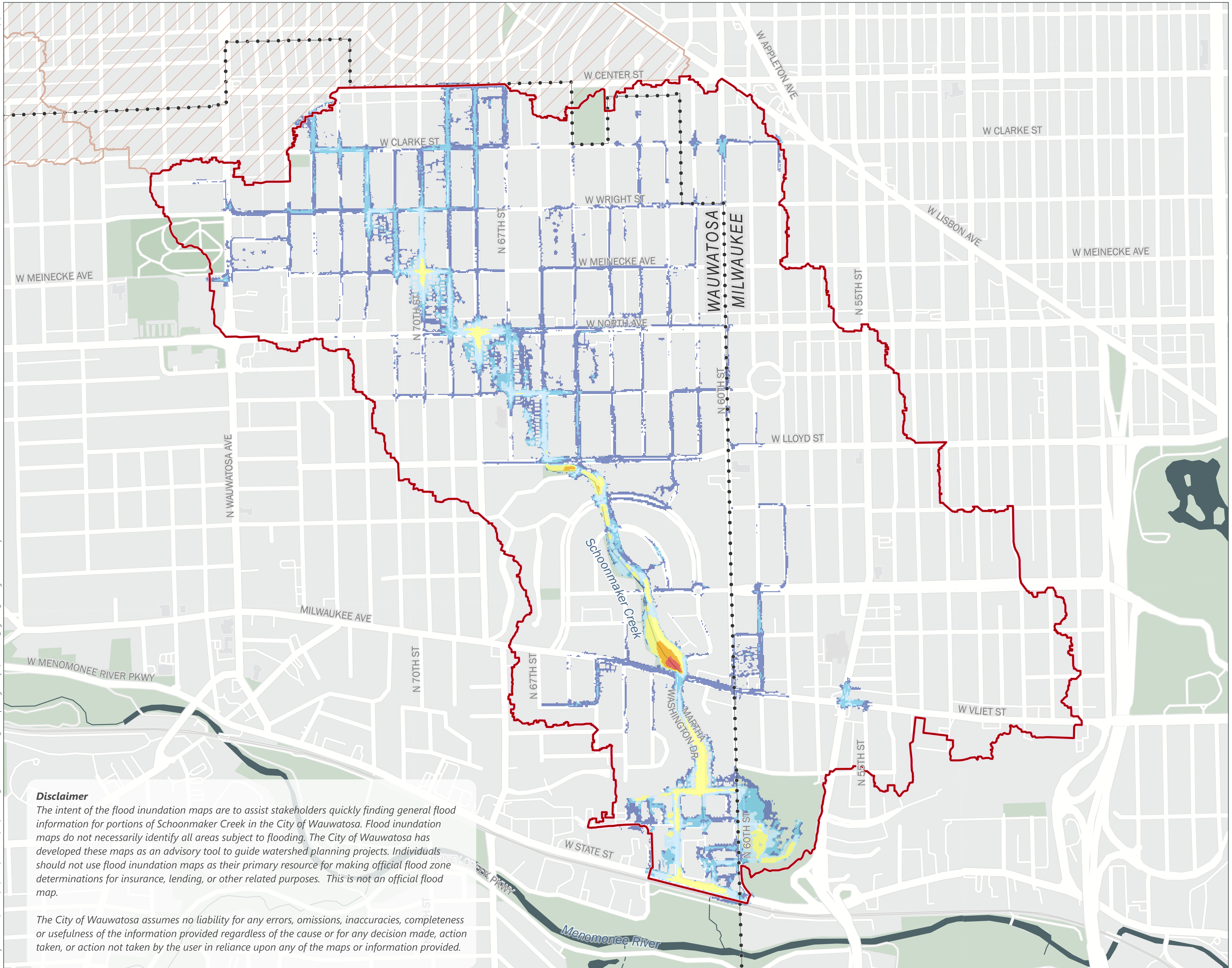
Print Date: 10/9/2024

Existing Conditions
50-yr, 24-hr Event

Figure 15

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Disclaimer

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Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area

Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 7
- 7+

Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

0 500 1,000 Feet

N

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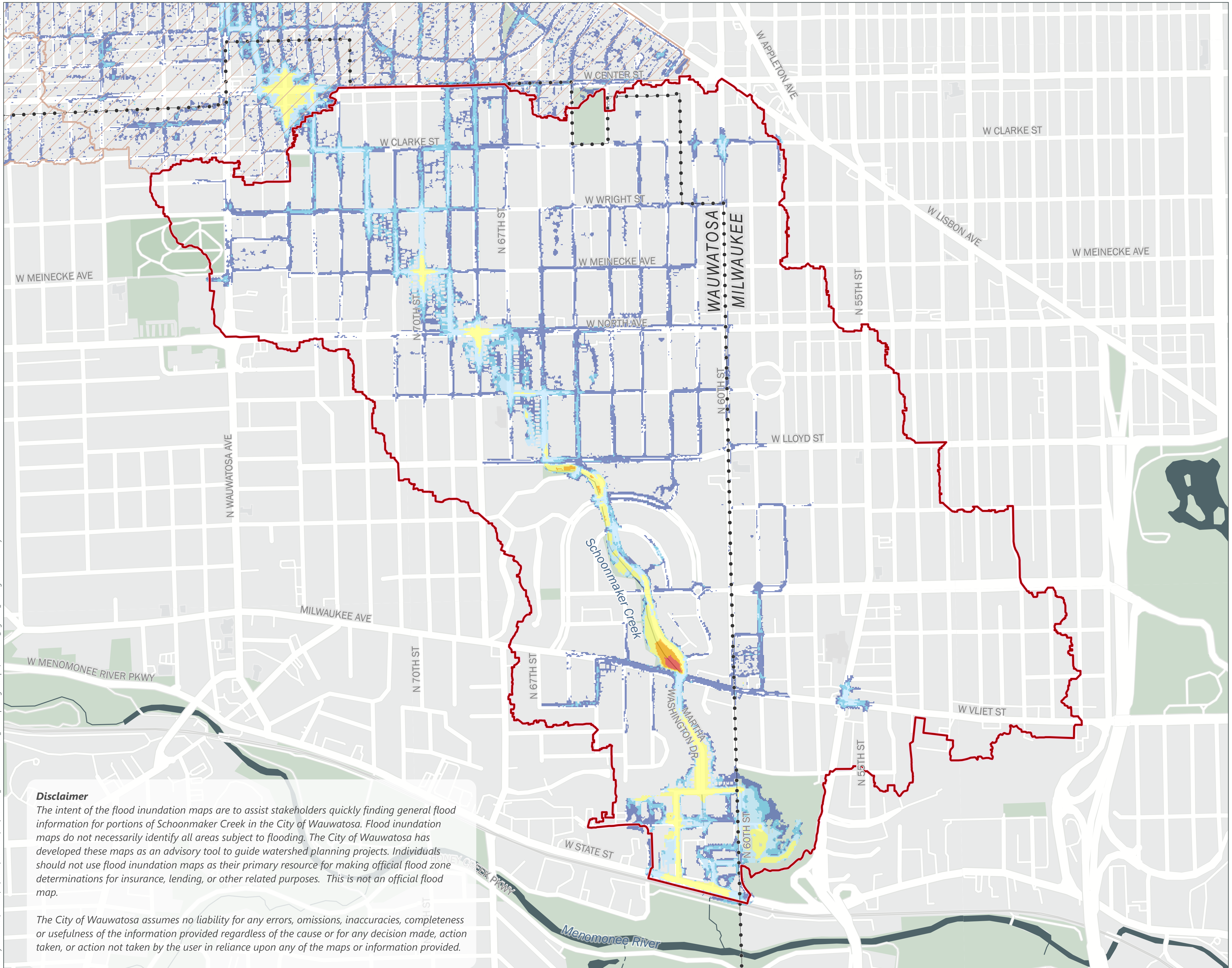
Existing Conditions
100-yr, 24-hr Event

Figure 16

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Disclaimer

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Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

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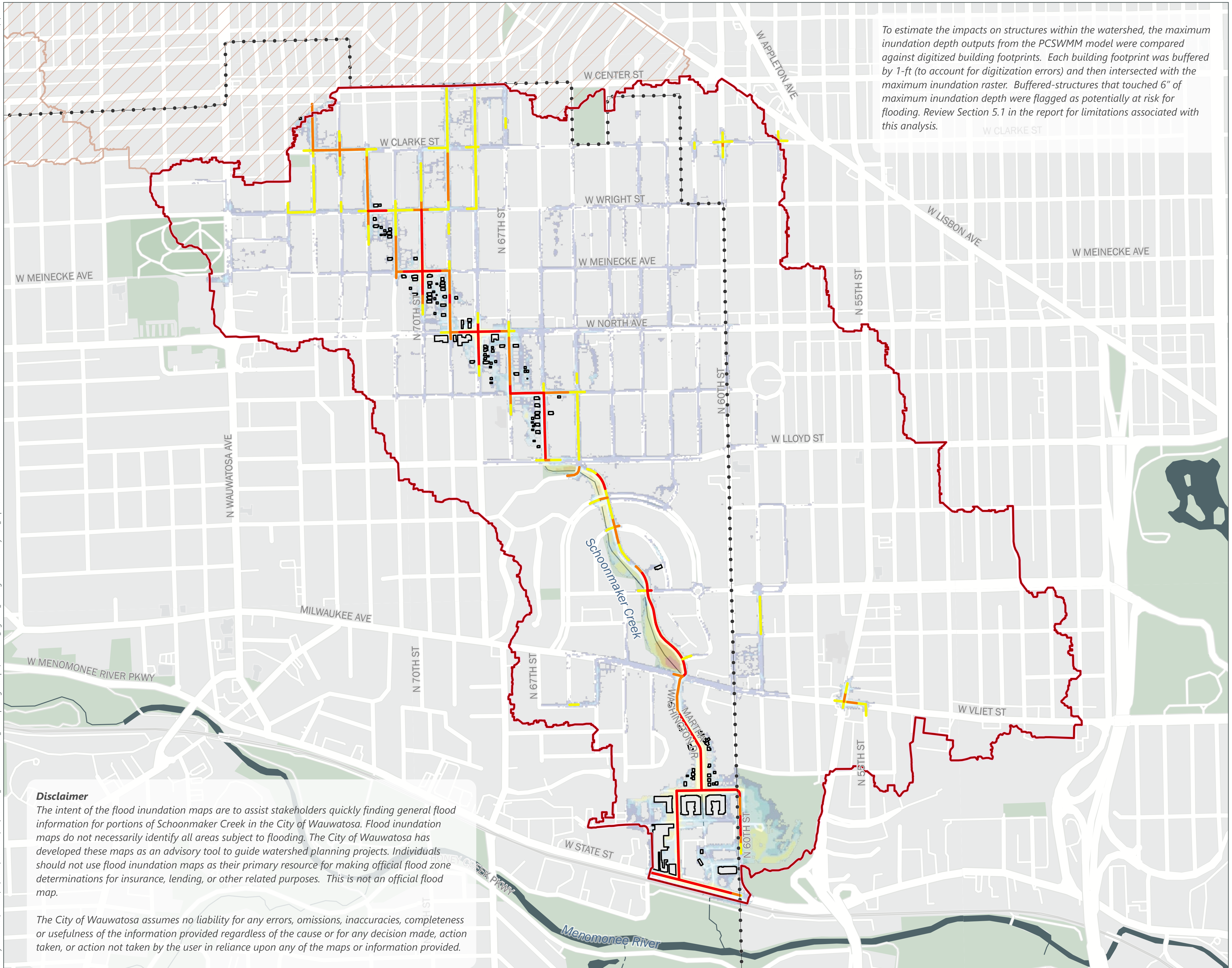
Existing Conditions
100-yr, 24-hr Event
Impacted Structures/Roads

Figure 17

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI

To estimate the impacts on structures within the watershed, the maximum inundation depth outputs from the PCSWMM model were compared against digitized building footprints. Each building footprint was buffered by 1-ft (to account for digitization errors) and then intersected with the maximum inundation raster. Buffered-structures that touched 6" of maximum inundation depth were flagged as potentially at risk for flooding. Review Section 5.1 in the report for limitations associated with this analysis.



Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area

Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 7
- 7+

Mean Water at Road Centerline

- 0.5 - 1.0
- 1.1 - 1.5
- 1.6+

Potentially Impacted Structure (more than 6" inundation)

Disclaimer
The intent of the flood inundation maps are to assist stakeholders quickly finding general flood information for portions of Schoonmaker Creek in the City of Wauwatosa. Flood inundation maps do not necessarily identify all areas subject to flooding. The City of Wauwatosa has developed these maps as an advisory tool to guide watershed planning projects. Individuals should not use flood inundation maps as their primary resource for making official flood zone determinations for insurance, lending, or other related purposes. This is not an official flood map.

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Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

0 500 1,000 Feet

N

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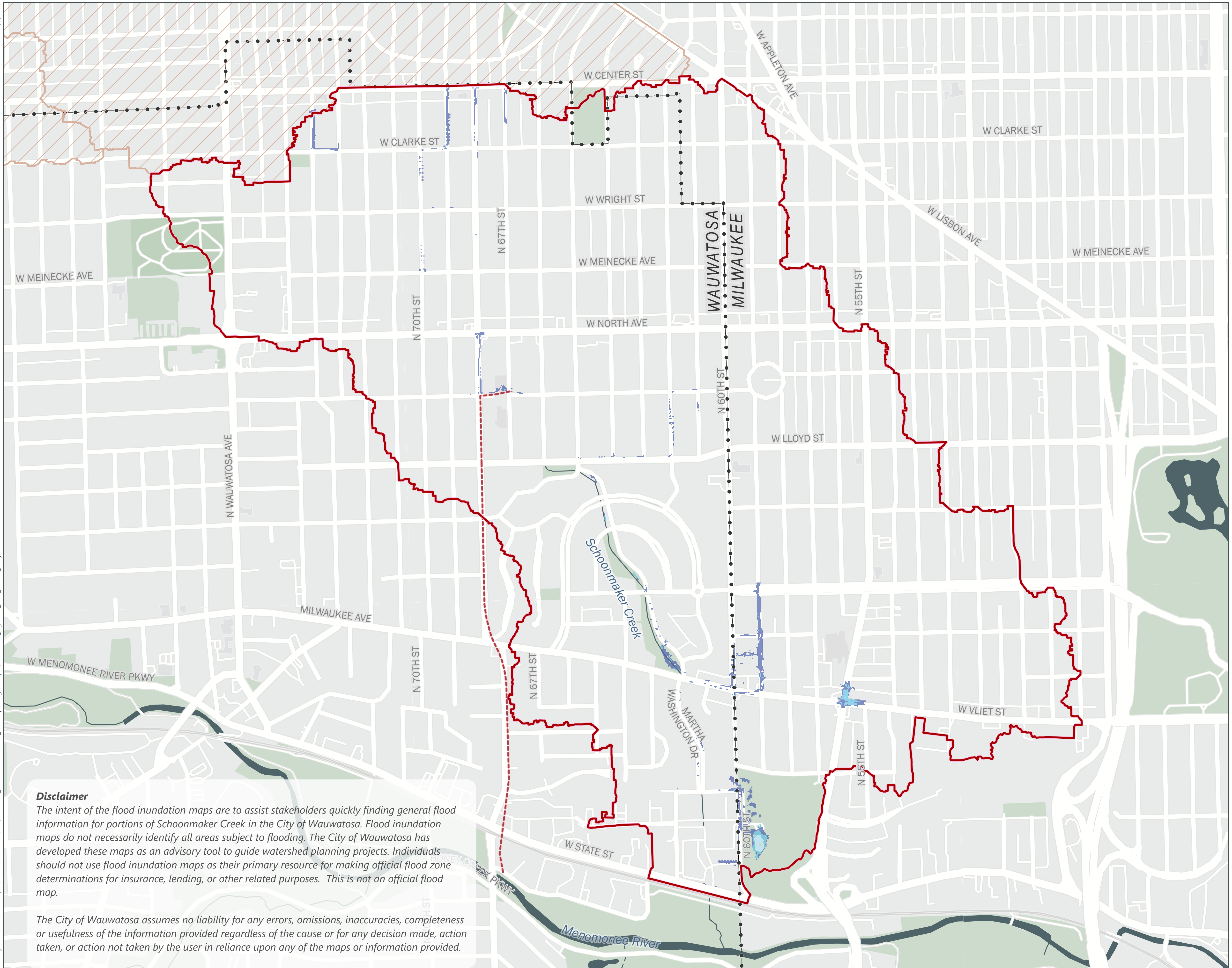
Option A: Tunnel 1-yr, 24-hr Event

Figure 18

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Disclaimer

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Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
Alt A: Deep Tunnel

Inundation Depth (ft)

0.1 - 0.5
0.5 - 1
1 - 2
2 - 5
5 - 7
7+

Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

0 500 1,000 Feet

Print Date: 10/9/2024

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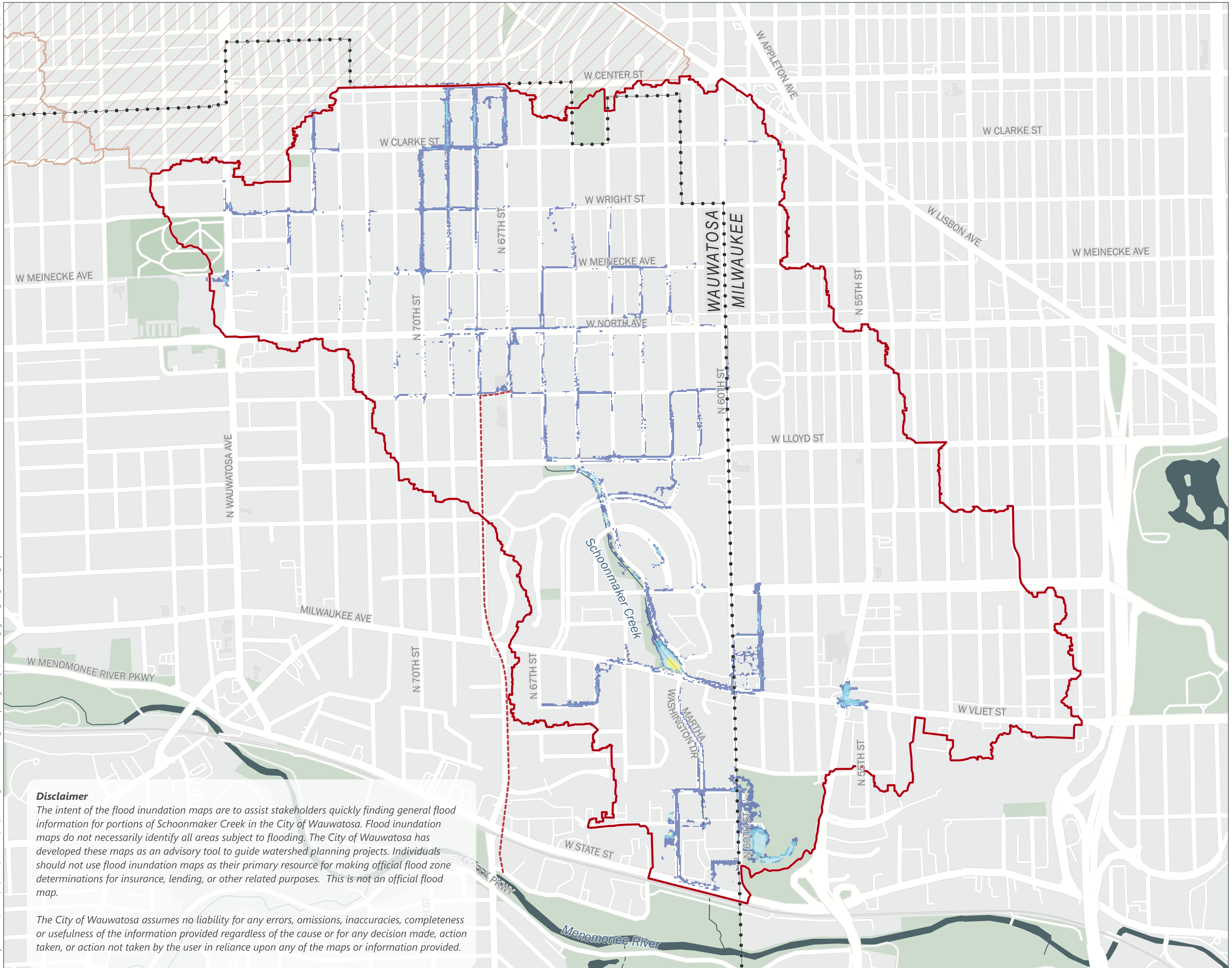
Option A: Tunnel 10-yr, 24-hr Event

Figure 19

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Disclaimer

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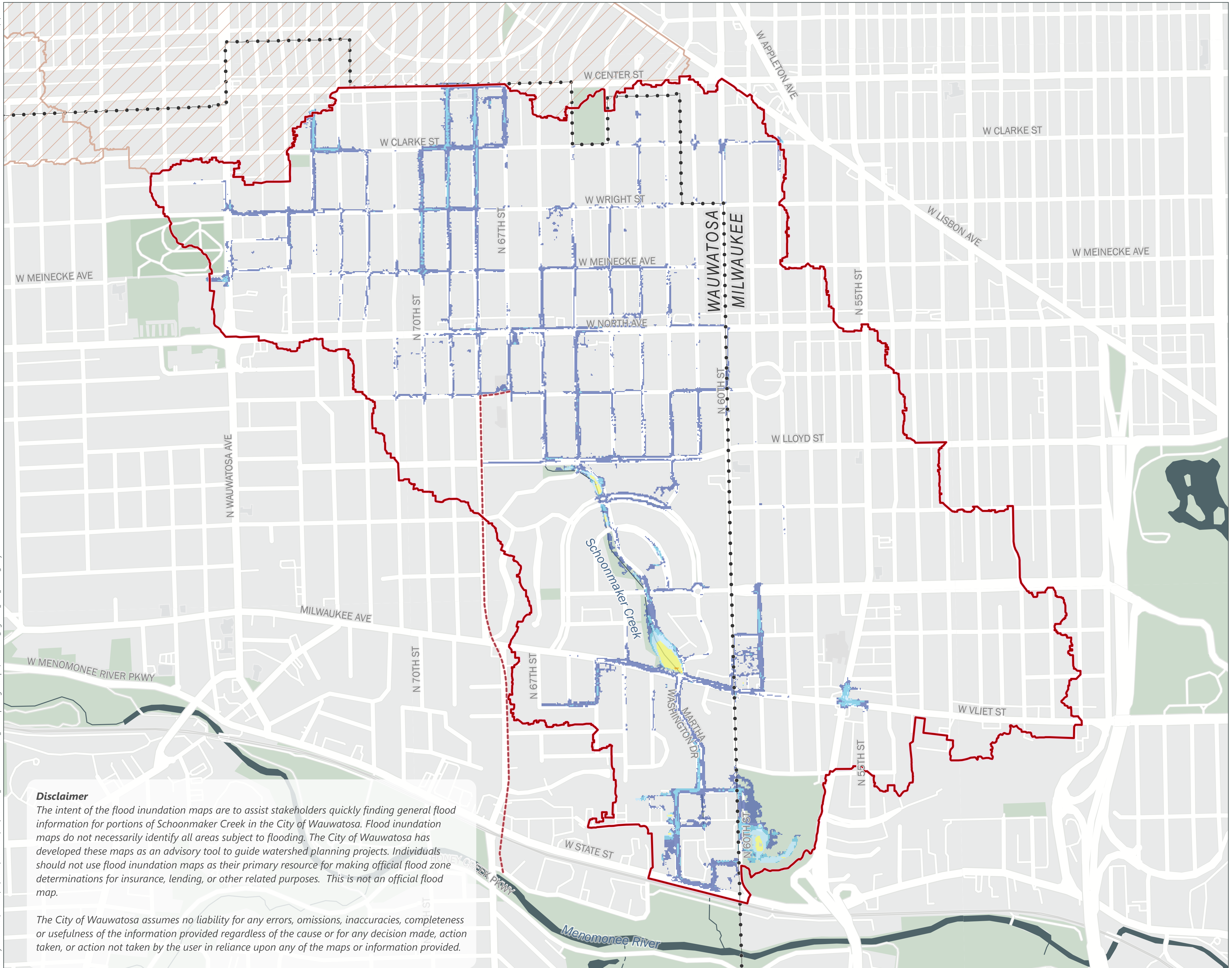
Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

Option A: Tunnel
25-yr, 24-hr Event

Figure 20

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
Alt A: Deep Tunnel

Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 7
- 7+

Disclaimer

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Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

0 500 1,000 Feet

N

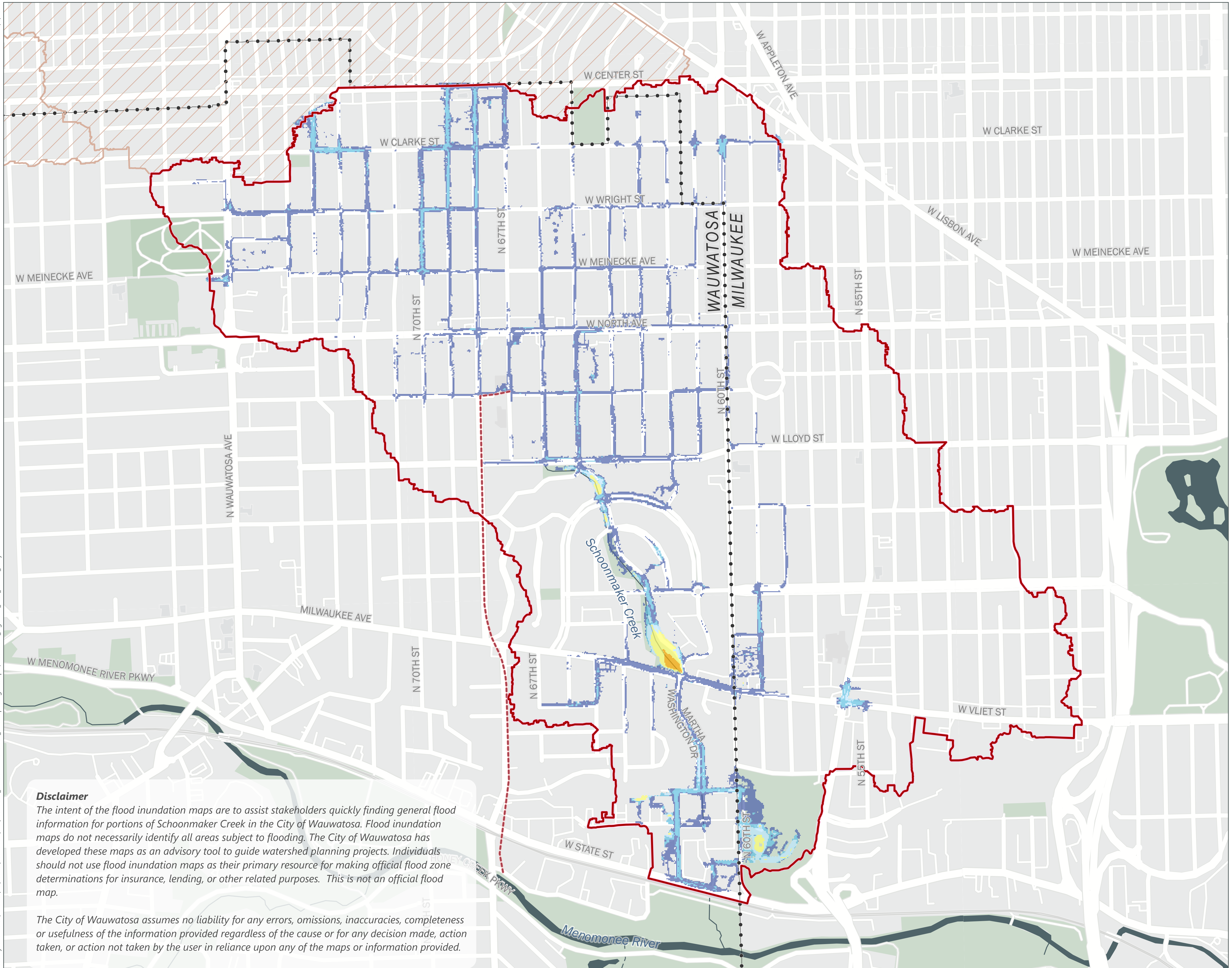
Print Date: 10/9/2024

Printed By: aconverse, File: G:\10\10310\10310004\GIS\10310004_SchoonmakerCreek_FinalReportFigures.aprx, 10310004_Figure20_AltA_Tunnel_025yr24hr

Option A: Tunnel 50-yr, 24-hr Event

Figure 21

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Disclaimer

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Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
Alt A: Deep Tunnel

Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 7
- 7+

Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

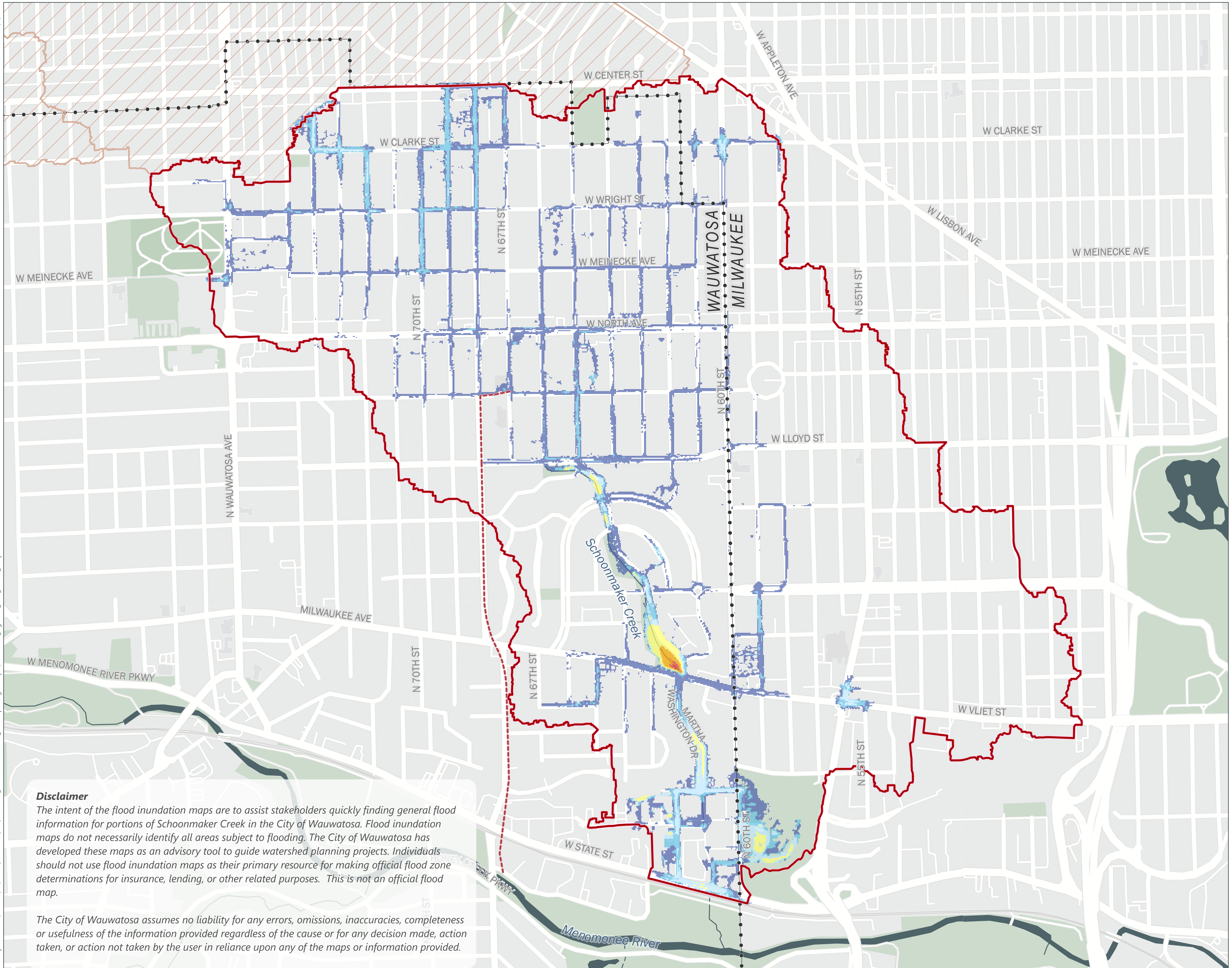
0 500 1,000 Feet

N

Option A: Tunnel
100-yr, 24-hr Event

Figure 22

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
Alt A: Deep Tunnel

Inundation Depth (ft)

0.1 - 0.5
0.5 - 1
1 - 2
2 - 5
5 - 7
7+

Disclaimer

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Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

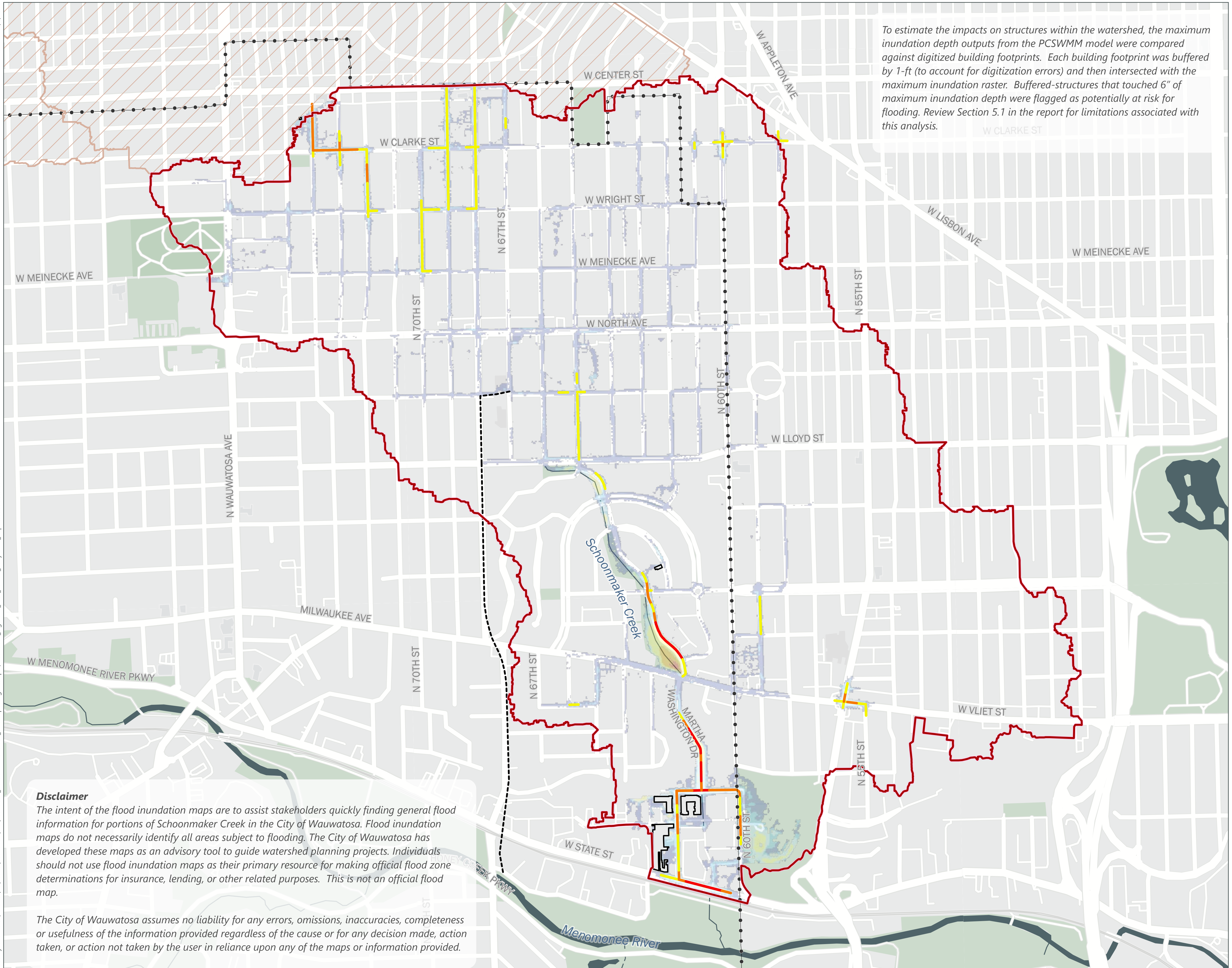
0 500 1,000 Feet

Print Date: 10/9/2024

Option A: Tunnel
100-yr, 24-hr Event
Impacted Structures/Roads

Figure 23

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



To estimate the impacts on structures within the watershed, the maximum inundation depth outputs from the PCSWMM model were compared against digitized building footprints. Each building footprint was buffered by 1-ft (to account for digitization errors) and then intersected with the maximum inundation raster. Buffered-structures that touched 6" of maximum inundation depth were flagged as potentially at risk for flooding. Review Section 5.1 in the report for limitations associated with this analysis.

Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
Alt A: Deep Tunnel

Inundation Depth (ft)

0.1 - 0.5
0.5 - 1
1 - 2
2 - 5
5 - 7
7+

Mean Water at Road Centerline

0.5 - 1.0
1.1 - 1.5
1.6+

Potentially Impacted Structure (more than 6" inundation)

Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

Disclaimer

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MSA

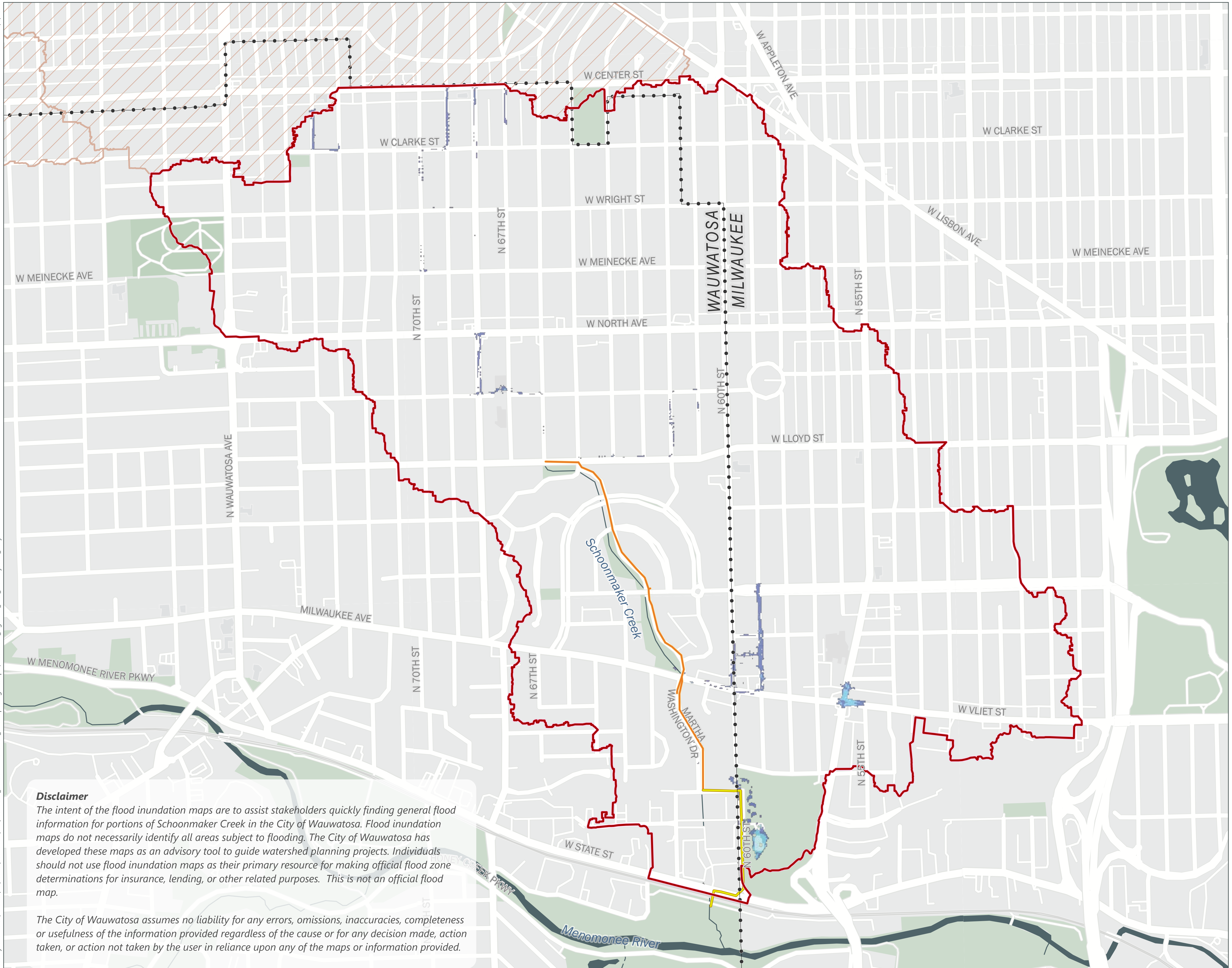
0 500 1,000 Feet

Print Date: 10/9/2024

Opt B: Storm Sewer 1-yr, 24-hr Event

Figure 24

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary

XPSWMM Model Area

PCSWMM Model Area

Alt B: Storm System (6x12 Box)

Alt B: Storm System (6x16 Box)

Inundation Depth (ft)

0.1 - 0.5

0.5 - 1

1 - 2

2 - 5

5 - 7

7+

Disclaimer

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Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

0 500 1,000 Feet

N

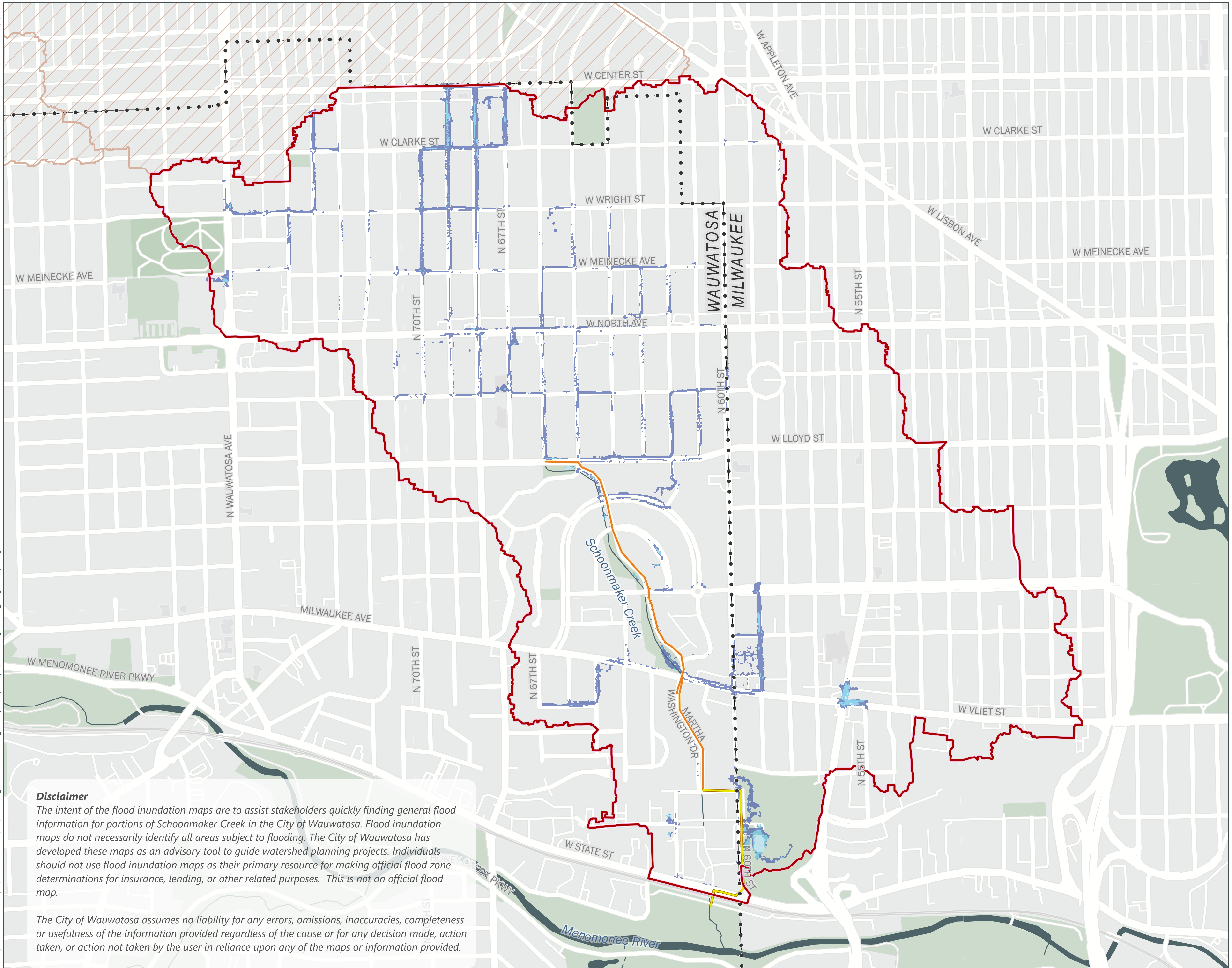
Print Date: 10/9/2024

Printed By: aconverse, File: G:\10\10310\10310004\10310004_SchoonmakerCreek\GIS\10310004_SchoonmakerCreek_FinalReportFigures.aprx, 10310004_Figure24_AltB_StormSystem_001yr24hr

Opt B: Storm Sewer 10-yr, 24-hr Event

Figure 25

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
Alt B: Storm System (6x12 Box)
Alt B: Storm System (6x16 Box)

Inundation Depth (ft)

0.1 - 0.5
0.5 - 1
1 - 2
2 - 5
5 - 7
7+

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Data Sources:
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Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

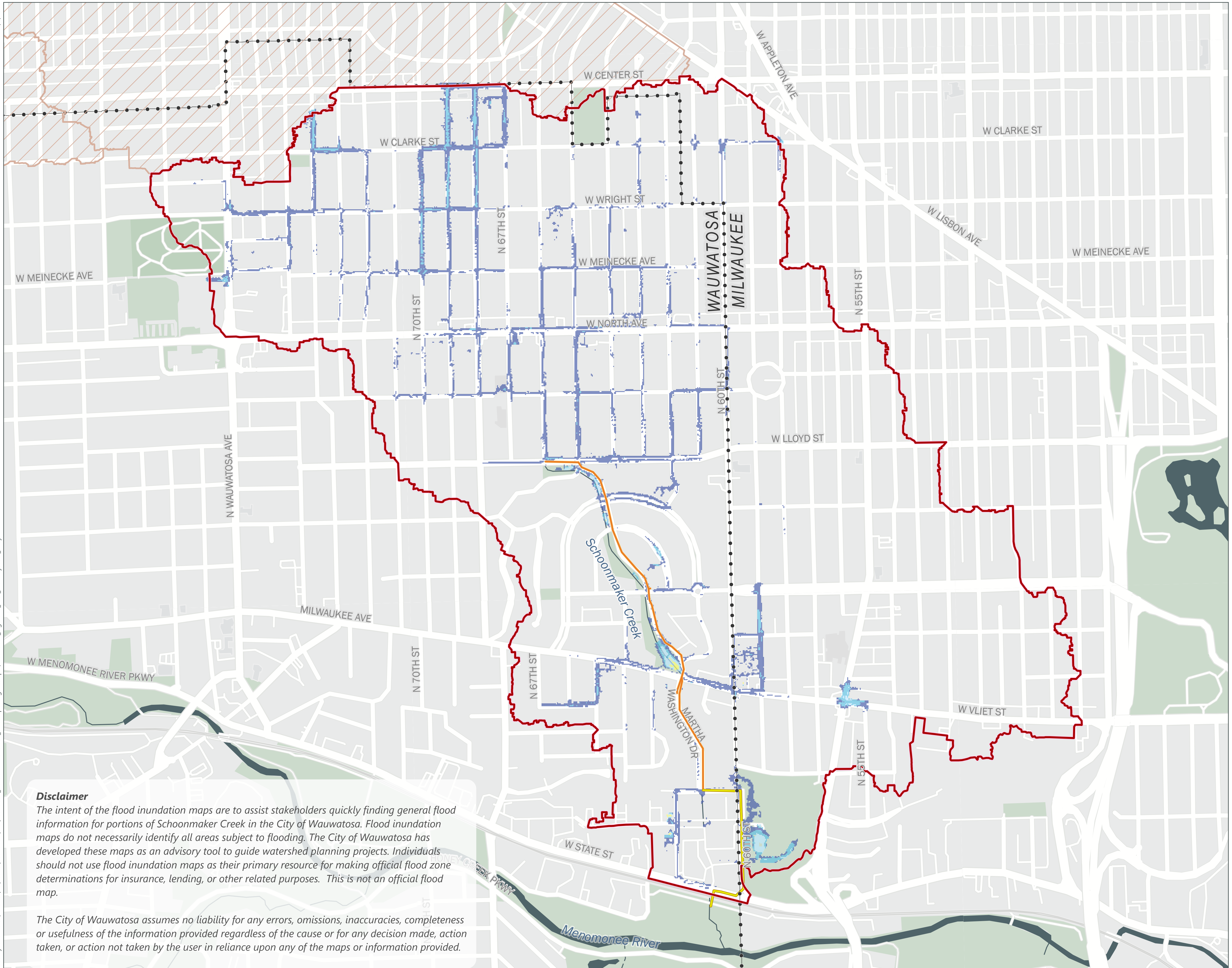
MSA

0 500 1,000 Feet

Opt B: Storm Sewer 25-yr, 24-hr Event

Figure 26

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



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Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
Alt B: Storm System (6x12 Box)
Alt B: Storm System (6x16 Box)

Inundation Depth (ft)

0.1 - 0.5
0.5 - 1
1 - 2
2 - 5
5 - 7
7+

Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

0 500 1,000 Feet

Print Date: 10/9/2024

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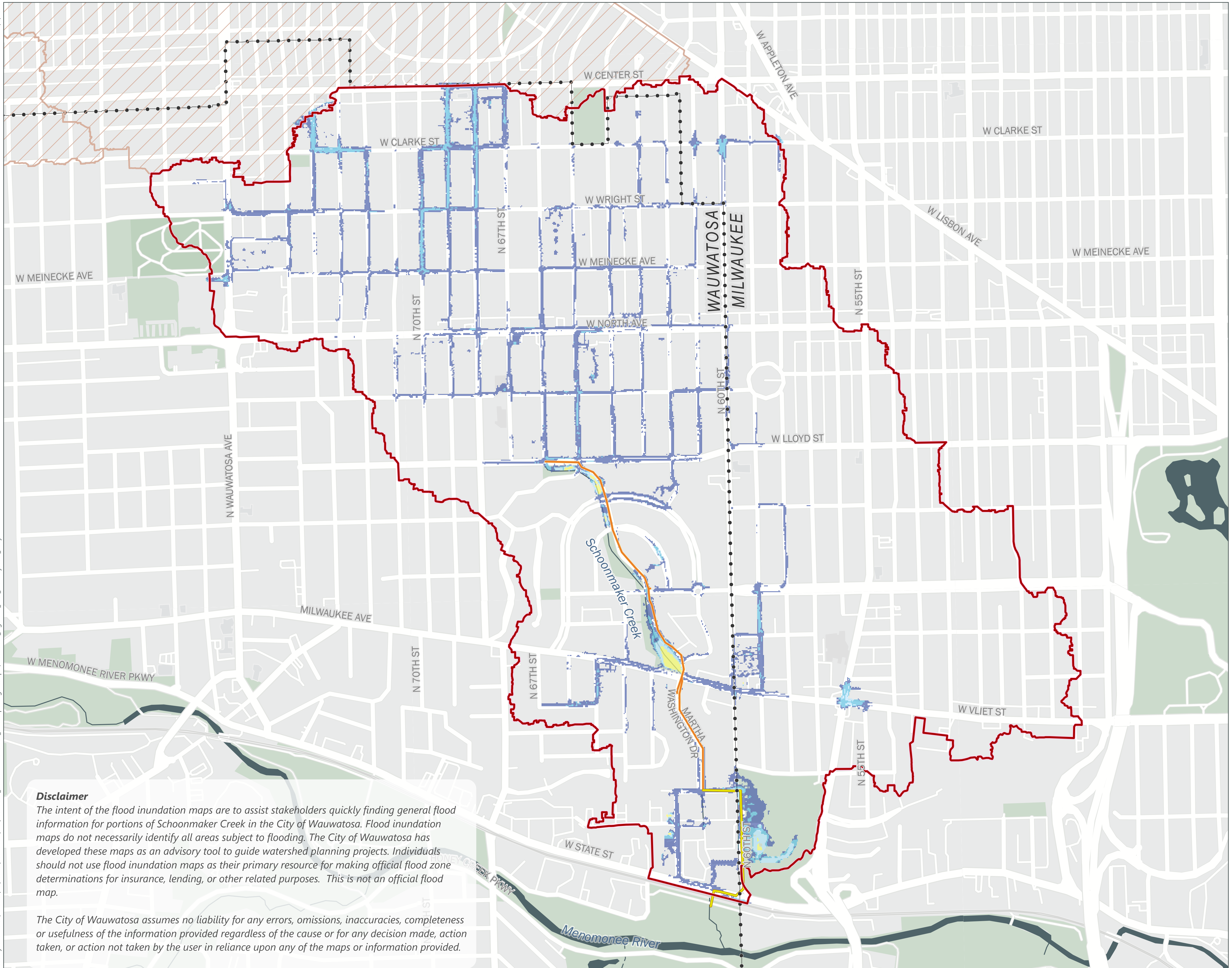
Opt B: Storm Sewer 50-yr, 24-hr Event

Figure 27

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary

XPSWMM Model Area

PCSWMM Model Area

Alt B: Storm System (6x12 Box)

Alt B: Storm System (6x16 Box)

Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 7
- 7+

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Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

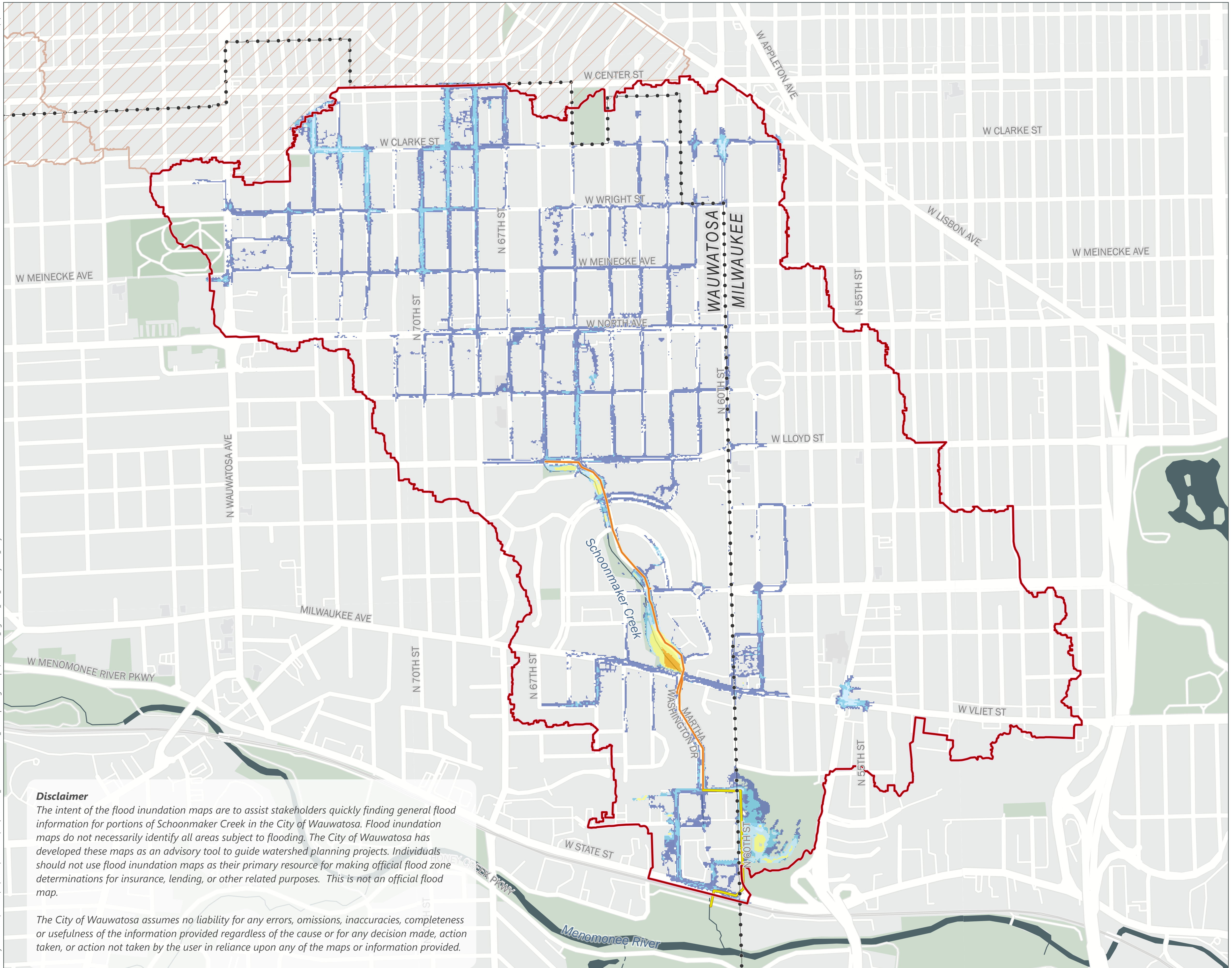
0 500 1,000 Feet

Print Date: 10/9/2024

Opt B: Storm Sewer 100-yr, 24-hr Event

Figure 28

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary

XPSWMM Model Area

PCSWMM Model Area

Alt B: Storm System (6x12 Box)

Alt B: Storm System (6x16 Box)

Inundation Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 7
- 7+

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Data Sources:
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Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

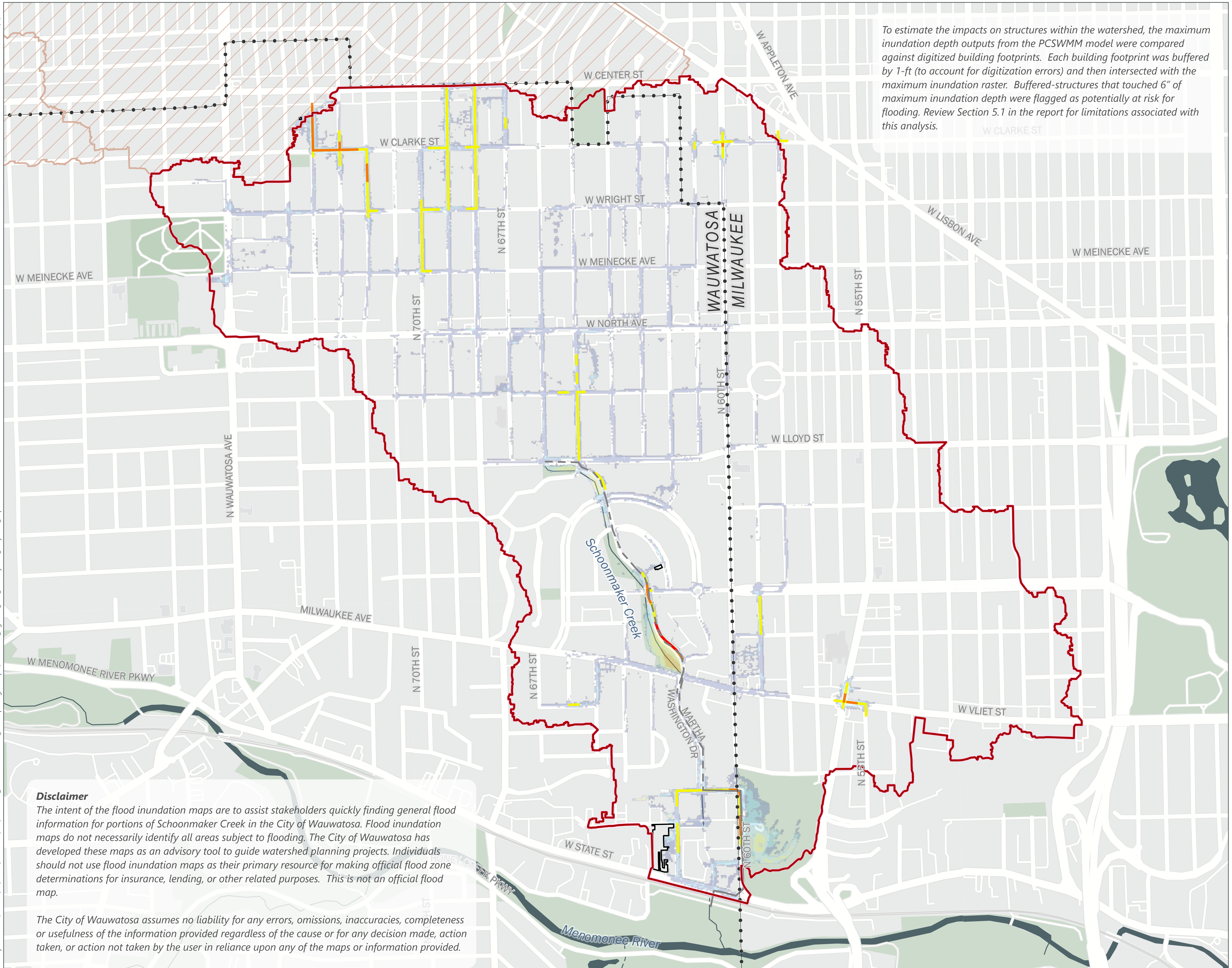
0 500 1,000 Feet

Print Date: 10/9/2024

Opt B: Storm Sewer
100-yr, 24-hr Event
Impacted Structures/Roads

Figure 29

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



To estimate the impacts on structures within the watershed, the maximum inundation depth outputs from the PCSWMM model were compared against digitized building footprints. Each building footprint was buffered by 1-ft (to account for digitization errors) and then intersected with the maximum inundation raster. Buffered-structures that touched 6" of maximum inundation depth were flagged as potentially at risk for flooding. Review Section 5.1 in the report for limitations associated with this analysis.

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Municipal Boundary
XPSWMM Model Area
PCSWMM Model Area
Alt B: Storm System (6x12 Box)
Alt B: Storm System (6x16 Box)

Inundation Depth (ft)

0.1 - 0.5
0.5 - 1
1 - 2
2 - 5
5 - 7
7+

Mean Water at Road Centerline

0.5 - 1.0
1.1 - 1.5
1.6+

Potentially Impacted Structure (more than 6" inundation)

Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

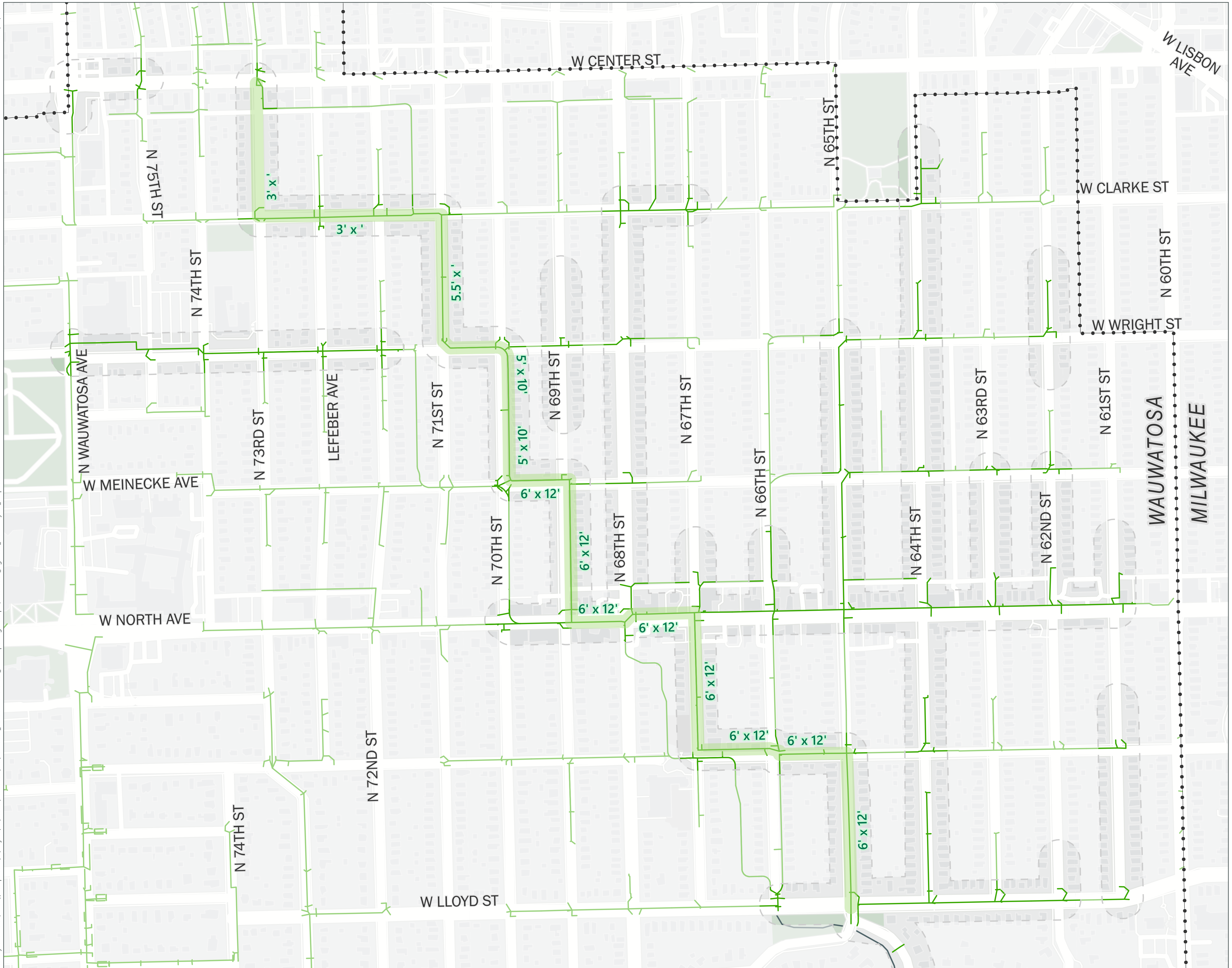
0 500 1,000 Feet

Print Date: 10/9/2024

Proposed Storm North of W Lloyd St

Figure 30

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary

100-ft Buffer, All Proposed Utility Improvements

Proposed Storm Pipes, Increased Capacity N of Lloyd St

Existing Storm Pipe

Data Sources:
Municipal Boundaries: Milwaukee County
Storm System: Wauwatosa
Proposed Storm: MSA
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

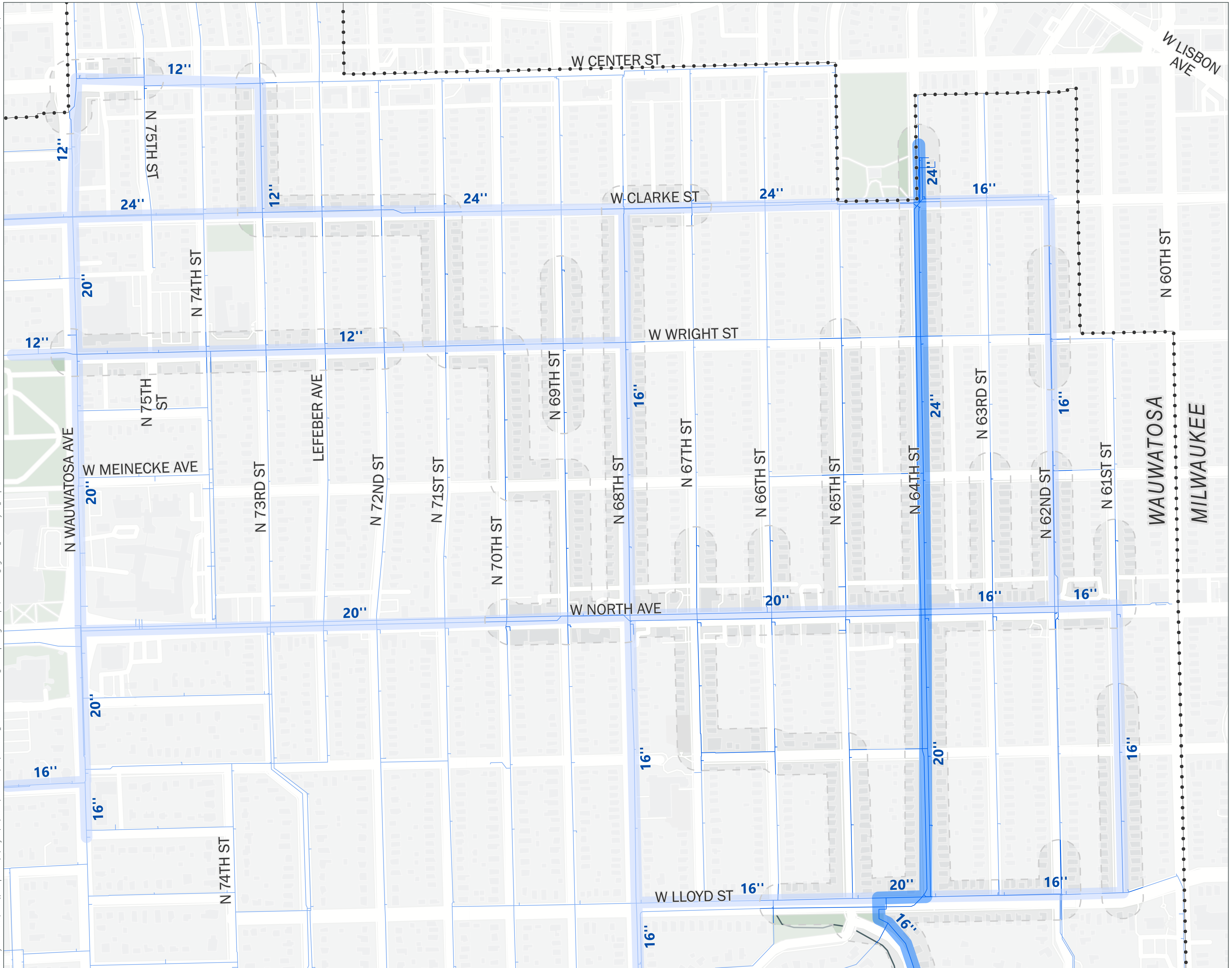
MSA

0 225 450 Feet

Proposed Water North of W Lloyd St

Figure 31

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary

100-ft Buffer, All Proposed Utility Improvements

Tosa Water Main Improvement, by Priority

High, drives reconstruction

Lower, only done if another improvement is needed

Water

Tosa Water Main

Data Sources:
Municipal Boundaries: Milwaukee County
Water System: Wauwatosa
Proposed Water Mains: Wauwatosa
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

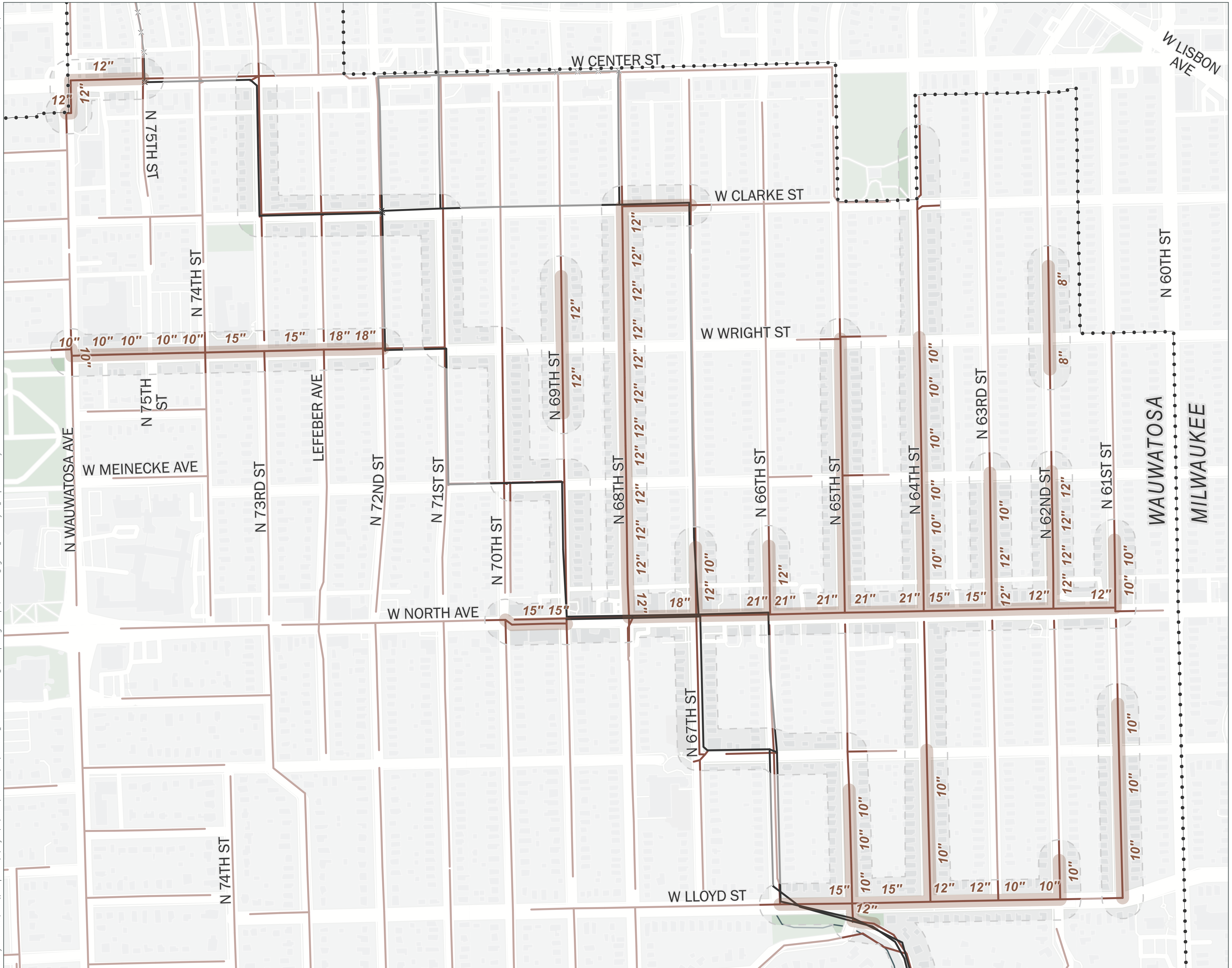
0 225 450 Feet

N

Proposed Sanitary North of W Lloyd St

Figure 32

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary

100-ft Buffer, All Proposed Utility Improvements

Alt A Tosa Sanitary Improvement (2011), with labeled sizing

Sanitary

Tosa Sanitary Main

MMSD Pipe, by Status

Active

Transferred

Retired in Place

Data Sources:
Municipal Boundaries: Milwaukee County
Sanitary System: Wauwatosa
Proposed Sanitary: Brown and Caldwell 20211 Report, on behalf of Wauwatosa
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

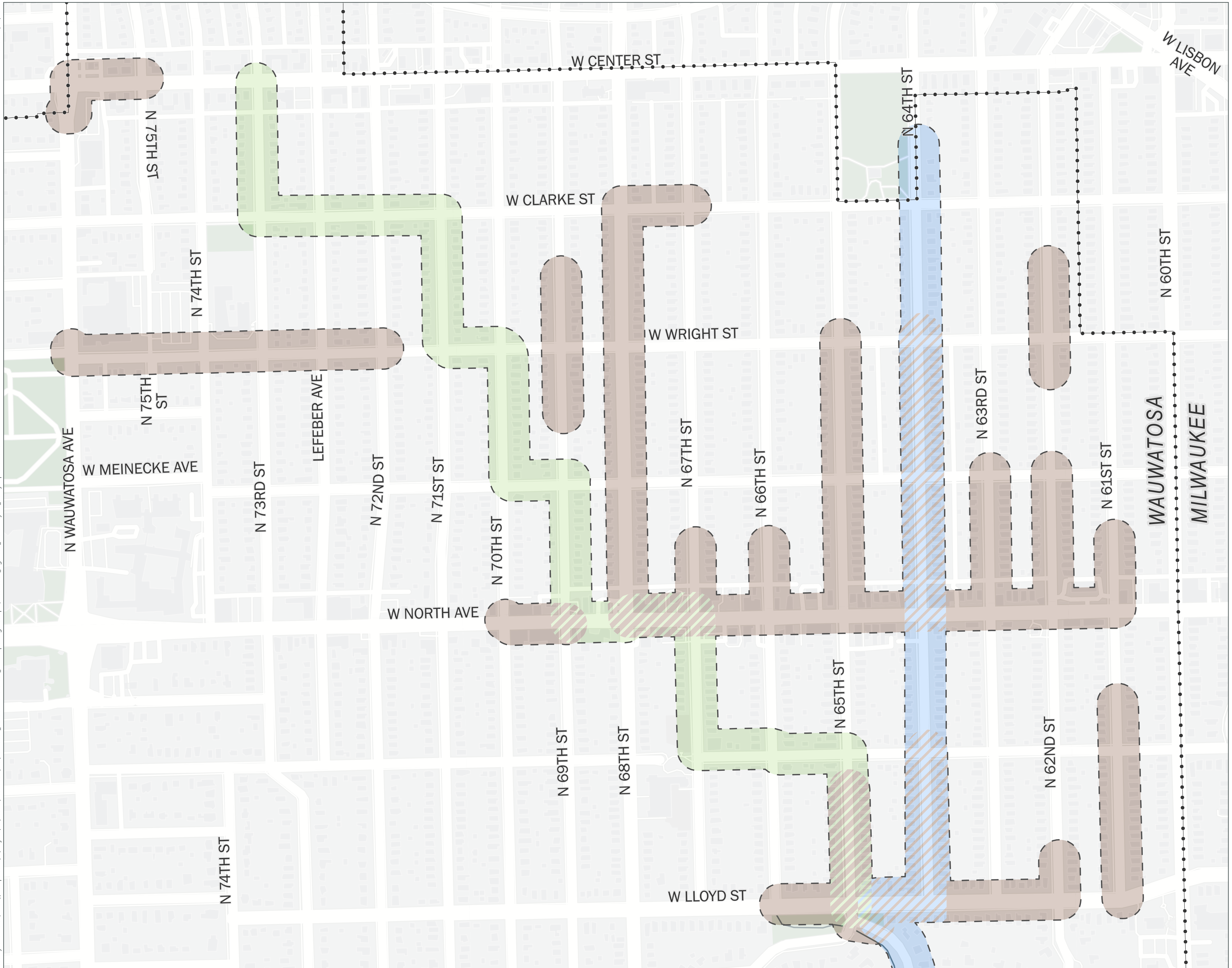
MSA

0 225 450 Feet

Utility Improvements North of W Lloyd St

Figure 33

Schoonmaker Creek Watershed Study
Wauwatosa, Milwaukee County, WI



Municipal Boundary

100-ft Buffer, All Proposed Utility Improvements

Utility that Drives Street Reconstruction

Sanitary

Storm

Water

Sanitary & Storm

Sanitary & Water

Sanitary & Water & Storm

Data Sources:
Municipal Boundaries: Milwaukee County
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

MSA

0 225 450 Feet

Appendix A. CDM Smith Preliminary Tunnel Alignment Evaluation

CDM Smith

WISCONSIN
GREGORY SANDERS
E-47148-6
KANSAS CITY MO
PROFESSIONAL ENGINEER

Memorandum

To: *Mike Steiner*

From: *Greg Sanders, P.E. (CDM Smith)*

Date: *4/8/24*

Subject: *Preliminary Tunnel Alignment Evaluation – Schoonmaker Creek Watershed Project*

1. Introduction and Background

CDM Smith Inc. (CDM Smith) has prepared this Technical Memorandum (TM) as part of the preliminary design of the Schoonmaker Creek Watershed Project (the Project) for the City of Wauwatosa, Wisconsin. This memorandum was prepared to document the evaluation and recommendations for the possible future tunnel alignment. This TM is being submitted as draft at this time since there are ongoing subsurface investigations that are and will be completed this year and the results of these may change some of the conclusions and recommendations included here. This technical memorandum will evaluate the alignment feasibility and analyze potential construction methods as well as provide special requirements and an estimate of probable construction costs. Elevations (El.) herein are in feet and referenced to the Milwaukee Vertical Datum. The Milwaukee Vertical Datum can be converted to the North American Vertical Datum of 1988 (NAVD 88) by adding 580.327 feet. Stations (STA) herein are also referenced in feet.

1.1 Project Description

The Schoonmaker Creek watershed is made up of roughly 1,100 acres (1.7 square miles) in the City of Wauwatosa and the City of Milwaukee. Historically the Schoonmaker Creek flowed in open channels from 74th and Center to the Menomonee River near 60th and State. Currently the creek now flows through a combination of open channel and underground stormwater sewer systems that daylight just south of West State Street where Schoonmaker Creek discharges to the Menomonee River.

The watershed has experienced numerous heavy storm events since 1986, causing flooding to streets, homes, and businesses due to undersized storm sewer capacity, a confined open channel, and inadequate enclosure capacity at the downstream end of the watershed. The goal of this portion of the project is to determine the most advantageous tunnel alternative to convey stormwater within the Schoonmaker Creek Watershed from the vicinity of 65th Street and Lloyd Street to the Menomonee River. Based on the initial modeling a internal tunnel diameter of 10 feet will be required.

1.2 Project Location

The Project is located within the City of Wauwatosa, Wisconsin. The alignment study covered by the memorandum extends from West Garfield Avenue in the north to the Menomonee River in the south and 58th street in the East to 70th street in the West.

2. Project Geology and Subsurface Conditions

2.1 Geology

The soil deposits overlying bedrock in Milwaukee County consists of glacial soils believed to consist of soils deposited during the Kansas, Illinoian, and Iowan, and Wisconsin glaciations. The soils deposited by each ice advance generally formed sheets of uniform material composition and are continuous over a large area. In some locations the individual deposits are separated by lacustrine and outwash deposits from interglacial intervals.

A series of north-south trending end moraines are also present in the area. The youngest deposits consist of silty clay and silty sands. Underlying the earlier formations, there are older deposits of a brown or reddish-brown very dense clay. This clay may contain some boulders and cobbles and may be laminated. It is thought that the compactness of this clay may be due to it having been overridden by later glaciation. Where this clay is laminated with fine sands, the beds are greatly crumpled and contorted, likely due to an overlying glacier. During the cycles of glacial regression, varying thicknesses of stratified clays, sand, and gravel have been deposited above the dense brown clay.

2.2 Sources of Geotechnical Data

This evaluation is based on limited geotechnical information obtained from the desktop geotechnical evaluation of historical data and 12 new borings drilled for the Project by Gestra Engineering Inc. (Gestra). A total of 79 historical borings were provided by the city for review. Most of the existing data was located south of State Street and along N 60th street.
To supplement this data additional borings were drilled between December 27, 2023 and January 26, 2024.. A data report with the laboratory test results and boring information has been prepared by Gestra and is included as Appendix D. Only information documented in the boring logs was used to better understand the anticipated ground conditions.

2.2 Preliminary Interpretation of Subsurface Conditions

Initial evaluation of both the historical and new borings showed that the soils typically consisted of soft to very stiff, brown to gray, CLAY, sandy CLAY and silty SAND with various amount of gravel. SPT N-values in the sand layer ranged from 3 bl/ft to 90 bl/ft at the exploration locations. Within this general sandy matrix there are anticipated to be isolated pockets of gravel, cobbles and boulders, typical of outwash deposits. Some historical borings showed auger refusal at shallow depths (approximately 15 feet) while other nearby borings showed sandy soils to at least a depth of 30 feet. The auger refusals may have been due to either boulder and cobbles or a highly variable top of rock surface. Based on boring where top of rock was verified in the boring logs, it has been assumed that the auger refusals noted in some historical logs were likely due to boulders. However, sufficient borings have not been performed between stations 100+00 and 135+00 to adequately address the risk of encountering rock during the tunnel excavation. At this time, it is anticipated that the tunnel will be constructed in both the clay and silty sand stratums, with much of the alignment consisting of silty sands with some cobbles and boulders. The anticipated stratum along the proposed tunnel is shown on the figure in **Appendix A**. The final design should include an additional geotechnical investigation. This investigation should focus on obtaining more information at critical areas such as shaft locations, and address data gaps such as the frequency of boulders and top of rock elevations between stations 100+00 and 135+00.

3. Preliminary Construction Methods Evaluation

The new Stormwater Conveyance Sewer tunnel should be constructed using a tunnel boring machine (TBM). Non-mechanized methods such as hand mining or remote-controlled methods such Microtunneling are not suitable for this project. Non-mechanized methods are typically employed for shorter lengths, where economy can be achieved by not purchasing a TBM, and ground conditions have good excavation face stability allowing hand mining techniques. Likewise, Microtunneling is typically used for shorter tunnel segments than what is proposed for the current alignments. While alignment up to 3000 feet are frequently performed using micro tunneling, they require the use of intermediate jacking stations (IJS). Intermediate Jacking station are typically installed every 500 to 1000 linear feet of tunnel. Each time a new IJS is installed it slows the tunnel advancement rate. While tunnel lengths greater than 3000 feet are technically feasible using microtunneling, the slower production rate at long distances makes it not economically viable. Therefore, microtunneling has not been considered for this evaluation.

TBM's, or Conventional tunneling shields, generally fall into one of three categories: 1) open face shields, 2) open or closed face wheel cutter machines, and 3) pressurized face TBMs. Pressurized face TBM's generally fall into two categories, Earth Pressure Balance TBM's (EPBM) and Slurry TBM's.

Conventional soft ground tunneling involves the use of a shield or TBM to excavate the tunnel, provide support to the ground during excavation, a safe place to erect the initial tunnel support and final lining, and a means of controlling ground loss and associated surface settlement during tunneling operations. The tunnel can be constructed in one or two passes. In the two-pass system, the first pass consists of mining and installing an initial support and the second pass consists of constructing a final lining. The one pass system combines the initial support and final lining into a single system. The shield or TBM is advanced with hydraulic jacks that push against the initial supports or one-pass lining system that is erected in the tail of the shield or TBM.

Conventional tunneling systems can typically negotiate tight horizontal and vertical curves. Drive lengths are typically only limited by the ability to efficiently transport materials and equipment to the face, convey muck out of the tunnel, and provide ventilation to the tunnel workspace.

3.1. Shield and Wheel Cutter

Open face shields are generally suitable in firm ground above the ground water table but may be equipped with sand shelves or breasting plates to accommodate fast raveling ground for limited reaches. They can also be equipped with flood doors for use in limited amounts of running ground to stabilize the heading, control the rate of excavation, and reduce ground losses. They may be used below the ground water table for heads of less than 20 feet in predominantly cohesive silts, clays, and clayey sands where favorable conditions are present over extended reaches and where settlement control is not essential. However, these machines present a significant risk of large ground losses, excessive surface settlements and construction delays should sand, gravels or non-plastic silts be encountered under high hydrostatic heads.

Wheel cutter machine have essentially the same limitations as the open face digger shield. These machines have a cutter wheel which is rotated to excavate the soil at the heading, but just as with the open face shield they cannot prevent ground loss due to running or flowing ground. In both open face shields and wheel cutter machines the excavation takes place in a non-pressurized environment.

Open face shields or wheel cutter machines can be used under compressed air to create a pressurized environment at the heading where unstable conditions are anticipated. However, due to the health risks and labor regulations involving compressed air, this technique has been seldom used in the USA for the last several decades.

Use of open face shields or open or closed face wheel cutter machines in this project would require controlling the groundwater in advance of the tunnel excavation. The silty sands and sand lenses within the silty clay along the planned tunnel elevation will be difficult to dewater. This could result in flowing ground, ground loss and surface settlement. Therefore, open face shield or wheel cutter machines are not considered suitable because of their increased risk due to their inability to control settlement and potential schedule delay if a large sand seam is encountered.

3.2. Earth Pressure Balance Tunnel Boring Machine

Earth Pressure Balance Machines (EPBM) can be used in a wide range of conditions but are particularly well suited for operation in poor ground where it is necessary to counterbalance earth and groundwater pressures. The EPBM maintains face pressure by holding tunnel muck in a chamber and withdrawing the muck at a controlled rate using a fully encased screw auger. EPBM's are best suited in plastic soils, such as silts and clays, but they can also be used in granular soils provided foam conditioners are added to "plasticize" the muck in the chamber and maintain face pressures.

The EPBMs resist pressure at the face by keeping the interior of the EPBM's plenum, or pressure chamber, filled with a mixture of excavated ground and additives. Pressure is controlled by adjusting the rate of muck removal through the screw conveyor. Typically, the ground is conditioned utilizing bentonite, polymer or foam conditioning agents, or their combination. As the excavation progresses, the pressure at the heading is maintained by adjusting the speed of muck removal and thrust of the machine. To control the face stability the pressure of the excavated ground and water within the pressure chamber must be maintained within the required range. The plasticity of the excavated muck has to be controlled at all times so that the screw conveyor can be used to control the pressures within the pressure chamber. The thrust force of the machine will vary according to the ground conditions encountered. In EPBMs, the handling of excavated material is less complex than with slurry TMB's, as it does not require slurry and soil separation in a separation plant. The muck mixed with slurry, can result in higher handling and disposal costs.

Provided the contractor operates the machine correctly and the hydrostatic pressure is controlled, major face collapses are unlikely as the face is constantly supported by a "muck plug" in the excavation chamber. The cutterhead of the EPBM will be equipped with tooth cutters. Each EPBM will be equipped with a jack propulsion system located in the tail of the machine. The machine will be advanced by pushing off the previously installed ring of segmental lining.

3.3. Slurry Tunnel Boring Machine

Slurry TBM's incorporate a watertight bulkhead behind the excavator head, which completely seals off the excavation face from the completed sections of the tunnel. In a slurry TBM, the slurry pressure applied to the tunnel face is regulated to counterbalance the earth and groundwater pressures providing for safe and efficient tunneling even under high hydrostatic pressure. Introduction of an air pressure cushion or a so-called "air bubble" in the excavation chamber allows for better control of slurry pressure. Soil passes through slots or ports in the cutterhead into a chamber at the front of the machine where it is mixed with slurry. The spoil-slurry mixture is pumped through slurry discharge pipes installed inside the tunnel and discharged to a slurry separation plant at the ground surface. Then the slurry is recirculated to the tunnel heading again, forming a closed system.

3.4. Tunneling Method Selection

If the proposed tunneling alignment is selected, we recommend that the requirements for tunneling method and TBM be defined in the construction contract documents. The tunneling methods and TBM definition should be broad enough as to not preclude contractor's innovation, but specific enough to prevent an irresponsible bidder from attempting the project by unworkable methods. Typically, this results in the designer specifying and listing specific machine requirements that will the determine the general type of machine (EPBM, Slurry, Open Face Machine).

The selection of the most appropriate tunnel excavation method and initial support is very much dependent upon expected ground behavior. Based on preliminary geotechnical data, the tunnel horizon contains sandy silts and clays below the groundwater table with occasional sand and gravel seams. This assessment is based on the preliminary geotechnical data, and a review of the historical data available for the area (see section 2.2). Additional geotechnical investigations will be required to confirm assumptions made as to the elevation and extend of the stratums shown on the vertical alignment profile. Groundwater level and soil permeability is crucial to a machine selection and should be a focus of future geotechnical investigations. The anticipated soils may not be capable of being mined with a non-pressurized TBM (wheel cutter machine) if high vertical porosity is present. Differential hydrostatic head could also cause face instability and ground loss (flowing ground) resulting in excessive surface settlements. It may be technically possible to prevent the sand seams from flowing, in a non-pressurized environment, by grouting to reduce permeability or by dewatering. However, grouting or dewatering would have to be performed over the entire alignment and would be very costly.

Pressurization of the face can be accomplished by either earth pressure balance or slurry. Although slurry machines are adaptable to a wide range of ground conditions, requirements for a slurry separation plant can significantly increase the surface space requirements and the muck handling and disposal costs when compared to EPBM operations. Additionally, the grain size of site soils is smaller than would normally be excavated by a slurry TBM process. Clay and silt materials are difficult to separate from the slurry and would require the use of centrifuges and sophisticated separation plants. This is a serious disadvantage of a slurry TBM and effectively removes this type of TBM from consideration for construction for the tunnel construction. The following chart shows the typical grain size distributions which are best suited to EPBM and slurry TBM's. The grain size results from the new boring locations have been overlayed in green. Additional, grain size data will be required during final design to determine a more accurate depiction of the anticipated grain size at specific station segments along the tunnel alignment. In addition, the procurement costs for slurry TBM's are typically higher than that of an EPBM. It should also be noted that there is much more experience with EPBM's than with slurry TBM's in the USA.

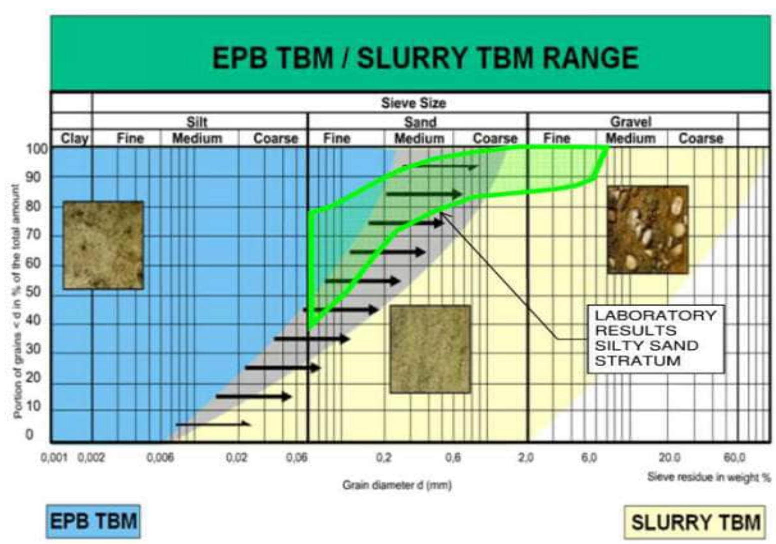


Figure 1 **EPB/Slurry TBM Soil Conditions**

The selection of the most appropriate tunneling method is dependent upon numerous factors such as ground conditions, cost, construction schedule, availability of skilled personnel and contractor, equipment availability, estimated ground settlements and aversion to risk. Actual settlement is affected mainly by the construction method, the size of the tunnel, soil conditions and many other factors. Based on the discussion above each trenchless method set forth, **Table 1** below summarizes the general applicability of the proposed methods to perform tunnel construction.

Table 1 Evaluation Summary of Construction Methods

Trenchless Method	Contractor Experience	Equipment Availability	Handling Expected Ground Condition	Handling Unexpected Obstructions	Pipe Size & Shape Availability	Relative Cost	Settlement/ Heave
Conventional TBM	Favorable	Favorable	Poor	Favorable	Fair	Favorable	Fair
EPBM	Fair	Fair	Fair	Fair	Fair	Fair	Favorable
Slurry TBM	Fair	Fair	Fair	Poor	Fair	Poor	Favorable

Given the difficulties associated with separation of the silty clay from a slurry mixture, our recommendation is that the tunnel excavation method should consist of an EPBM. Contractors have embraced these types of machines since they eliminate the need for grouting or dewatering while mining below the water table. Further geotechnical investigation may result in determining that the tunnel face conditions do not require a pressure face machine. In that case the use of an open face cutter type machine would be recommended. This is a method that has been successfully employed in the Milwaukee area on several projects and would result in a cost saving for the project.

4. Tunnel Alignment and Profile Design Criteria

The vertical and horizontal alignments are crucial design elements both for design and operation of the new tunnel. The vertical profile needs to consider the subsurface conditions carefully, minimize changing ground conditions, maintain tunnel profile is ground that is better suited for tunneling and the specific tunneling method, and balance that against surface impacts, cost and schedule. The tunnel's horizontal alignment is intended to minimize easement and property acquisition needs.

4.1 Plan Alignment Constraints

The alignment is constrained horizontally or vertically by factors such as geological conditions, proposed access shaft or outfall locations, connections to existing infrastructure (drop shafts), existing underground structures, or available right of way space. Traditionally, alignments will follow paths with limited surface obstacles to avoid sub-surface property acquisition/easements and to mitigate the risk of settlement. However, in dense urban locations, the alignment may pass under or close to existing structures (e.g., buildings, underground utilities, or other below-ground structures) or pass under an unoccupied area that will be a future development site and may result in imposing additional load on the tunnel.

Several criteria were identified and prioritized for the alignment evaluation based on discussions between CDM Smith and the City in the latter stages of the concept feasibility study. The major criteria included capital costs, right of way requirements, existing utility impacts, stakeholder impacts and community impacts. The key alignment criteria are to minimize property acquisition and/or subterranean easements.

Other criteria included traffic management, hydraulics, soil management, permitting and environmental impacts. The evaluation criteria and assigned weights were utilized to develop each alternative to establish the framework for selecting the preferred alternative.

4.2 Profile Constraints

The maximum longitudinal gradient should not exceed 10 percent to allow for use of equipment within the tunnel during construction. However, line and grade control for tunneling will be determined by hydraulic requirements which are anticipated to be less than 10 percent. As minimum the line and grade should be maintained within a ± 2-inch tolerance of the design flowline. Flows will be conveyed by gravity so precise grade control will be of particular importance to minimize debris buildup and silting of the system during operation. The minimum longitudinal gradient should not be less than 0.2 percent to allow for a reasonable drainage of inflowing groundwater during construction.

The tunnel vertical alignment must be capable of maintaining the design hydraulic performance and of not impacting nearby structures and avoiding the underground utilities and other structures and foundations. The tunnel invert elevation is set at the outfall end and has vertical constraints including the several utility crossings along or near State Street. A railroad crossing is also located just south of State Street approximately 500 feet north of the Menomonee River with an approximate top of rail elevation of 63 feet. The proposed vertical alignment must navigate between these constraints and maintain adequate cover under the railroad tracks.

Soil cover should be at a depth sufficient to minimize settlement, which possibly could lead to damage to the underground utilities and surface structures. Generally, a minimum depth of the tunnel crown below the ground surface should be equal to or greater than two times the excavated diameter of the tunnel.

4.3 Tunnel Profile Envelope

The tunnel profile envelope is defined as the area around the tunnel alignment where the ground conditions may affect the tunnel or where the tunnel excavation may have a significant effect on the ground or underground utilities. For this project the tunnel profile envelope is considered to consist of a zone 1.5 times the tunnel excavated diameter (estimated at 12.5 feet for a 10-foot ID tunnel) centered at the springline of the proposed pipe.

4.4 Subsurface Strata Considerations

The tunnel envelope should be situated predominantly in a geotechnically favorable geology that provides the most stable face conditions to prevent over excavation and reduce settlement. Soft soils should be avoided when possible. Ideally, the number of times that the tunnel excavation changes from one soil type to another should also be minimized to make construction easier.

4.5 Horizontal and Vertical Curvature

Horizontal and vertical curves should be of a single arc radius. Curve radii standards provide "Minimum", "Design", and "Exceptional" values. However, even the "Exceptional" figures can be improved upon. Tunneling operations where a precast pipe is installed within a temporary tunnel lining can typically accommodate minimum horizontal and vertical curves in alignments ranging from 800 feet to 1000 feet based on an excavated diameter of 12.5 feet and the anticipated pipe segment lengths. Segmental lined tunnel can negotiate horizontal curves with a minimum radius of 500 feet using special segments design for tight radius curves. It is recommended that the design radius exceed the minimum radius in order to provide tunneling contractors the capacity to make alignment corrections in the event a deviation from the design alignment. For the Schoonmaker Creek Project, the recommended design radius is set at 1,200 feet.

4.6 Settlement potential

For existing infrastructure and surface structures, there is a significant risk of damage caused by excessive or uncontrolled settlements. Even with a closed face machine, settlement due to ground loss at the tunnel excavation face is still an issue that must be addressed. To minimize settlement resulting from ground loss, a deeper tunnel alignment and correspondingly a larger soil cover is preferred. However, a deeper tunnel alignment causes higher soil pressure on the final lining of the tunnel as well as additional cost for the construction of the launching and receiving shafts. Therefore, an optimum balance between tunnel depth, settlement monitoring and the possible use of ground improvement to offset possible settlement must be found in the design.

5. Tunnel Alignment Alternatives

The tunnel's plan profile was developed to minimize easement and property acquisition needs. The geotechnical information obtained for this project provided the basis for developing the preliminary level vertical tunnel profile and identifying the appropriate tunneling methodology. The main purpose of the alignment analysis was to identify the most feasible, constructable, and cost-effective alignment to minimize impacts to the community and stakeholders. Each of the alternative alignments with the minor variations is shown in Appendix A.

5.1 Alternative 1

Horizontal alignment analysis

The initial stages of the concept feasibility study included a tunnel alignment that ran west along West Lloyd then south along North 68th Street. The original proposed alignment had several 90 degree turns that would make construction of a tunnel difficult. During the preliminary tunnel workshop, the need for additional analysis to further evaluate the proposed alignment was identified. The alignment analysis focused on the minimizing the required staging areas by eliminating the 90 degree turns and replacing them with a curved alignment. Alignment 1A moved the starting point of the tunnel from the intersection of 65th and West Lloyd to the intersection of W Garfield Avenue and North 68th street. This shortened the tunnel alignment by approximately 700 feet and moved the staging area for the receiving shaft out of the busier Lloyd Street. The new receiving shaft staging area would be located on approximately ½ acre consisting of the green space and the dead-end street near Washington Elementary School. Alignment 1A also added two 1200-foot radius curves where the tunnel alignment crosses Milwaukee Avenue. This change to the alignment would require an underground easement below the Wauwatosa Ace hardware property but would eliminate two staging areas and construction shafts within Milwaukee Avenue that would be required using the previous alignment. The final change to the alignment is at another 1200 radius curve approximately 500 feet north of West State Street. The purpose of this curve is to eliminate the need for a staging area within 68th street.

Two other alternate alignment corridors (alignments B and C) with minor variations were considered during the alignment study. Alignment 1B consisted of lengthening the final 1200-foot radius curve so that the tunnel alignment crossed 68th street and moved the outfall location to the west of the 68th street bridge within Hart Park. Although the alignment 1B shortened the tunnel alignment by approximately 100 feet the disruptions to Hart Park makes this alignment less desirable than alignment 1A and it was eliminated from further consideration. Alignment 1C consisted of adding a new shaft within the parking area of Metcalfe's Market at the corner of North 68th street and an additional tunnel section along west State Street allowing for the outfall to be constructed near the existing Schoonmaker Creek outfall location. This option adds approximately 2000 feet of additional tunnel length and requires construction of an additional shaft. The tunnel alignment would also be required to cross the railway at an angle which is not preferred by Canadian Pacific Railway (CP). Since this alignment alternative is anticipated to be significantly more expensive and is expected to have permitting issues with the railways it was not developed further.

Vertical alignment analysis

The proposed storm sewer within this section has a proposed depth of 20 feet from ground level to pipe crown. Typical depth for water, underground electric (UGE) and underground telecommunication (UTC) lines is 2-7 feet below grade. The vertical profile is largely controlled by the underground sanitary sewer locations. Specifically, it is necessary to avoid the 24-inch sanitary sewer that is located parallel to state street. As proposed, the tunnel excavation passes only 10 feet below the sanitary sewer.

In general, the tunnel invert at the outfall (station 1+00) is located at elevation 28.23 with a 0.2% grade to station 107+30. From station 107+30 the tunnel follows a 2% Grade to elevation 122.84 at the drop shaft location at station 151+00. The depth of cover above the tunnel crown ranges from

15 to 76 feet. A profile of this alignment and relevant underground utilities is shown in Appendix B. Several significant underground storm and sanitary sewers are present at locations along the alignment listed below:

- Sanitary Sewer - An existing 8-inch sanitary sewer is in N68th street with a centerline near the center of the street.
- Sanitary Sewer - An existing 8-inch sanitary sewer crosses N68th street at Hillcrest Drive.
- Storm Sewers - An existing 18-inch storm sewer crosses N 69th street at the State Street intersection.
- Sanitary Sewer - An existing 24-inch sanitary sewer crosses N 69th street at the State Street intersection located at approximate elevation 50.
- MMSD Sewer - An existing 192-inch MMSD sewer crosses N 69th street at the State Street intersection at approximate elevation -223.54.

5.2 Alternative 2

Horizontal alignment analysis

Alignment 2 starts near the intersection of west Lloyd Street and north 65th Street. The tunnel then generally follows Martha Washington Drive to the south. The alignment is constrained at the west Washington Boulevard Bride where the tunnel must pass between the bridge abutments. Currently, it is unknown what type of foundation supports the bridge. Further south the alignment passes through the green space between buildings for the Enclave Luxury Apartment and the Reserve at Wauwatosa Village.

Multiple curves are required along the alignment, and it would likely be difficult for a contractor to construct. The alignment then crosses west State Street and ends at a new outfall location to be constructed to the west of the current outfall location. The contractor's additional risk of constructing an alignment with multiple curves would likely result in an increase in pricing that would be difficult to predict.

Vertical alignment analysis

The proposed storm sewer within this section has a proposed depth of approximately 50 feet from ground level (elevation 82.6) to pipe crown and a constant slope of 1.5%. The alignment vertical alignment is controlled in the north by the 27-inch sanitary that follows Martha Washington Drive near the mid-point where the tunnel must cross under the existing Schoonmaker Creek Culvert and in the south by the 48-inch MMSD sewer at State Street. Once the tunnel reached the new outfall location it would enter a 56-foot-deep riser shaft to reach the new outfall. Several significant underground storm and sanitary sewers are present at locations along the alignment listed below:

- Sanitary Sewer - An existing 12-inch sanitary sewer follows Martha Washington Drive ranging in elevation from 108 to 98.
- Sanitary Sewer - An existing 18-inch sanitary sewer located to the west of Martha Washington Drive ranging in elevation from 93.3 to 86.
- Sanitary Sewer - An existing 27-inch sanitary sewer follows Martha Washington Drive ranging in elevation from 93.3 to 84.69.
- MMSD Sewer - An existing 27-inch sanitary sewer follows Martha Washington Drive ranging in elevation from 95.75 to 73.6.
- Storm Sewers - The existing Schoonmaker creek culvert which consist of a mix ob box culverts and 72 inch RCP pipe that follows Martha Washington Drive ranging in elevation from 78.15 to 41.32.
- MMSD Sewer - An existing 48-inch sewer that follows that follows Martha Washington Drive ranging in elevation from 68.08 to 44.09.
- MMSD Sewer - An existing 48-inch sewer that follows State Street and is located at an elevation 39.63.
- MMSD Sewer - An existing 192-inch MMSD sewer crosses entrance to the Reserve at Wauwatosa Village at the State Street intersection at approximate elevation -223.54.

5.3 Alternative 3

Horizontal alignment analysis

Alignment 3 follows that same path as alignment 2 until approximately 300 feet north of west Vliet Street where the tunnel alignment tuns to the west in a 1200-foot radius curve and then follows north 63rd street south until it passes under a private residence and then precedes south with three 3000-foot radius curves. South of West Martin Drive the tunnel passes through several access roads and parking areas for industrial properties north of State Street. After crossing State Street, the tunnel alignment proceeds south to the location at the river. Like alignment 2 this alignment also requires multiple curves. However, the curves radius are much larger and easier to construct and this alignment also alleviates the need to cross under the existing Schoonmaker Creek culvert.

Vertical alignment analysis

The proposed storm sewer within this alternative start at the same elevation as alignment alternative 1. However, the slope north of west Vliet Street would be reduce to 0.6% to match 27-inch diameter sanitary sewer. When the tunnel turns to go down north 63rd street the tunnel elevation would be approximately 47 feet deep. The tunnel slope would continue at 1.5% to the end of north 63rd street. It would pass under the private residence at a depth of 65 feet and emerge from the base on the bluff at a depth of 20 feet. The tunnel would continue at a slope of 2% until it passed under the MMSD sewer at State Street and then the slope would change to 0.2% until it reached the new outfall at the river edge. At the river a 47.5-foot-deep riser shaft would convey the flow upward to the new outfall. Several significant underground storm and sanitary sewers are present at locations along the alignment listed below:

- Sanitary Sewer - An existing 12-inch sanitary sewer follows Martha Washington Drive ranging in elevation from 108 to 98.
- Sanitary Sewer - An existing 18-inch sanitary sewer located to the west of Martha Washington Drive ranging in elevation from 93.3 to 86.
- Sanitary Sewer - An existing 27-inch sanitary sewer follows Martha Washington Drive ranging in elevation from 93.3 to 84.69.
- MMSD Sewer - An existing 27-inch sanitary sewer follows Martha Washington Drive ranging in elevation from 95.75 to 73.6.
- MMSD Sewer - An existing 48-inch sewer that follows State Street and is located at an elevation 39.63.
- MMSD Sewer - An existing 192-inch MMSD sewer crosses the intersection of N 63rd street and State Street at approximate elevation -223.54.

6. Easements

6.1 Private Property Easements

The Project will require permanent subterranean (primarily) and surface easements, and temporary (construction) surface easements for specific parcels along the tunnel alignment and adjacent to the proposed work zones. Temporary surface easements will be required at certain locations along the tunnel alignment to secure land for additional staging and construction activities. The staging and construction areas required will be discuss later in this memorandum. Permanent surface easements will be required for certain drop/working shafts, to facilitate construction, and provide access for future operation and maintenance.

Subterranean easements will be required for several parcels along the tunnel alignment for construction. This type of easement is for the tunnel only and does not involve surface rights since access to the tunnel is not needed through the impacted parcels.

The property easements that are expected along each of the proposed tunnel alignments are listed in **Table 2** through **Table 4** below. The anticipated easement for parcels is based on the outside diameter of the tunnel at approximately 12.5 feet with an additional 5 feet on each side of the tunnel for a total width of 22.5 feet, centered along the tunnel alignment centerline.

Table 2 List of Anticipated Private Property Easements Limits for Alternative 1A

Parcel No.	Location	Associated Tunnel Feature	Ownership
3450296000	Washington Elementary School	Tunnel Alignment/Retrieval Shaft	Wauwatosa School District
3450617000	1615 Mountain Ave	Tunnel Alignment	Private Property
3690356000	Ace Hardware 1525 N 68th St	Tunnel Alignment	Private Property
3840009001	Metcalfeis Market 6650 W State St.	Tunnel Alignment	Private Property
3709997000	CP Railroad Crossing	Tunnel Alignment	Private Property
3840043001	Park Maintenance 1150 N 68th St.	Tunnel Alignment/Working Shaft	Milwaukee County

Table 3 List of Anticipated Private Property Easements Limits for Alternative 2

Parcel No.	Location	Associated Tunnel Feature	Ownership
3690106001	1307 Martha Washington Dr.	Tunnel Alignment	Private Property
3690109001	1291 Martha Washington Dr.	Tunnel Alignment	Private Property
3840002001	1200 N 62nd St.	Tunnel Alignment	Private Property
3840001001	6100 W State St.	Tunnel Alignment	Private Property
3709997000	CP Railroad Crossing	Tunnel Alignment	Private Property

Table 4 List of Anticipated Private Property Easements Limits for Alternative 3

Parcel No.	Location	Associated Tunnel Feature	Ownership
3450793000	6240 MILWAUKEE AVE	Tunnel Alignment	Private Property
3840020000	1205 N 62ND ST	Tunnel Alignment	City of Wauwatosa
3840009004	1200 N MAYFAIR RD #310	Tunnel Alignment	Private Property
3840008001	6228 W STATE ST	Tunnel Alignment	Private Property
3709997000	CP Railroad Crossing	Tunnel Alignment	Private Property

6.2 Private Property Acquisitions

The proposed Alignment 3 includes one private residence where it would be necessary to tunnel under the residence. To facilitate construction and reduce risk to the City, a property acquisitions is recommended in the event that anticipated settlement results in damage to the structure. The proposed property acquisition is listed in Table 5 below.

Table 5 List of Anticipated Private Property Acquisitions

Parcel No.	Location	Associated Tunnel Feature	Ownership
3690087000	6305 W McKinley Blvd.	Tunnel Alignment	Private Property

7. Shaft Location Requirements and Options

A minimum of two (2) Vertical shafts will be required for the construction of each of the proposed alignments. Additional shaft locations can be added to the alignments to provide maintenance access in the future if the tunnel design is progressed but have not been included in this alignment analysis. The two shafts will consist of a launching shaft and a retrieval shaft.

This project will require large number of construction workers, and quantities of material and equipment to be transported to and from the project site(s). Some of the space requirements will be based on the contractor means and methods. For example, the launching area will need to accommodate TBM launching shaft, power substations, the crane for servicing the shaft, surface processing/treatment plants and truck access for hauling spoils and unloading material, personnel, and tunneling equipment. The launch shaft size could range from a circular shaft with a minimum diameter of 35 feet in diameter to a linear trench with a length of up to 230 feet. The receiving shaft could range between 25 to 30 feet in diameter depending on the equipment dimensions.

In addition to the equipment requirements for each site, space will also be required to store the tunnel lining material to be transported underground to support the tunnelling operations. Likewise, large quantities of muck and ground water removed from the excavation will also require storage area at or near the shaft location until it can be transported off-site for proper disposal. The spoil storage area should have adequate capacity for temporarily storing muck quantity equal to a week of tunnel excavation to mitigate the risk of external spoil management factors impacting tunnel advance rates. At average output rate of 50 feet per day it is estimated that a 10-foot ID tunnel will produce approximately 3100 yd^3 per week (after allowing bulking at 1.7). The storage area will therefore require a capacity of approximately 5,600 ft^2, assuming an average muck pile height of 15 feet. At peak output rate of 90 feet per day it is estimated that the tunneling will produce approximately 5600 yd^3 per week and a required capacity of approximately 10,000 ft^2 – if such advance rates can be sustained over a full week. Spoil is assumed to be removed from the launch shaft by a crane or a vertical conveyor that is used to service the shaft and dump the excavated soil in the muck storage pile on the surface. Transport from the muck stockpile to the commercial dump trucks will be by one or more wheeled loader(s).

It is not uncommon for owners to purchase properties, or negotiate temporary construction easements, for providing the contractor staging area to facilitate construction. If properties are purchased, these could then be either dedicated to other uses after project completion or possibly sold to recover the capital investment. When making property acquisitions it should be noted that the larger the available space, the more efficiently a contractor can plan and execute work. Constrained staging area sites will increase work schedule, and, in turn, project costs. The minimum space requirement around the shaft locations typically range from ½ acre at the receiving area and two acres or more are preferred for the launching area. The proposed working area for each alignment will be discussed further in this section.

7.1 Alignment 1

The tunnel launch area and outfall for the proposed alignment 1 will be located within the Parks Maintenance property located north of the Menomonee River just east of 68^{th} street. The property currently includes 0.85 acres consisting of a mix of green space and paved parking area. This area is large enough to support the immediate tunnel need but obtaining and additional acre or more of storage area nearby is recommended. One possible location for obtaining additional storage area is the city owned property 1500 feet to the east near the existing outfall.

Initially the site will be used for launching the TBM and to support the tunneling operation. After tunnel construction is completed open cut construction will be used to cross river parkway and construct the future location for the outfall. Access to the site is obtained via 68th street. The conceptual site area for the tunnel launch area is shown in **Figure 2.**

Figure 2 Alignment 1 Receiving Shaft Site

At the north end of the tunnel alignment a retrieval shaft will be required for removal of the TBM. The receiving shaft could range between 25 to 30 feet in diameter depending on the TBM dimensions and will be approximately 27-feet deep. Once the TBM has been removed the shaft can then be used for construction of a drop shaft to convey the flow from the existing storm sewer connection to the new tunnel. A short open cut section would be required to connect the drop shaft location to the existing storm sewer located on the east side of 67th street. The size requirements of the drop shafts will be determined during final design.

The proposed receiving location for the alignment 1A offers approximately 0.6 acres of space for the contractor to stage construction. The site is located on the north side of Washington Elementary School. The school is currently in use but the property may be acquired in the future. If the school property can be used, an additional 0.75 acres consisting of the current paved playground area could be available for the construction. Access to the site will be via the West Garfield Avenue with dead ends at the site. The abutting properties are primarily residential and provisions for noise reduction will be required. The shaft can be constructed from top down using soldier piles and lagging or liner plate to minimize the site support requirements. The site will require space for a large crane to recover the TBM and smaller crane for the shaft construction support, stockpiles and material storage, and additional space for the construction equipment to navigate about the site. The conceptual site area is shown in **Figure3.**

Figure 3 Alignment 1 Receiving Shaft Site

7.2 Alignment 2 & 3

The tunnel launch area and outfall for the proposed alignments 2 and 3 will be located within the existing city property located north of the Menomonee River just south of the intersection of 62^{nd} street and West State Street. The property currently includes over 7 acres consisting of open relatively flat green space. This area is large enough to support multiple options for shaft locations Given the amount of available space it is anticipated that the contractor will construct a longer launching trench instead of a shaft so that a larger portion of the TBM trailing gear can be assembled prior to launch, which allows for a more efficient excavation sequence once tunnelling begins and, more importantly, reduce project specific risks related to starting and stopping the TBM at launch for trailing gear installation when launching in challenging mixed face ground conditions with groundwater table above the tunnel horizon.

Initially the site will be used for launching the TBM and to support the tunneling operation. After tunnel construction is completed, the outfall can be constructed at the TBM launch location. open cut construction will be used to cross river parkway and construct the future location for the outfall. Access to the site is obtained via 63rd street. The conceptual site area for the tunnel launch site is shown in **Figure 4**.

Figure 4 **Alignment 2 & 3 Launch Shaft Site**

The receiving shaft could range between 25 to 30 feet in diameter depending on the TBM dimensions and will be approximately 45 to 55 feet deep depending on the location. Once the TBM has been removed the shaft can then be used for construction of a drop shaft to convey the flow from the existing storm sewer connection to the new tunnel. A short open cut section would be required to connect the drop shaft location to the existing open channel to the west or the open channel could be enclosed to the existing box culvert outfall at 66th street. The size requirements of the drop shafts will be determined during final design.

The proposed receiving location for the Alignment 2 offers approximately 0.2 acres of space for the contractor to stage construction. The site is on city owned property located in between West Lloyd Street and Martha Washington Drive. The site has several trees, is well landscaped and has a steep downward slope toward Martha Washington Drive. The site does not have enough required space for the receiving shaft and equipment. To make construction feasible additional space could be obtained during peak construction activities by closing the adjoining streets for durations of up to a month at a time during shaft construction and TBM recovery. The slope of the site would also require extensive regrading to make the site usable. Access to the site will be via the Revere Avenue to the west. The abutting properties are primarily residential and provisions for noise reduction will be required. The shaft can be constructed from top down using soldier piles and lagging or liner plate to minimize the site support requirements. The site will require space for a large crane to recover the TBM and smaller crane for the shaft construction support, stockpiles and material storage for the shaft construction equipment. The limited site area and high density of residential structures will make working at this site very difficult. However, other available space in the area is very limited. The conceptual site area is shown in **Figure 5.**

Figure 5 Alignment 2 & 3 Receiving Shaft Site

8. Tunnel Lining

Tunnel linings are required to provide ground support and to serve as a pipeline to convey stormwater flows. The lining must be compatible with the tunneling method and must be designed to resist external dead and live loads, jacking and handling loads, and service loads. The lining must also satisfy hydraulic requirement and be resistant to corrosion. Linings can be installed in either single- or two-pass tunneling operations depending upon the construction sequence, construction method, and project requirements.

In the two-pass tunneling process, an initial soil support system is installed immediately behind the TBM and the tunnel excavation is completed for its entire length. After completion of the tunnel excavation and initial support system, a second pass is made in which a final interior lining system that will convey the stormwater is placed within the tunnel. The type of initial support system is dependent upon several factors including soil type, excavated tunnel strength without support, water content, and the permeability of the strata. Commonly used initial support systems include steel ribs with timber lagging, or steel liner plates. For shorter runs and better ground conditions a two-pass system can be economical because the cost of creating molds and castings one pass segments is avoided.

After the tunneling is completed a precast pipe can be installed in the tunnel and grouted in place. The ultimate curve radius of the tunnel alignment is usually determined by the length of the pipe segments for the final lining and the amount of deflection possible at each joint. Very sharp turns can be accommodated using special joints, but this results in increased pipe cost. Given, the tunnel has a planned inside diameter of about 10-feet and an assumed pipe thickness of 8 inches a outer pipe diameter of at least 11.5 feet would be required. Based on this diameter and an anticipated pipe length or 10 feet and standard joints a 1000-foot radius curve is considered viable with standard joints.

Finding manufacturers 11.5-foot diameter pipe or larger is difficult as pipe of this size is only manufactured in limited batches. This can result in additional cost as precast manufactures have to retool their production line to produce the larger pipe. Additionally, transportation of precast concrete pipe with a width of greater than 8.5 feet would require oversized load permitting under Wisconsin law. Typically, travel for oversized load trucking is permitted from ½ hour before sunrise to ½ hour after sunset 7 days per week. Additionally, to meet the required 11.5 ft. oversized permit height clearance low clearance trailers would be required. A maximum of pipe length 8 feet could be transported on each truck. A two-pass system may not be a feasible alternative because of the costs and logistical difficulties associated with transporting pipe of that diameter but should be evaluated further.

With one-pass tunneling, tunnel ground support is installed as the heading is advanced and serves to support both external ground loads and convey future stormwater flows. One-pass systems are typically used when the ground will not stand unsupported and/or groundwater inflows may require a sealed system to allow successful advancement of the excavation. The purpose of a one-pass system is to install a final support system as part of the initial excavation in order to prevent excessive ground movement and surface settlements. One-pass systems where feasible can also help accelerate the schedule because the second step of creating a final lining is eliminated.

Precast Concrete Segmental Linings are commonly constructed with a one-pass tunneling process. Typically, segments are manufactured using a high strength Portland cement concrete although the concrete segments can be lined with a PVC or HDPE membrane to inhibit corrosion if required. The longitudinal and circumferential joints can be gasketed to resist infiltration/exfiltration. Segments are assembled using bolts or self-locking nylon dowels (pocketless). Typically, the segments are bolted on their radial joints. It is possible however to design segments without bolts. Non-bolted segments are secured with dowels and rods and have a smooth internal surface. Fabrication of the segments will be accomplished at an off-site casting plant and shipped to the site for installation stacked on trucks holding 1-2 complete segments depending on the segment weight.

Segments can accommodate curves in the tunnel alignment and typically allow for longer runs between work shafts. Segmental linings are transported from the working shaft by rail within the tunnel and assembled in the tunnel boring machine using erector arms. Almost all pressurized face tunnel boring machines utilize a precast concrete segmental and gasketed one pass lining system. The precast concrete gasketed segments are watertight, and therefore prevent the flow of groundwater and soil. Additionally, the segments themselves provide sufficient strength to resist jacking forces of the machine.

The one-pass system will stabilize tunnel opening during construction, serve as a final lining and keep the tunnels watertight. The segments will be designed and detailed to allow their installation to match the configuration and curvature of the tunnel. Since the one-pass system acts as the initial and final lining of the tunnel, the segments must be capable of supporting the anticipated external loads due to overburden, surcharge, and groundwater. Once lining installation is complete, bolt pockets are filled with grout to provide a smooth surface for flow. The segments must be able to withstand handling and erection loads and all loads due to jacking forces in advancing the TBM, as well as any internal hydrostatic pressures. As the tunnel advances, grout will be injected into the annulus between the outside of the concrete segment and the excavated soil surface. This will aid in developing uniform external pressure around the segments.

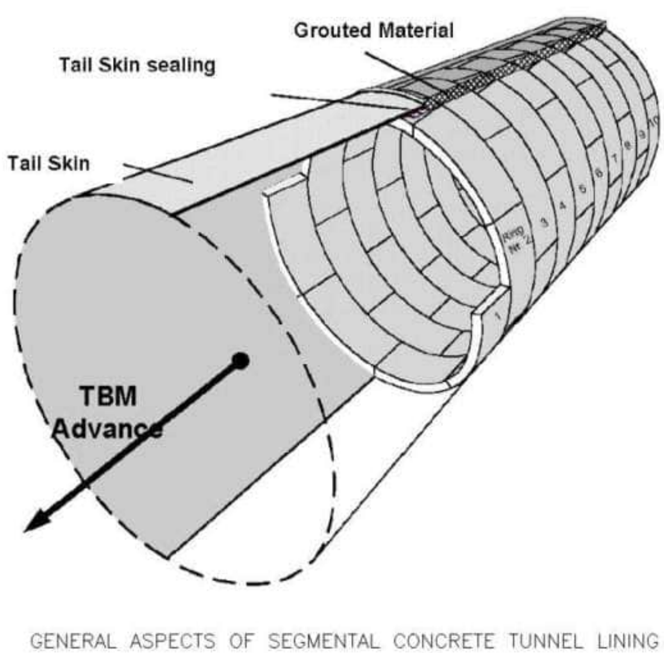


Figure 6 **Segmental Tunnel Lining**

9. Outfall Structure

Regardless of the tunnel alignment chosen the tunnel will be lower than the river 100-year flood elevation. At the outfall location we recommend that the tunnel rise vertically to the outfall structure and that the discharge point be located above the 100-year floodplain to avoid possible flood waters from depositing debris into the tunnel. The outfall structure will be equipped with the following:

- An energy dissipation structure, or stilling basin.
- Security precautions to prevent vandalization and personal injury.
- Checkered plate grating on the roof for maintenance access.

An energy dissipation structure, or stilling basin, will reduce the overall energy of the discharged flow. Additionally utilizing a baffle wall with openings near the bottom of the outfall structure can also be used to prevent scouring of the surrounding area. Dimensions for the dissipation structure will be determined during final design if the tunnel concept is advanced. Further development with site-specific characteristics is also required to define structure requirements fully. A concept rendering of the outfall structure is shown in **Figure 7**.

Figure 7 Outfall Structure Concept Rendering

10. Opinion of Probable Project Costs

CDM Smith prepared an opinion of probable project costs (OPPCs) for the tunnel alignments to understand the anticipated construction, engineering and implementation costs (Appendix C). Project costs include estimated construction costs, a 25-percent construction contingency, engineering and implementation costs. Construction costs have not been adjusted for inflation. Costs for land acquisition and easements are not included. As shown in Appendix C, alignment alternative 1 is the lowest cost option. The conceptual-level opinion of probable project cost (-15% to +50% probability) for the alignment 1 tunnel is approximately $48.5 million**.**

11. Preliminary Recommendations

Based on our evaluation tunneling is viable. However, during final design, more project and site-specific geotechnical information will be needed, and an additional geotechnical investigation should be part of the next phase, once a decision is made to select either trenched or trenchless method of construction. This additional investigation should focus on determining an estimate of the number of boulders that may be present along the alignment, determining a more accurate representation of the subsurface stratum, and obtaining additional grain size and permeability data along the tunnel alignment. Additionally, a risk workshop discussion on the possible risk of each construction method should be performed during design. Maximum allowable surface settlements should be established for all infrastructure and private residences that lies within the tunneling influence zone. Tolerances should be based on the anticipated impacts of settlement to each facility, acceptable level of risk for the selected construction method, facility owner input, and permitting requirements. If the tunnel option is progressed our final tunneling approach and design will use this as a metric to ensure that tunneling-induced settlements do not violate these critical values.

Based on our discussion above, our initial assessment has identified the following design recommendations:

- Alignment 1 is the most favorable alignment alternative. The alignment has less curves and will be easier to construct for the contractor. Additionally, unlike alignment 2 and 3 there are fewer utilities directly above the tunnel alignment and less risk of tunnel induced settlement resulting in damage to adjacent infrastructure.

- A pressurized face Earth Pressure Balance will likely be employed for the tunnel excavation.

- A minimum tunnel depth of two tunnel diameters below the ground surface is assumed to be reasonable for the assumed settlement tolerances for underground utilities, nearby residences and building and the crossing of the railway. The vertical profile for tunneling will need to be carefully revaluated during final design to determine if lowering the tunnel will provide more favorable hydraulics or geology once the project-specific ground investigation is complete and data is available for interpretation.

- The launching shaft will be located on the Parks Maintenance site and the receiving shaft (which requires less space) will be located north of Washington Elementary School.
- The launching shaft is anticipated to be up to 35 feet in diameter, and the receiving shaft/pit to be up to 30 feet in diameter.
- Shaft depths based on the vertical alignment of two tunnel diameters are anticipated to be 35 feet for the Parks Maintenance site area and 27 feet for the Washington Elementary School.
- For preliminary planning discussions with the railway, an estimated maximum settlement of one inch should be considered.

Appendices

Appendix A Preliminary Alignment Figure

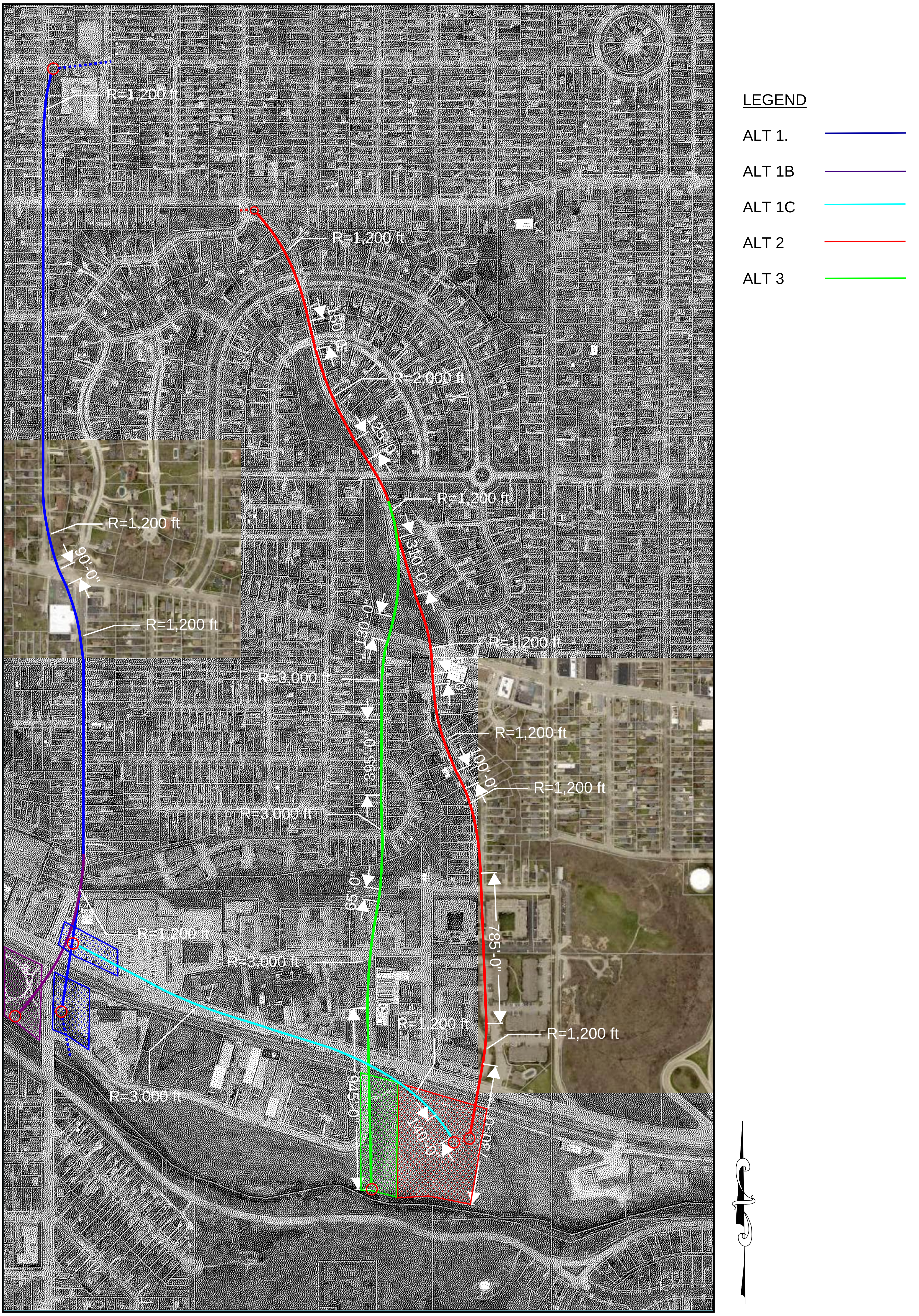
Appendix B Preliminary Vertical Alignment Figures

Appendix C Estimate of Probable Cost

Appendix D Gestra Preliminary Geotechnical Report.

Appendix A

Preliminary Alignment Figure



CDM Smith

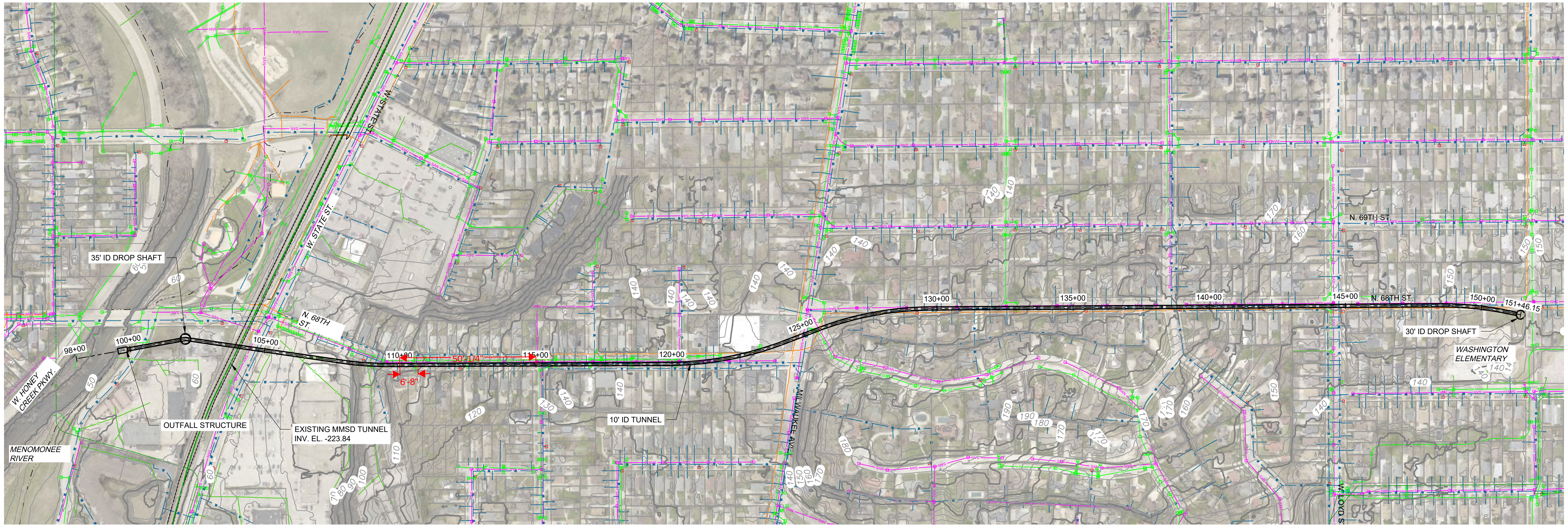
ALIGNMENT ALTERNTIVES

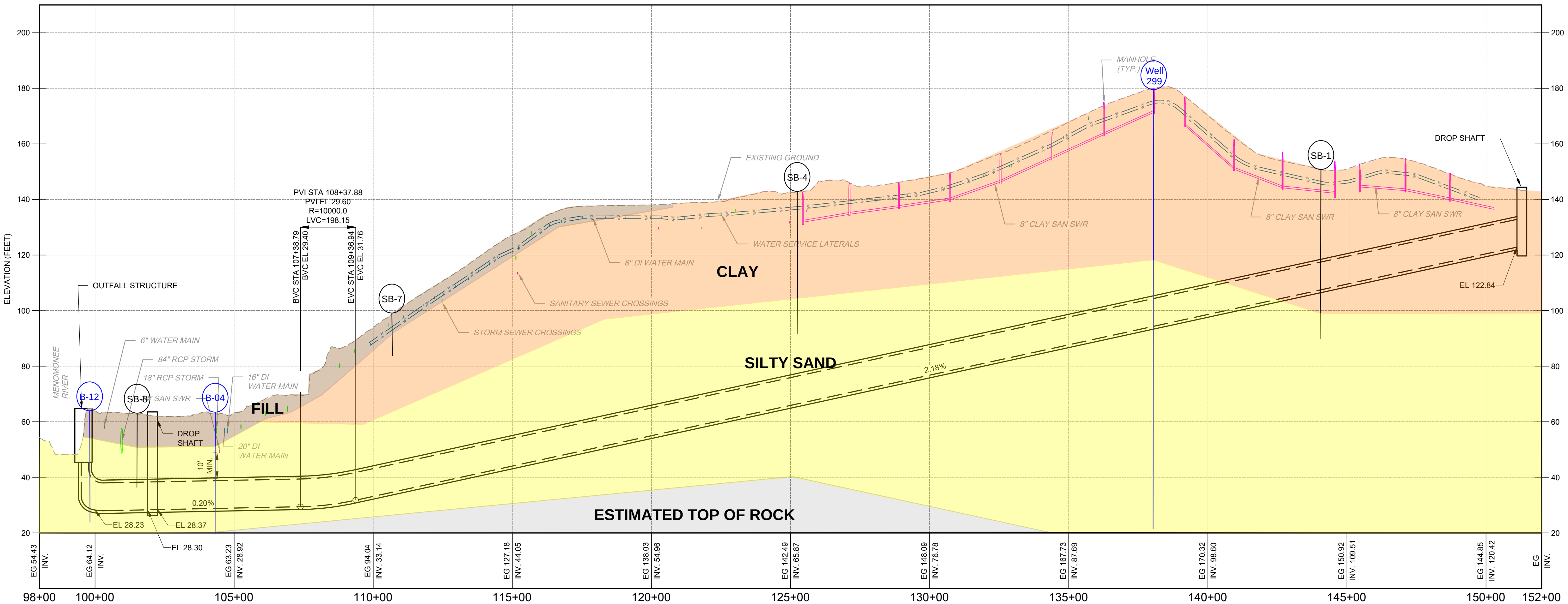
FIGURE NO.

A.1

Appendix B

Preliminary Vertical Alignment Figures





HORIZ. 0 200' 400'

VERT. 0 20' 40'

LEGEND:

- SANITARY SEWER
- STORM DRAIN
- WATER LINE
- FIBER OPTIC
- TUNNEL LINNING
- TUNNEL BASELINE
- MANHOLE/ INLETS
- FIRE HYDRANTS
- MMSD TUNNEL CENTER

NOTE:

1. FIBER OPTIC AND ELECTRICAL CONDUIT NOT SHOWN IN PROFILE FOR CLARITY

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: G. SANDERS
DRAWN BY: A. BOCANEGRA
SHEET CHK'D BY: --
CROSS CHK'D BY: --
APPROVED BY: --
DATE: FEBRUARY, 2024

CDM Smith
670 North Commercial Street, Suite 208
Manchester, NH 03101
Tel: (603) 222-8300

CITY OF WAUWATOSA, WISCONSIN

SCHOONMAKER CREEK TUNNEL

ALTERNATIVE 1

PROJECT NO. 291846
FILE NAME:
SHEET NO.
B-1

ROUTE ALTERNATIVES FIGURES

Appendix C

Estimate of Probable Cost

ESTIMATE OF PROBABLE COST Schoonmaker Creek Alignment 1		ESTIMATE OF PROBABLE COST Schoonmaker Creek Alignment 2		ESTIMATE OF PROBABLE COST Schoonmaker Creek Alignment 3	
ITEM DESCRIPTION	**TOTAL COST**	**ITEM DESCRIPTION**	**TOTAL COST**	**ITEM DESCRIPTION**	**TOTAL COST**
Mobe/Demobe		**Mobe/Demobe**		**Mobe/Demobe**	
MOBILIZATION (Mobe equipment site includes MTBM shipping cost, cutters, seal etc.)	$ 410,072.04	MOBILIZATION (Mobe equipment site includes MTBM shipping cost, cutters, seal etc.)	$ 410,072.04	MOBILIZATION (Mobe equipment site includes MTBM shipping cost, cutters, seal etc.)	$ 410,072.04
Receiving Shaft		**Receiving Shaft**		**Receiving Shaft**	
TEMPORARY FENCE, (8 ft. high, chain link)	$ 37,363.04	TEMPORARY FENCE, (8 ft. high, chain link)	$ 37,363.04	TEMPORARY FENCE, (8 ft. high, chain link)	$ 37,363.04
CHAIN LINK VEHICULAR GATE, (8 ft. X 20 ft.)	$ 16,681.52	CHAIN LINK VEHICULAR GATE, (8 ft. X 20 ft.)	$ 16,681.52	CHAIN LINK VEHICULAR GATE, (8 ft. X 20 ft.)	$ 16,681.52
GRAVEL SITE WORK AREA	$ 141,394.40	GRAVEL SITE WORK AREA	$ 141,394.40	GRAVEL SITE WORK AREA	$ 141,394.40
SHORING (assume 30 foot dia 23 foot deep)	$ 401,772.36	SHORING (assume 25 foot dia 54 foot deep)	$ 948,698.76	SHORING (assume 30 foot dia 54 foot deep)	$ 948,698.76
EXCAVATE SHAFT - Soil 30 foot dia 23 foot deep	$ 57,657.84	EXCAVATE SHAFT - Soil 25 foot dia 54 foot deep	$ 144,144.60	EXCAVATE SHAFT - Soil 30 foot dia 54 foot deep	$ 144,144.60
POUR MUDSLAB (assume 3 foot thick)	$ 34,276.87	POUR MUDSLAB (assume 3 foot thick)	$ 34,276.87	POUR MUDSLAB (assume 3 foot thick)	$ 34,276.87
HAUL SPOILS (Shaft) 6-mile cycle	$ 47,467.20	HAUL SPOILS (Shaft) 6-mile cycle	$ 94,934.40	HAUL SPOILS (Shaft) 6-mile cycle	$ 94,934.40
SHAFT STRUCTURE	$ 700,905.00	SHAFT STRUCTURE	$ 1,823,505.30	SHAFT STRUCTURE	$ 1,823,505.30
SHAFT EXCAVATION	$ 672,656.27	SHAFT EXCAVATION	$ 672,656.27	SHAFT EXCAVATION	$ 672,656.27
	$ 2,110,174.50		$ 3,913,655.16		$ 3,913,655.16
Launching shaft		**Launching shaft**		**Launching shaft**	
SHORING (assume 35 foot dia 35 foot deep)	$ 727,984.20	SHORING Secant Piles(assume 35 foot dia 56 foot deep)	$ 1,133,536.56	SHORING (assume 35 foot dia 47. foot deep)	$ 950,804.76
EXCAVATE SHAFT - Soil 35 vf	$ 115,315.68	EXCAVATE SHAFT - Soil 56 vf	$ 201,802.44	EXCAVATE SHAFT - Soil 47 vf	$ 172,973.52
POUR MUDSLAB (assume 3 foot thick)	$ 38,989.42	POUR MUDSLAB (assume 3 foot thick)	$ 38,989.42	POUR MUDSLAB (assume 3 foot thick)	$ 38,989.42
HAUL SPOILS (Shaft) 6-mile cycle	$ 83,067.60	HAUL SPOILS (Shaft) 6-mile cycle	$ 130,534.80	HAUL SPOILS (Shaft) 6-mile cycle	$ 106,801.20
MONITOR SETTLEMENT ARRAY	$ 106,559.41	MONITOR SETTLEMENT ARRAY	$ 166,499.08	MONITOR SETTLEMENT ARRAY	$ 139,859.22
	$ 1,071,916.31		$ 1,671,362.30		$ 1,409,428.12
Outfall		**Outfall**		**Outfall**	
DISCHARGE STRUCTURE	$ 1,568,680.00	DISCHARGE STRUCTURE	$ 1,568,680.00	DISCHARGE STRUCTURE	$ 1,568,680.00
OPEN CUT PIPE	$ 575,000.00	DISCHARGE CHANNEL	$ 156,000.00		
	$ 2,143,680.00		$ 1,724,680.00		$ 1,568,680.00
Tunnel		**Tunnel**		**Tunnel**	
TBM ASSEMBLY/LAUNCH	$ 3,140,148.62	TBM ASSEMBLY/LAUNCH	$ 3,140,148.62	TBM ASSEMBLY/LAUNCH	$ 3,140,148.62
TUNNEL 120 inch	$ 17,094,819.20	TUNNEL 120 inch	$ 18,050,450.47	TUNNEL 120 inch	$ 18,795,552.58
HAUL SPOILS (Tunnel) 6-mile cycle	$ 3,516,639.00	HAUL SPOILS (Tunnel) 6-mile cycle	$ 3,684,098.00	HAUL SPOILS (Tunnel) 6-mile cycle	$ 3,851,557.00
TBM DISASSEMBLY/REMOVAL	$ 1,449,574.31	TBM DISASSEMBLY/REMOVAL	$ 1,449,574.31	TBM DISASSEMBLY/REMOVAL	$ 1,449,574.31
	$ 25,201,181.13		$ 26,324,271.40		$ 27,236,832.51
Subtotal	$ 30,937,023.98		$ 34,044,040.90		$ 34,538,667.83
GC General Conditions	$ 3,093,702.40		$ 3,404,404.09		$ 3,453,866.78
Permits and Bonds	$ 1,242,121.51		$ 1,366,868.24		$ 1,386,727.51
Overhead and Profit	$ 3,527,284.79		$ 3,881,531.32		$ 3,937,926.21
Construction Contingency Class 5	$ 9,700,033.17		$ 10,674,211.14		$ 10,829,297.08
Escalation to 2025	$ -		$ -		$ -
TOTAL	$ 48,500,165.85		$ 53,371,055.69		$ 54,146,485.42

Appendix D

Preliminary Geotechnical Engineering Report.

PRELIMINARY GEOTECHNICAL ENGINEERING REPORT

City of Wauwatosa
Schoonmaker Creek Watershed
Wauwatosa, Wisconsin

GESTRA Project No.: 23414-10
April 3, 2024

Prepared For:
MSA Professional Services, Inc.
1702 Pankratz Street
Madison, WI 53207

GESTRA

Preliminary Geotechnical Engineering Report

City of Wauwatosa
Schoonmaker Creek Watershed
Wauwatosa, Wisconsin

GESTRA Project No. 23414-10
April 3, 2024

Prepared For:

MSA Professional Services, Inc.
1702 Pankratz Street
Madison, WI 53704

Prepared By:

GESTRA

GESTRA Engineering, Inc.
191 W. Edgerton Avenue
Milwaukee, WI 53207
(414) 933-7444

Table of Contents

Preliminary Geotechnical Engineering Report
City of Wauwatosa
Schoonmaker Creek Watershed
Wauwatosa, Wisconsin

1.0 INTRODUCTION

GESTRA Engineering, Inc. (GESTRA) was authorized by MSA Professional Services, Inc. to complete a subsurface exploration and preliminary geotechnical engineering report for the City of Wauwatosa Schoonmaker Creek Watershed Preliminary Engineering Analysis project located in Wauwatosa, Wisconsin. This report presents the results from the subsurface soil exploration and describes the field exploration, laboratory test results, and provides preliminary geotechnical engineering recommendations pertaining to the design and installation of the proposed storm sewer.

The engineering recommendations and analysis contained within this report are based on the following project information which is a projection of GESTRA's understanding of the project. If for any reason the actual project information differs from what is reported below, GESTRA should be contacted so that we can review our recommendations in light of any new information.

1.1 PROJECT INFORMATION

At the time of preparing this report, the City of Wauwatosa is considering two alternatives for the relocation of a storm sewer. The two alternatives being considered are an open cut excavation option along West Llyod Street and Martha Washington Drive and a tunneling option along North 68th Street.

Based on CDM Smith Preliminary Tunnel Alignment Evaluation – Schoonmaker Creek Watershed, dated February 7, 2024, if the tunneling method is chosen, the inside diameter of the pipe is planned to be 10 feet. If open cut excavation is planned to be used, the proposed sewer will a be 6-foot by 12-foot box storm sewer. A map showing the alignment of each option has been included in Appendix I.

2.0 SCOPE OF SERVICES

GESTRA has performed the following services for the project:

- Contacted Diggers Hotline to locate the public utilities at the site.
- Located the boring locations on site using a Geomax Zenith 35 GNSS-INS (GPS) receiver. Elevation and coordinates of the boring locations determined by the GPS equipment were referenced to Wisconsin State Plane South Coordinate System (NAVD88).
- Completed a total of 12 standard penetration test (SPT) soil borings, SB-01 through SB-05 and SB-07 through SB-13. Boring SB-06 was not completed as this was cancelled by the City of Wauwatosa as it was outside of the proposed two alternatives. The SPT soil borings were completed between depths of 15 feet and 61 feet. At the completion of drilling, boreholes were abandoned per WDNR requirements. Borings completed in pavement were surfaced patched with cold patch asphalt.

- Performed laboratory soil testing to assign classification and engineering properties to the soils encountered. The laboratory testing included hand penetrometer, moisture content, Atterberg limits, grain size analysis, and unconfined compression strength tests.
- Prepared this preliminary geotechnical engineering report presenting the results from the field and laboratory testing and provide the following recommendations:
  a. Discussion related to the subsurface soil conditions, groundwater conditions, and bedrock depths.
  b. Lateral earth pressures parameters of soils at each borehole location.
  c. Construction considerations for both open cut excavation and tunneling installation.

3.0 EXPLORATION RESULTS

3.1 Site Conditions

The project site is located within the City of Wauwatosa. The project area is bounded by West Lloyd Street to the north, West State Street and River Parkway to the south, North 60th Street to the east and North 68th Street to the west. The general topography for the site slopes downward from the north to the south with grades of the site varying between 630 feet and 760 feet.

3.2 Subsurface Soil Profile

All of the borings were completed within City of Wauwatosa right-of-way. Borings SB-01, SB-04, SB-05, SB-07, SB-08, SB-09 and SB-13 were completed within the roadways along the proposed project alignments. Table 3-1 provides a summary of the pavement section at each of the above boring locations.

Table 3-1: Summary of Pavement Section

Boring No.	Street Name	Asphalt Thickness (inches)	Concrete Thickness (inches)	Base Course Thickness (inches)
SB-01	West Llyod Street	8.5	None	6
SB-04	Mountain Avenue	4.5	None	9
SB-05	Martha Washington Drive	7	None	7
SB-07	North 68th Street	6	None	11
SB-08	North 68th Street	None	8	Unknown [2]
SB-09	West State Street	5.5	4	7

Boring No.	Street Name	Asphalt Thickness (inches)	Concrete Thickness (inches)	Base Course Thickness (inches)
SB-13	West Martin Drive	5.5	None	5

[1] Measurements were taken to the nearest ½-inch.

[2] An accurate base course thickness was unable to be determined due to the similarity between the base course material and the underlying subgrade soils.

The remaining borings, SB-02, SB-03, SB-10, SB-11 and SB-12, were completed in the landscaped grass area within City of Wauwatosa right-of-way. The topsoil thickness at the above locations was measured to be less than 6 inches, with the exception in boring SB-02. In boring SB-02 the topsoil thickness was measured to be approximately 20 inches.

The project site is located in an urban area. Fill material was encountered in multiple borings and varied in soil type, consistency and depth. The soil types ranged from lean clay with various amount of sand and gravel to granular soil with various amounts of fines. In boring SB-05 trace pieces of asphalt was observed within the fill.

The native soil profile varied along each of the proposed alignments. North of Milwaukee Avenue the generalize native soil profile primarily consisted of medium stiff to very stiff lean clay soil which transitioned to very stiff to hard lean clay soil. In borings SB-01 and SB-03 which were completed deeper, granular soil was encountered below the very stiff to hard lean clay soils. The depth to granular soil was observed to be below a depth of 50 feet in SB-01 and below a depth of 25 feet in SB-03. Borings performed south of Milwaukee Avenue the depth to granular soil was observed to be shallower in borings SB-05, SB-12 and SB-13 typically within less than 15 feet to 20 feet below the ground surface (bgs) and even shallower in borings SB-07, SB-08 and SB-09 along West State Street, within less than 5 feet to 10 feet bgs.

Results of the field and laboratory tests, observations, transition and thicknesses of each stratum are depicted on the individual boring logs included in Appendix I. In addition, strength values for each stratum are presented on the soil parameter tables also included in Appendix I. Soils were grouped together based on similar observed properties. The stratification lines were estimated by the reviewing engineer based on available data and experience. The actual in-situ changes between layers may differ slightly and may be more gradual than depicted on the boring logs. Subsurface and groundwater conditions can vary between borehole locations and in areas not explored.

It is important to note that the soil observations, fill depths, topsoil, and pavement thickness estimates were made in small diameter boreholes. Therefore, it should be understood that thicker or thinner deposits of the individual strata are likely to be encountered within other portions of the project. Furthermore, the estimation of strata thickness at a particular location can differ from person to person due to a sometimes-indistinct transition between the soils encountered. Additionally, it must be recognized that in the absence of foreign substances and/or debris within the soil samples obtained, it is sometimes difficult to distinguish between natural soils and clean soil fill.

3.3 BEDROCK INDICATORS

Bedrock coring was not completed in any of the borings as this was out of GESTRA's scope of services for the project and if needed, will likely be completed once the design has been further developed. Another indication of potential bedrock may be auger refusal or slow tri-cone advancement during drilling operations. Auger refusal was observed in three of the borings completed. Table 3-2 summarizes the boring locations where auger refusal was encountered prior to reaching the assigned termination depth.

Table 3-2: Potential Depth and Elevation of Bedrock at Borehole Locations

Boring Number	Depth to Auger Refusal or Slow Tri-cone Advancement (feet)	Elevation of Auger Refusal or Slow Tri-cone Advancement (feet)
SB-03	39.9	633.6
SB-05	33.1	637.7
SB-07	15.0	661.1

Based on the Preliminary Bedrock Topography Map of Milwaukee County Wisconsin by T.J. Evan dated 2004, bedrock within the project area primarily varies between an elevation of 600 feet and 650 feet. The exception is noted in a small area that appears to be located near North 68th Street just north of West State Street. At this location the bedrock is mapped slightly higher between an elevation of 650 feet and 700 feet, which seems to compare to where auger refusal was noted in boring SB-07.

It should be noted that the estimated bedrock depths noted in the above table are estimates. To determine if auger refusal was caused due to bedrock, additional borings with rock core should be performed at these locations and/ or geophysical topography study should be performed.

3.4 GROUNDWATER OBSERVATIONS

Groundwater observations were made during and at the completion of drilling operations. Table 3-3 provides a summary of groundwater observations made during and at the completion of drilling operations.

Table 3-3: Observed Water Levels During and at the Completion of Drilling Operations

Boring Number	Observed Water Table During Drilling Operations		Observed Water Table at the Completion of Drilling Opeartions	
	Depth (feet)	Elevation (feet)	Depth (feet)	Elevation (feet)
SB-01	20.5	706.7	45	682.2

Boring Number	Observed Water Table During Drilling Operations		Observed Water Table at the Completion of Drilling Opeartions	
	Depth (feet)	Elevation (feet)	Depth (feet)	Elevation (feet)
SB-02	30	677.5	No Measurement Recorded	
SB-03	12	661.6	No Measurement Recorded	
SB-04	35	689.1	50	674.1
SB-05	20	650.8	25	645.8
SB-07	Water Not Present		Water Not Present	
SB-08	24	617.9	19.5	622.4
SB-09	7.5	626.0	15	618.5
SB-10	24.5	672.4	Water Not Present	
SB-11	Water Not Present		Water Not Present	
SB-12	23	636.3	21	638.3
SB-13	25	617.8	Water Not Present	

The groundwater measurements made in the boreholes may not be a true representation of the actual groundwater table. Therefore, the measurements taken in the boreholes should be considered a temporary condition. It should be noted that the groundwater table within clay and silt soils may require several days to recharge and stabilize due to the low permeability rate of clay and silt soils. Therefore, it is recommended installation and monitoring of observation wells be installed to assess the true groundwater along the project alignment.

Groundwater level fluctuations may occur with time and seasonal changes due to variations in precipitation, evaporation, surface water runoff and local dewatering. Perched water pockets and a higher water table may also be encountered during wet weather periods, particularly in more permeable silt and sand seams or granular fill material overlying less permeable clays.

4.0 ANALYSIS AND RECOMMENDATIONS

It is unknown if the project will install the new storm sewer by either open cut excavations or by using tunneling methods. The below sections provide considerations for both options and any concerns that may arise during construction. The recommendations provided in this section should be taken as preliminary as the final design details have not been provided and additional information may be needed once the design has been further developed.

4.1 RECOMMENDED SOIL PARAMETERS

Subsurface exploration and laboratory test data was used to approximate the subsurface profile at each borehole location. The actual transition of soil stratum between sample intervals and borehole locations may be different in-situ than inferred from the boring logs. Some of the engineering properties were directly measured from laboratory tests, and other properties were interpreted based on published correlations with SPT blow counts and soil index properties, or generally accepted engineering judgment. The recommended soil parameters are included in Appendix I.

4.2 OPEN CUT EXCAVATION CONSIDERATIONS

Along the proposed open cut excavation alternative, a total of nine soil borings were completed, SB-01, SB-02, SB-03, SB-05, SB-09, SB-10, SB-11, SB-12 and SB-13. Based on the Plan and Profile drawings, dated March 3, 2024 provided by MSA the alignment using open cut methods will follow along West Llyod Street starting from North 68th Street to Matha Washington Drive, at Martha Washington Drive the storm sewer will follow the roadway south to West Martin Drive and North 60th Street, where it will cross below West State Street and discharge in the Menomonee River.

Based on the soil borings completed it appears that there is a change in the native soil profile where excavations will primarily occur in native granular soil (sand and gravel) and native clay soil. The transition appears to occur between borings SB-05 and SB-13. Boring SB-12 was complete between the two borings but had deeper fill, therefore it is difficult to determine if excavations at this location will primarily occur through native granular or clay soil. Additional borings may be warranted between borings B-05 and B-13 to help determine more accurately the transition where excavations will occur primarily through native granular soil or clay soil.

Based on the soil borings it appears that excavations north of B-05 will primarily occur through the native clay soil, and excavations south of B-13 will primarily occur through the native granular soils. It should be noted that fill was encountered in majority of the borings and that the project is located in an urbanized area. Based on the fill material observed in the borings it is likely that the fill material will consist of a mixture of granular and fine-grained soils.

Based on the Plan and Profile drawings and borings performed, the new storm sewer will likely be supported directly on the native soils. The native soils encountered in the borings at the base of the proposed storm sewer soils should be suitable to support the new pipe or box.

Reuse of Excavated Soil for Backfill Material

Proper selection and compaction of the storm sewer bedding and cover materials is essential to reduce the amount of storm sewer deflection and settlement of the trench backfill in open cut areas. Bedding material should be placed in accordance with normally accepted procedures for the class of pipe being used. Placement of bedding should be done in such a way as to provide relatively uniform lateral support to the storm sewer until the backfill extends over the pipe. This can be done by alternating fill placement at approximately one-foot intervals to both sides of the storm sewer.

The majority of soils encountered in the borings contained a significant percentage of fine-grained soils (clay and silt). Fine grained soil can be difficult to compact or moisture condition in trench backfill situations. Improper placement of fine-grained soil can result in excess settlement or consolidation of the fill material if not placed and compacted in a controlled manner. Therefore, to limit the risk of improper placement we do not recommended using excavated soil as backfill material within pavement areas. Excavations performed within pavement areas should be backfilled using either granular fill or low strength flowable fill.

The project may consider the reuse of excavated soil in green space area. However, it should be noted that there is still the concern for settlement and consolidation of the fill material. This could result in creating a ditch or an area for potential ponding to occur during storm events. As an alternate to reuse of excavated material the design could also consider using either granular fill or low strength flowable fill as backfill in green space areas.

Dewatering

Based on the soil borings performed, substantial water is not anticipated to be encountered during majority of the excavations with the exception of the southern end of the project where the pipe will cross below West State Street to the outfall structure.

If water is encountered during shallow excavations north of Station 31+75, we anticipate the appropriate number of temporary sump pits and pumps should be sufficient to remove anticipated volume of water in the excavation. The contractor should be prepared to control groundwater and surface water and prevent it from accumulating in excavations or otherwise affecting construction.

South of Station 31+75 the profile of the pipe will be lowered to cross under existing utilities in West State Street, and it is anticipated that excavations will then need to be performed below the static groundwater table. The contractor should be prepared to install a construction dewatering system in this area. It is recommended that the water level during construction be kept a minimum of 2 feet below the deepest excavation during construction and until the final structure and backfill material is placed a minimum of 2 feet above the static water table.

Based on soil borings B-09 and B-13 the static groundwater table is anticipated to be between an elevation of 617 feet and 620 feet. Topographic map on the Milwaukee County LIO website also indicated that the Menomonee River is around an elevation of 620 feet, which correlates with the observed water level measurements in the borings. It should be noted that in boring B-09 water was observed to be at an elevation of 626.8 feet during drilling. Since the measured water level at the completion of drilling was noted to be lower this may be indication that perched water seams may also be encountered in excavation in this area.

A specialty dewatering contractor should be consulted for appropriate dewatering methods during construction as well as to evaluate potential impact on the proposed construction and surrounding structures. If the dewatering system is not properly designed, a boiling and/or heaving subgrade could occur possibly resulting in loss of ground support and detrimental effect to the nearby existing structures.

4.3 TUNNELING CONSIDERATIONS

Based on CDM Smith Preliminary Tunnel Alignment Evaluation – Schoonmaker Creek Watershed, dated February 7, 2024, the most favorable alignment alternative is Alignment 1. The alignment has less curves and will be easier to construct for the contractor. Additionally, unlike alignment 2 and 3 there are fewer utilities directly above the tunnel alignment and less risk of tunnel induced settlement resulting in damage to adjacent infrastructure. The recommendations presented in this section are based on the assumption that Alternative 1 will be the selected alternative, provided that tunneling is selected over open cut excavation.

Along Alignment 1, a total of four soil borings were completed, SB-01, SB-04, SB-07 and SB-08. The plan and profile drawing included in the Preliminary Tunnel Alignment Evaluation – Schoonmaker Creek Watershed was used to evaluate the soil conditions along the alignment and provide any concerns that may arise during construction. Based on soil borings performed, it is likely that tunneling operations may occur through clay and/ or granular soils or mixed faces, such as soil and bedrock.

At boring location SB-01, on the north end of the site, the tunneling operations may likely occur through clay soils. At boring location SB-07 (approximate STA 110+00) the tunneling operations may then likely occur through bedrock, indicated by auger refusal, and at boring location SB-08, on the south end of the site, tunneling operations may occur through granular soils.

Where tunneling operations will occur through the clay soils, it is anticipated that the soils will exhibit a “firm” behavior. Based on Figure 1-8 Soil Expansion Prediction (after Holtz et al. 2011) and results from the Atterberg limit test the clay soil is considered to have low to non-swelling potential. Where tunneling operations will likely occur through sandy silt soils, and will likely occur below the water table, it is anticipated that the soils will exhibit more of a “fast raveling” to potential “flowing” behavior.

Where tunneling operations will occur below the water table, the project should consider a dewatering plan or the use of shield tunnel to prevent the running or flowing of wet sand, silt and gravel soil. In addition, to the additional borings above, we recommend that the design team and owner considers installing monitoring wells along the southern portion of the alignment and performed slug testing to determine the permeability rate of the in-situ soils to design a proper dewatering system. The dewatering plan should also consider the effects of lower the water level may have on nearby utilities and structures.

It should be noted that the above assumptions were based on limited soil information collected in the borings. At some locations the borings did not extend below the proposed bottom of the pipe elevation. Therefore, if Alternative 1 and tunneling installation is selected as the preferred method of installation, additional borings must be completed along the alignment to confirm soil and bedrock conditions. Rock coring must be done to determine the condition and type of bedrock in the area. A geophysics study could be completed to better define the horizontal and vertical limits of bedrock.

4.4 GEOTECHNICAL CONSIDERATIONS

Excavation Stability

Caving is a common issue for excavation side walls during construction, especially if fill material, granular soils, and/or water seepage are observed. An excavation plan should be developed and the length of excavation left open should be limited to prevent caving soil from covering the suitable bearing soils.

A temporary soil retention system may also be necessary in order to prevent caving or provide support of surrounding structures or utilities during construction. Providing recommendations or designing the retention system is out of the scope for GESTRA. The contractor must comply with the federal, state, local and updated OSHA regulations during excavation and in retention system design to ensure excavation safety.

Occupational Safety and Health Act (OSHA) has instituted strict standards for temporary construction excavations. These standards are outlined in 29 CFR Part 1926 Subpart P. Excavations within unstable soil conditions or extending five feet or more in depth should be adequately sloped or braced according to these standards. Excavation safety is the responsibility of the contractor. Material stockpiles or heavy equipment should not be placed near the edge of the excavation slopes. The actual stable slope angle should be determined during construction and will depend upon the loading, soil, and groundwater conditions encountered.

Weather Implications

The subgrade soil or the soil at foundation level might become unstable with exposure to adverse weather such as rain, snow and freezing temperatures. The unstable areas due to weather exposure may require an additional undercut or stabilization and the representative geotechnical engineer should assist with the determination of the depth of additional undercut or stabilization procedure based on observation of the field condition.

Soil Sensitivity

Soil at the construction site will be exposed to moisture and disturbance from construction traffic, construction equipment and human factors. If the soil is disturbed, it may become more moisture sensitive. The contractor should try to lessen the exposure of the soil at the construction site to moisture and disturbances. Therefore, the manhole and pipes or box sections should be installed immediately after the review of the representative geotechnical engineer.

5.0 EXPLORATION AND TESTING PROCEDURES

5.1 LAYOUT AND ELEVATION PROCEDURES

A total of twelve (12) SPT soil borings were completed at the approximate locations shown on the attached Borehole Location Map in Appendix I. The location of the borings were selected and located in the field by the City of Wauwatosa. The borings were offset from the original staked located if there was a conflict due to access or utilities.

Elevation of the boreholes were obtained by GESTRA using a Geomax Zenith 35 GNSS-INS receiver. Elevations shown on the boring logs are reference to the Wisconsin County Coordinate System-Milwaukee County (NAVD 88). Coordinates and elevation were not obtained by a licensed surveyor.

5.2 FIELD TESTING PROCEDURES

The boreholes were drilled using either a track or truck mounted drill rig. The boreholes were initiated and advanced by using hollow stem augers. Split spoon samples were collected at 2-1/2 foot intervals to a depth of 11 feet, and then at 5 foot intervals to the assigned termination depth, unless auger refusal was encountered prior. At the completion of drilling the boreholes were backfill per WDNR requirements and surfaced patched with cold patch asphalt.

All representative soil samples were taken in general accordance with the “Standard Method for Penetration Test and Split-Barrel Sampling of Soils” (ASTM D1586) or “Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes” (ASTM D1587). After each sampling, a soil sample was retained and placed in a jar and recorded for type, color, consistency, and moisture, sealed and then transported to the laboratory for further review and testing, if required. The specific drilling method used including the depths, rig type, crew chief, are included on each of the individual boring logs as it may change for each borehole.

5.3 LABORATORY TESTING PROCEDURES

After completion of drilling operations, all of the retained soil samples were transported to GESTRA's laboratory and classified by a geotechnical engineer using the Unified Soil Classification System (USCS). A chart describing the classification system used is included in Appendix I. The engineer assigned laboratory testing suited to extract important index properties of the soil layers. These tests included hand penetrometer, moisture content, Atterberg limits, grain size analysis, and unconfined compression strength test.

STANDARD OF CARE

Our exploration was limited to evaluating subsurface soil and groundwater conditions pertaining to the proposed project. GESTRA did not perform any environmental, chemical, or hydrogeologic testing as these were not part of our work scope.

This report should be made available in its entirety to bidding contractors for information purposes. The soil boring logs and borehole location map should not be detached from this report. Our report is not valid if used for purposes other than what is described in the report.

All OSHA regulations such as those regarding proper sloping and temporary shoring of excavations should be followed during the entire construction process.

GESTRA has presented our professional opinions in this report in the form of recommendations. Our opinions are based on our understanding of current project information and related accepted engineering practices at the time of this report. Other than this, no warranty is implied or intended.

Sincerely,

GESTRA Engineering, Inc.

Report Prepared By:

Eric Jeske P.E. Eric Jeske P.E. 2024.04.02 14:43:02 -05'00'

Eric Jeske, P.E.
Senior Engineer

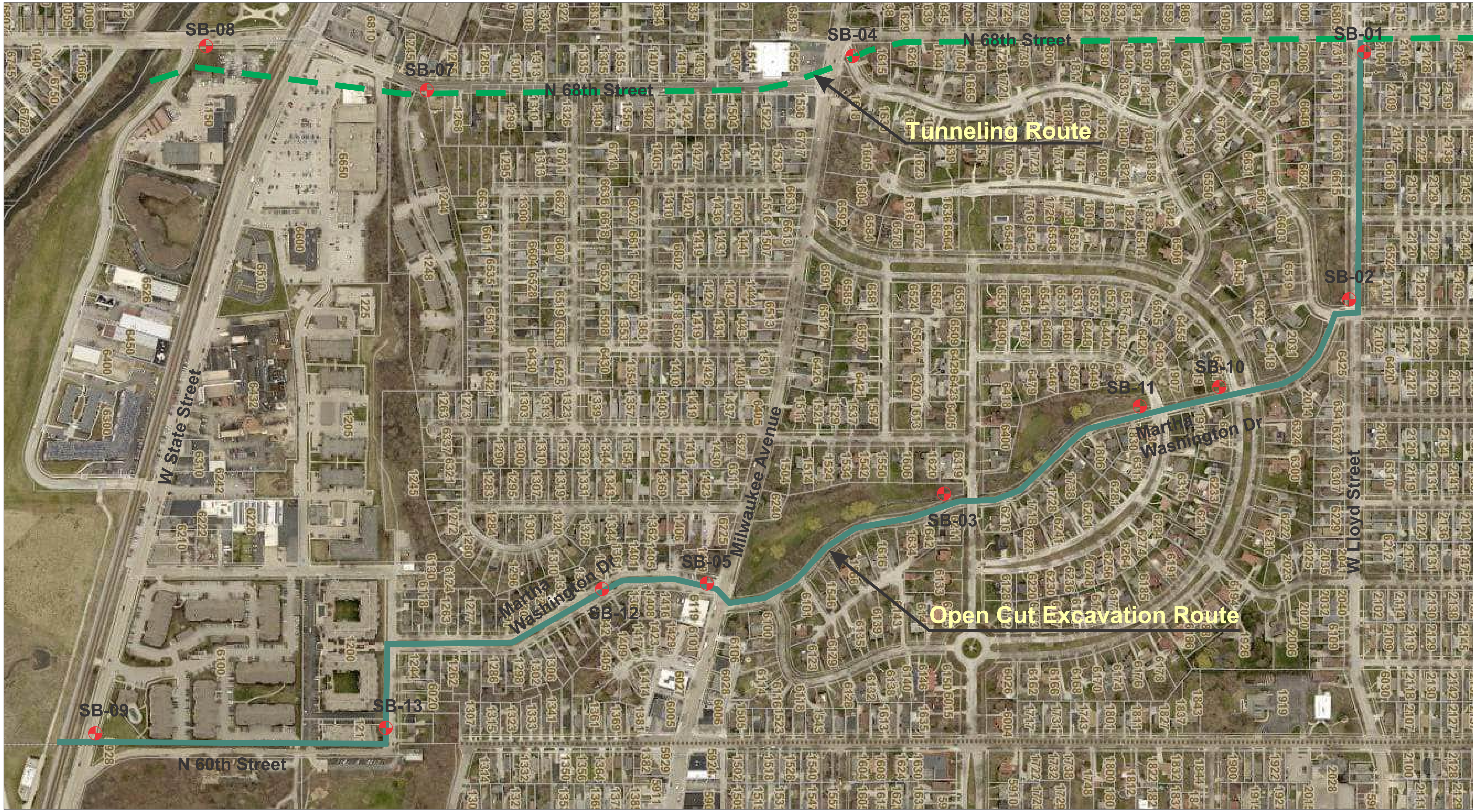
Report Reviewed By:

Doug Bath, P.E. Doug Bath, P.E. 2024.04.02 14:45:36 -05'00'

Doug Bath, P.E.
Senior Engineer

APPENDIX I

BOREHOLE LOCATION MAP, PLAN AND PROFILE DRAWINGS, SOIL BORING LOGS, RECOMMENDED SOIL PARAMETERS, GENERAL NOTES AND SOILS CLASSIFICATION



Base map obtained from Milwaukee County LIO website

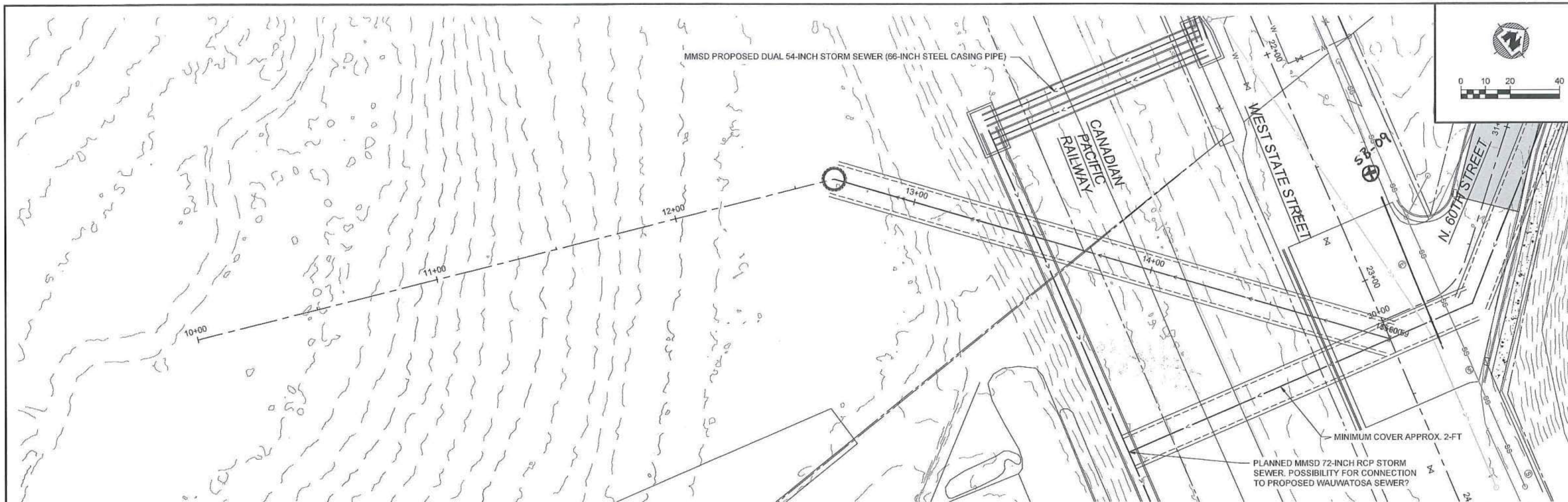
ROUTES ARE APPROXIMATE. ACTUAL ROUTE MAY VARY SLIGHTLY FROM WHAT IS SHOWN

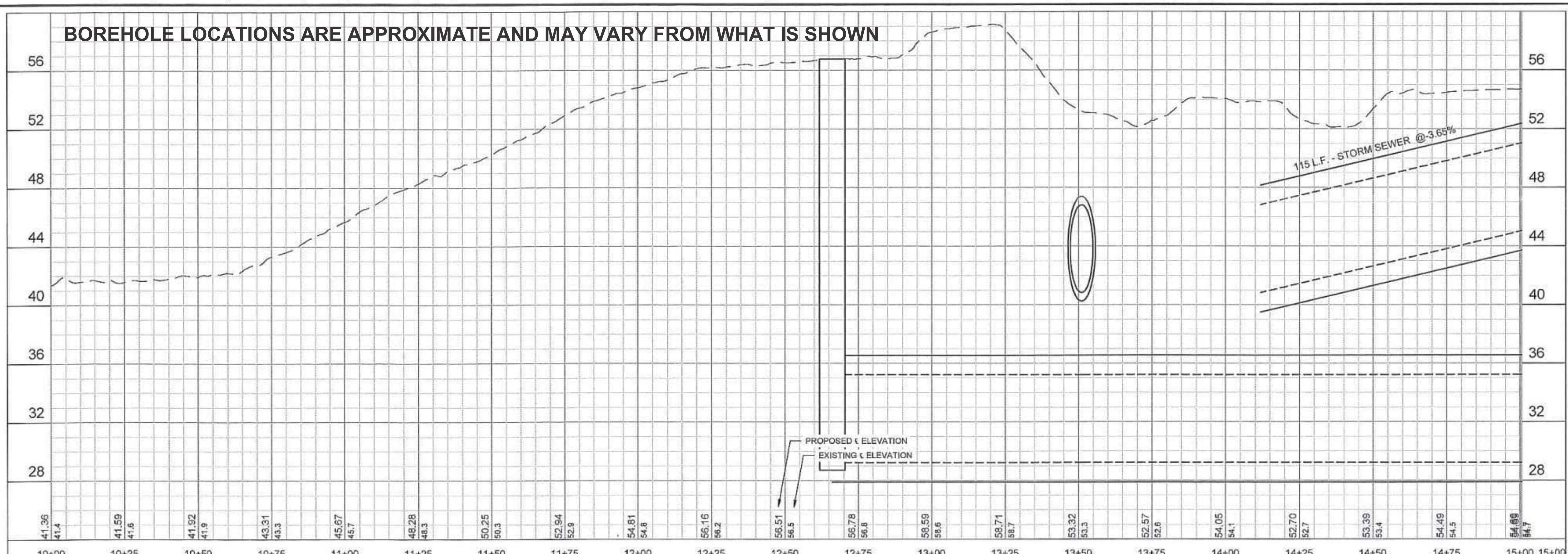
⊕ = APPROXIMATE BOREHOLE LOCATION

GESTRA

GESTRA Engineering, Inc.
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: (414) 933-7444
Fax: (414) 933-7844

Project Name & Location: City of Wauwatosa, Schoonmaker Creek Watershed, Wauwatosa, Wisconsin	Scale: 1" = 6,500'
	Drawing No.: 1 of 1
Drawing Title: Borehole Location Map	Prepared by: ESJ
	Checked by: DB
Project No.: 23414-10	Date: March 25, 2024





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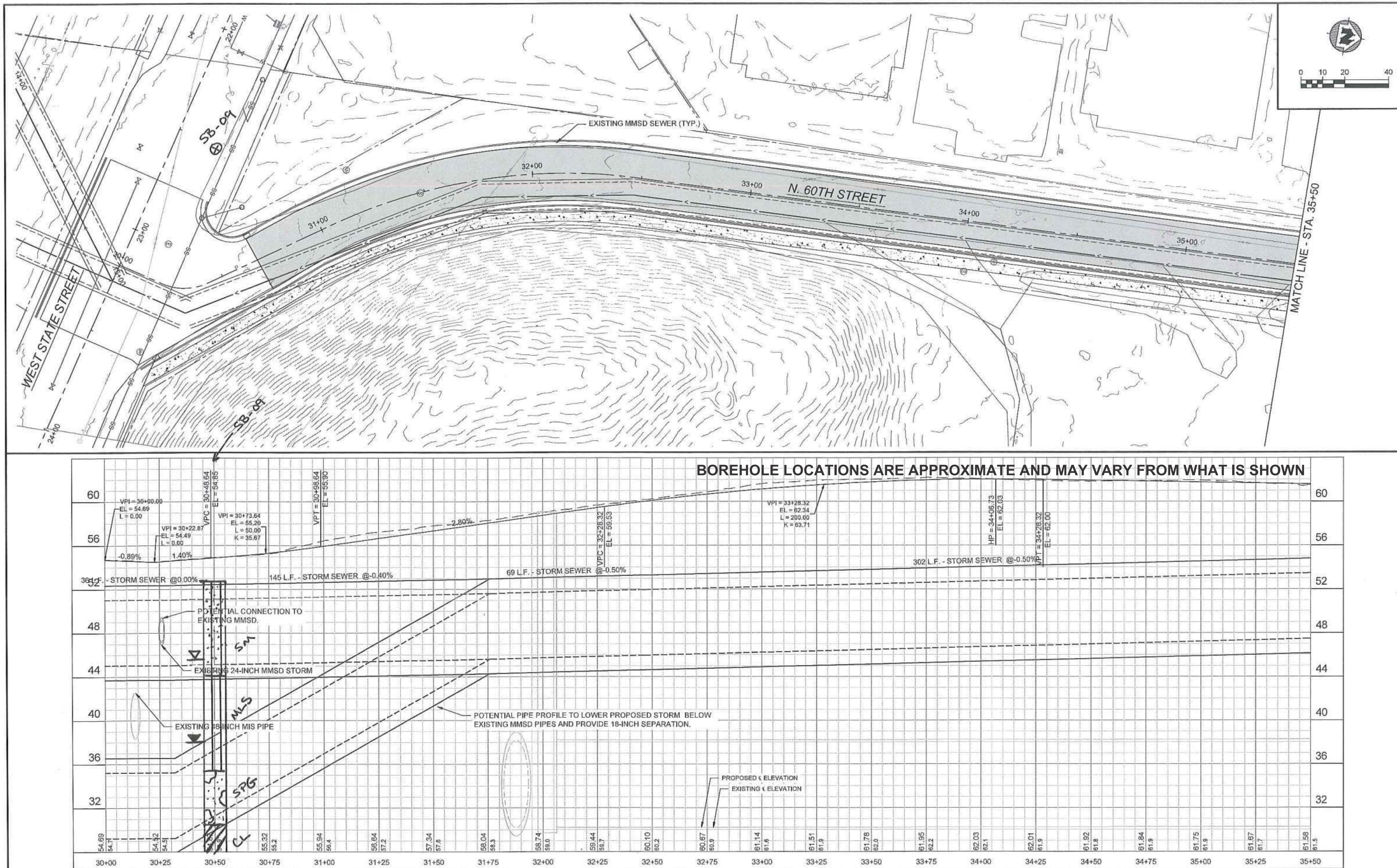

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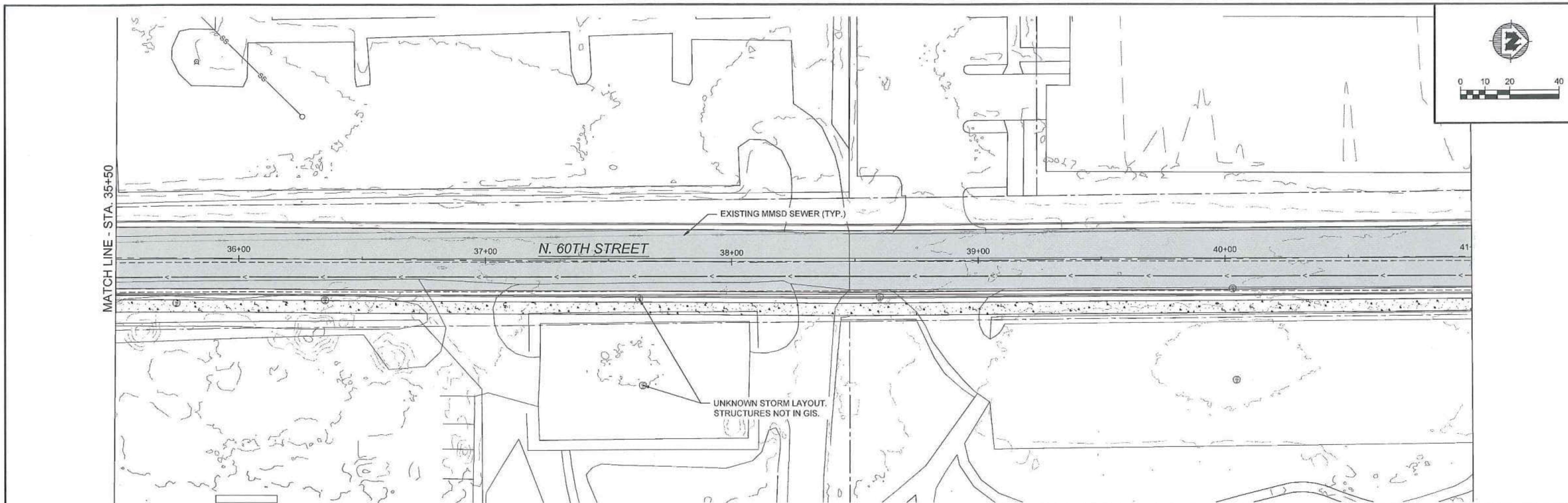

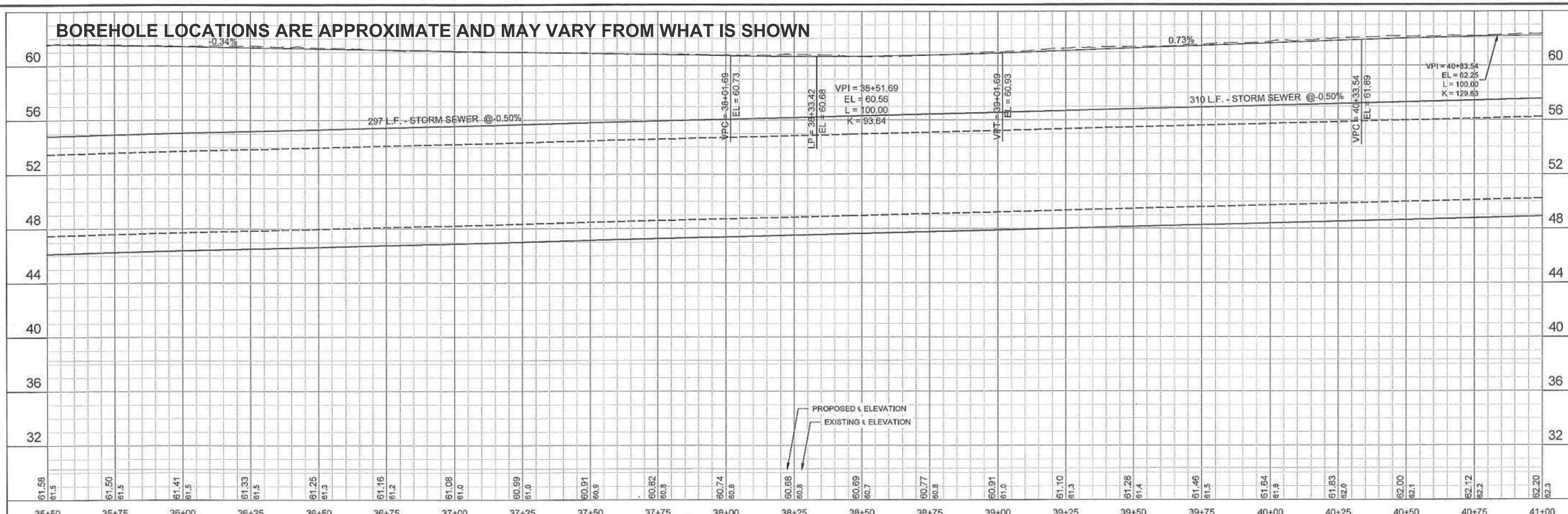

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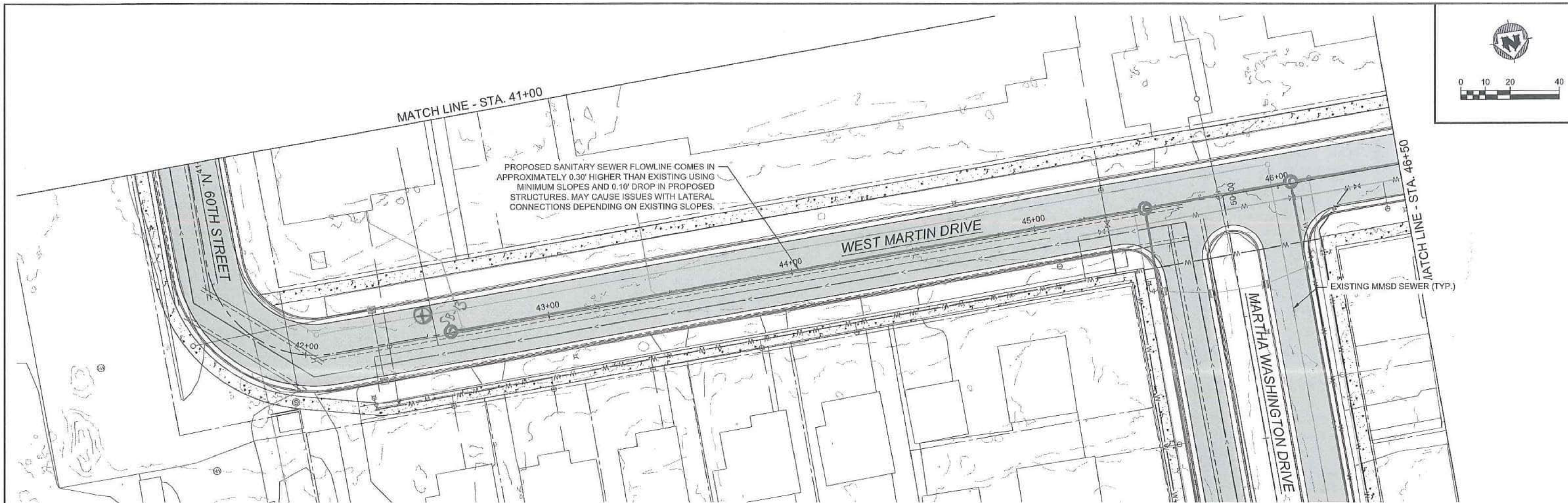

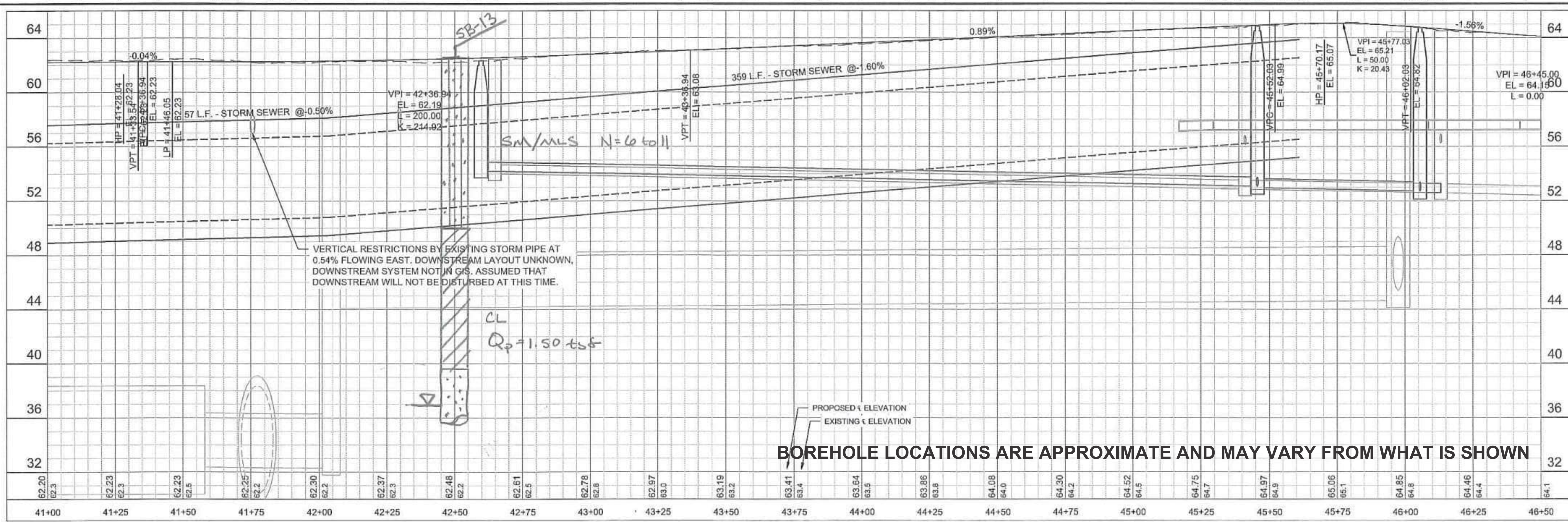

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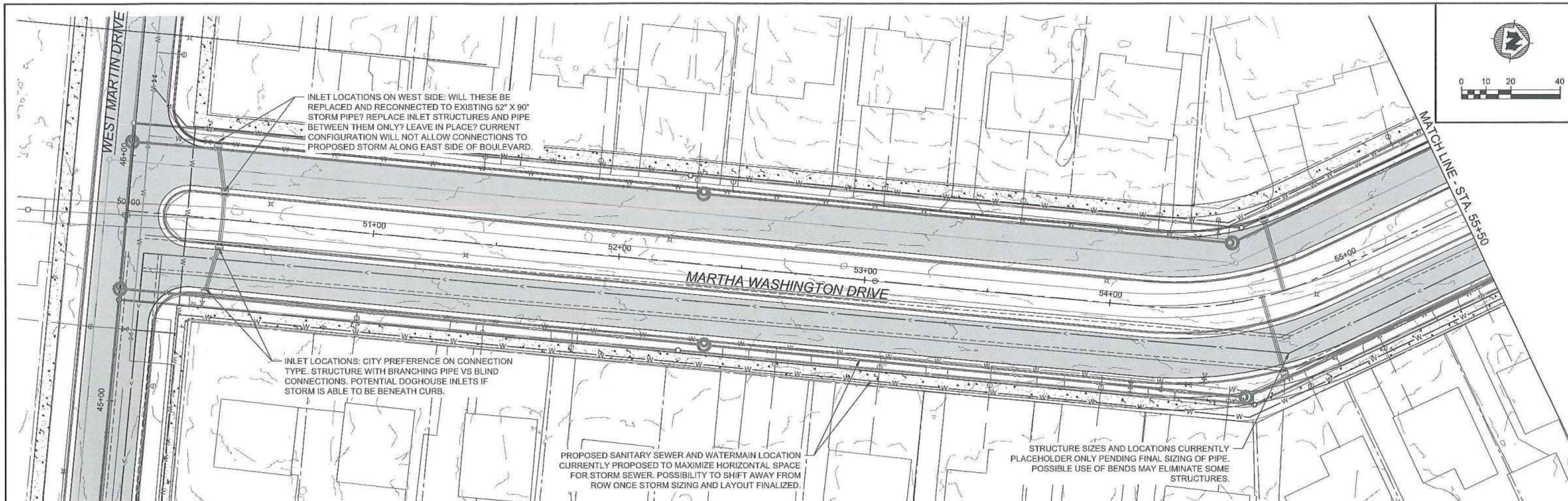

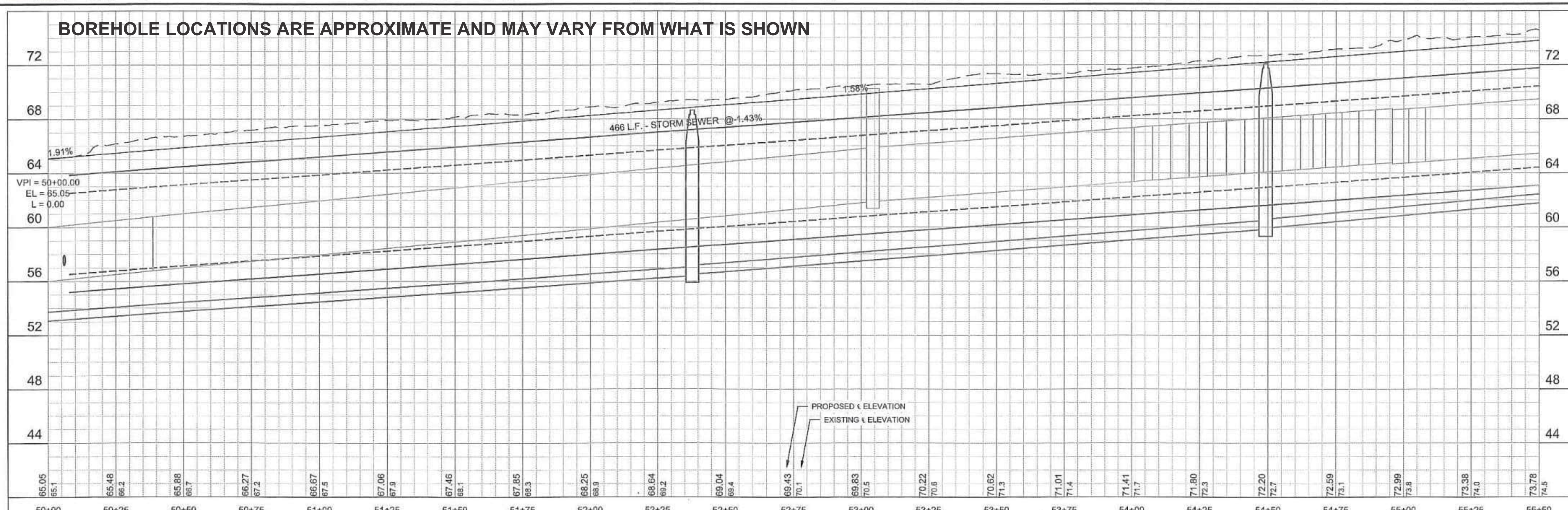

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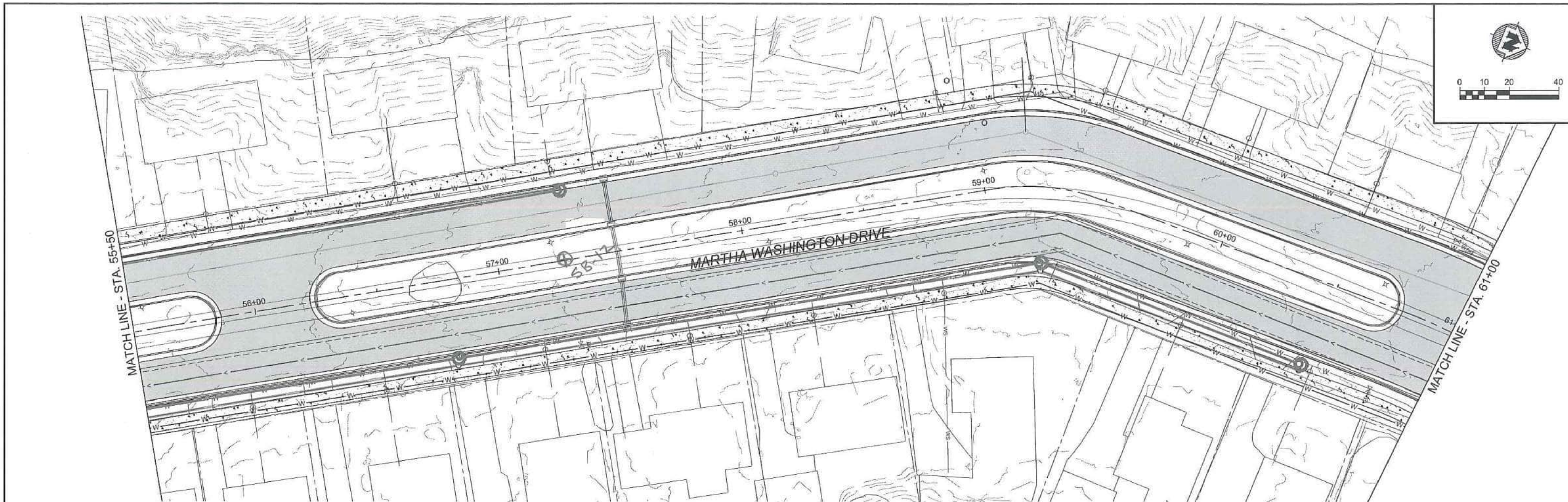

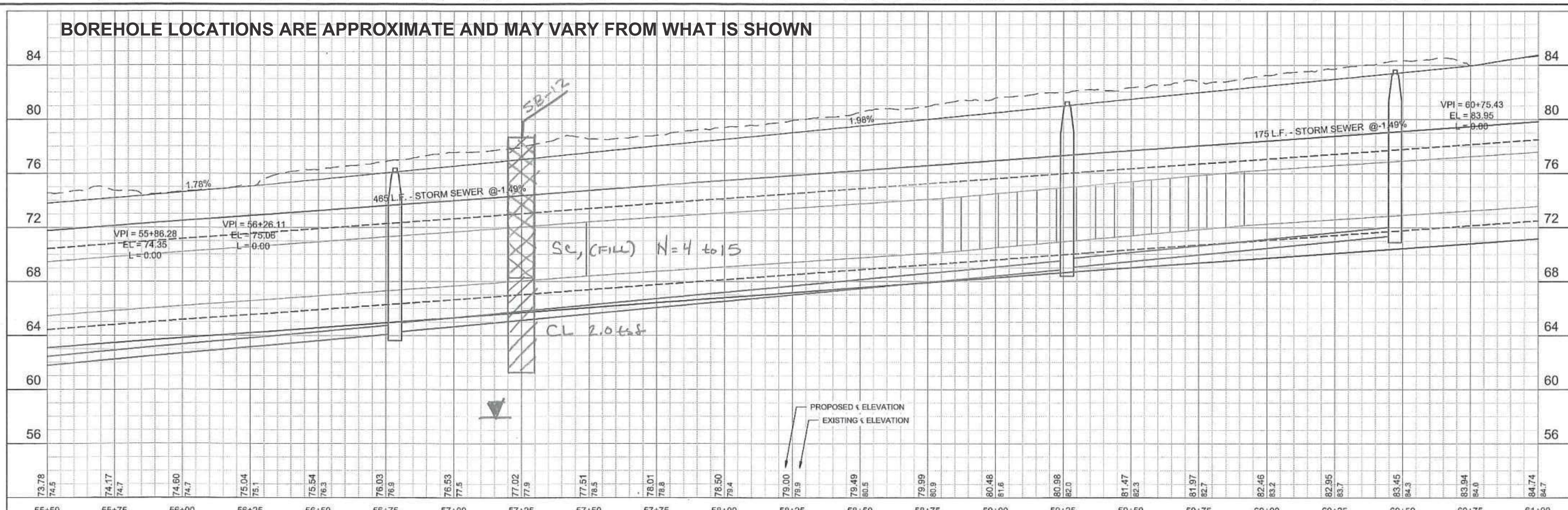

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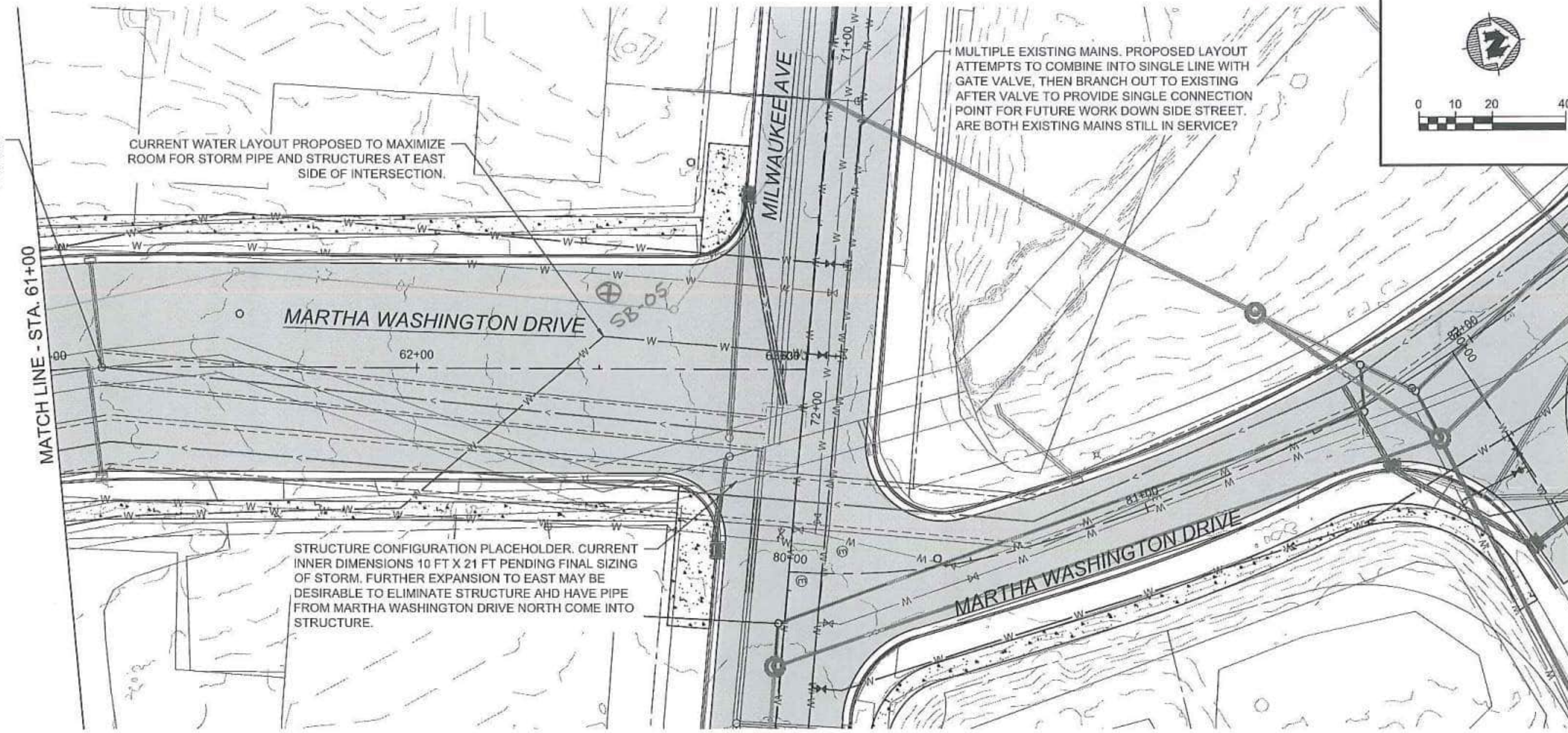
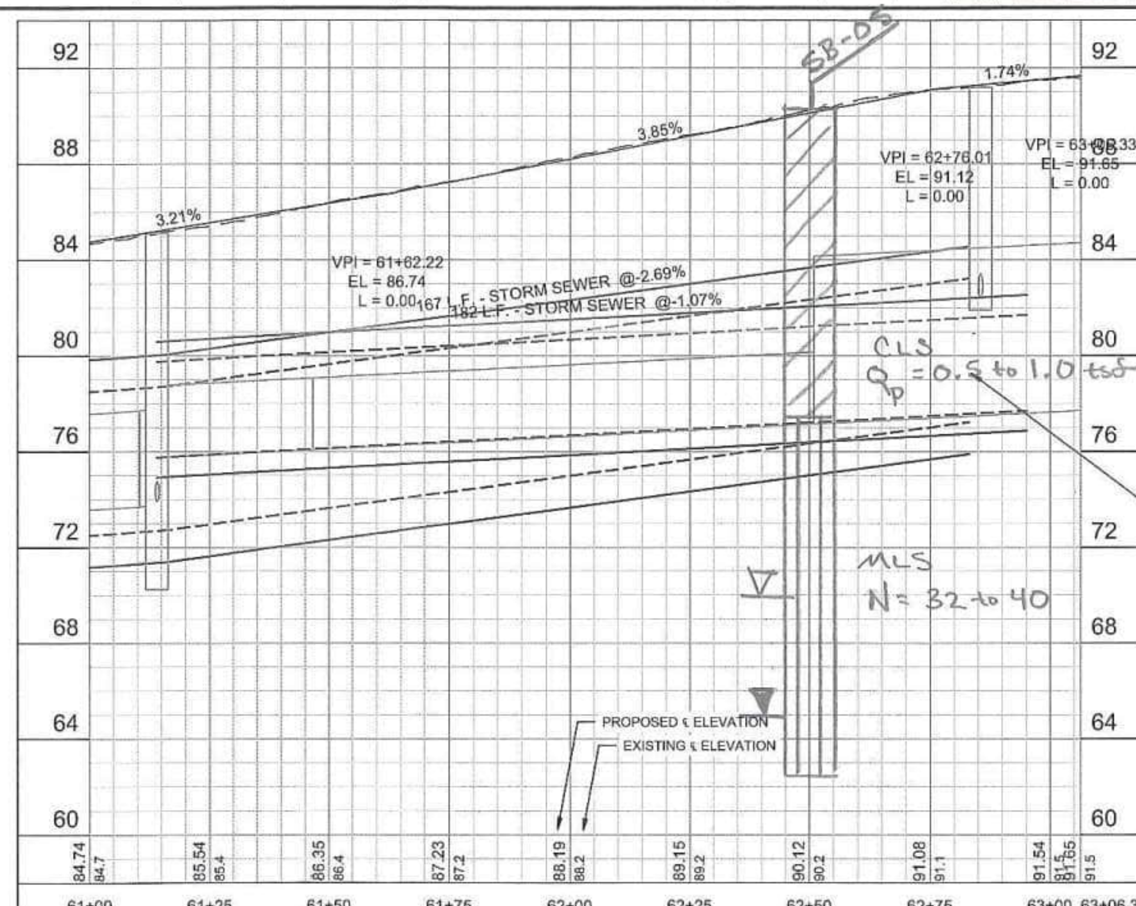


BOREHOLE LOCATIONS ARE APPROXIMATE AND MAY VARY FROM WHAT IS SHOWN



PIPE SLOPE AND CONNECTION POINTS PENDING FINAL SIZING OF STORM PIPE AND CONFIGURATION OF STRUCTURE IN INTERSECTION.

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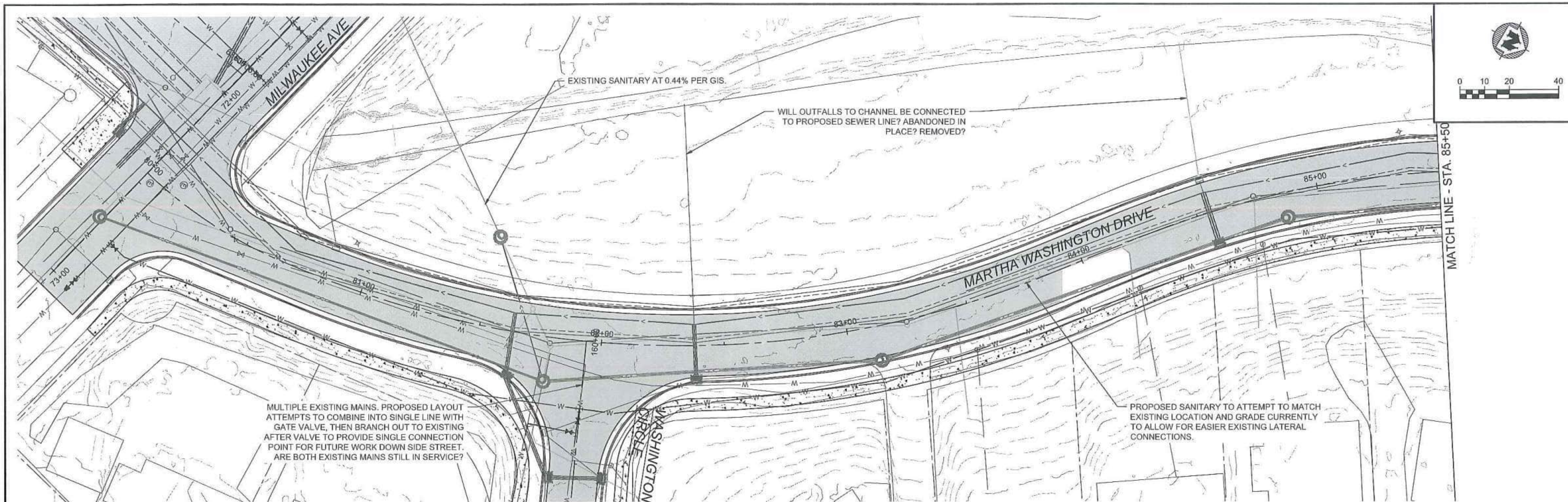

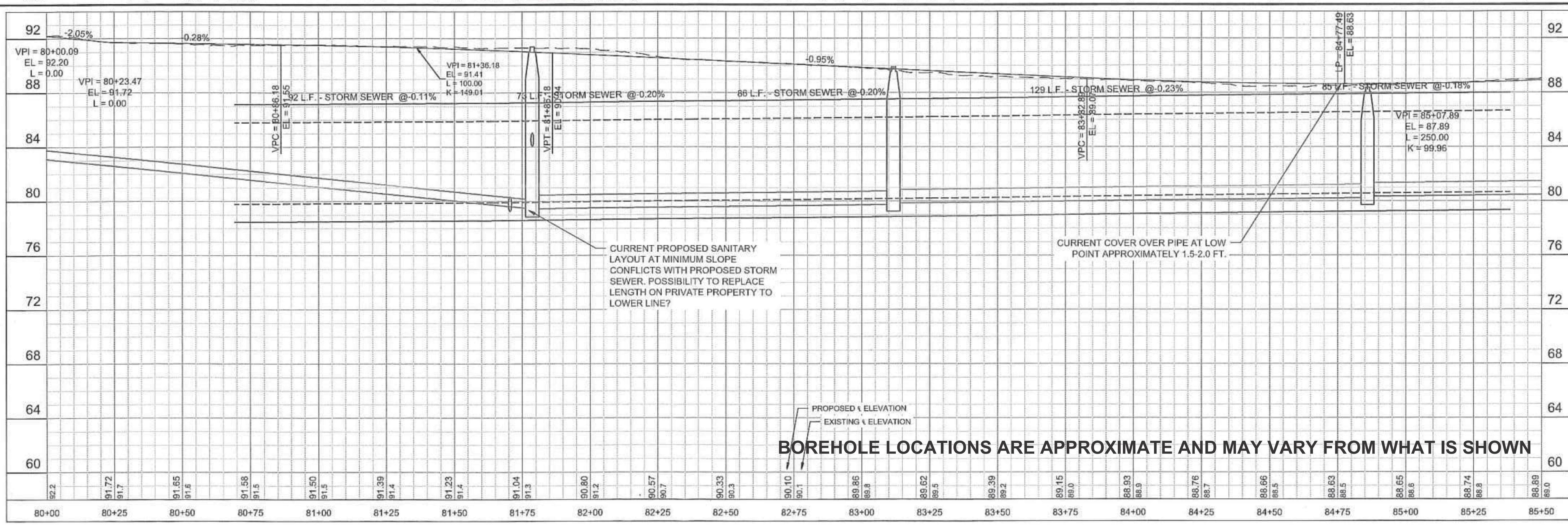

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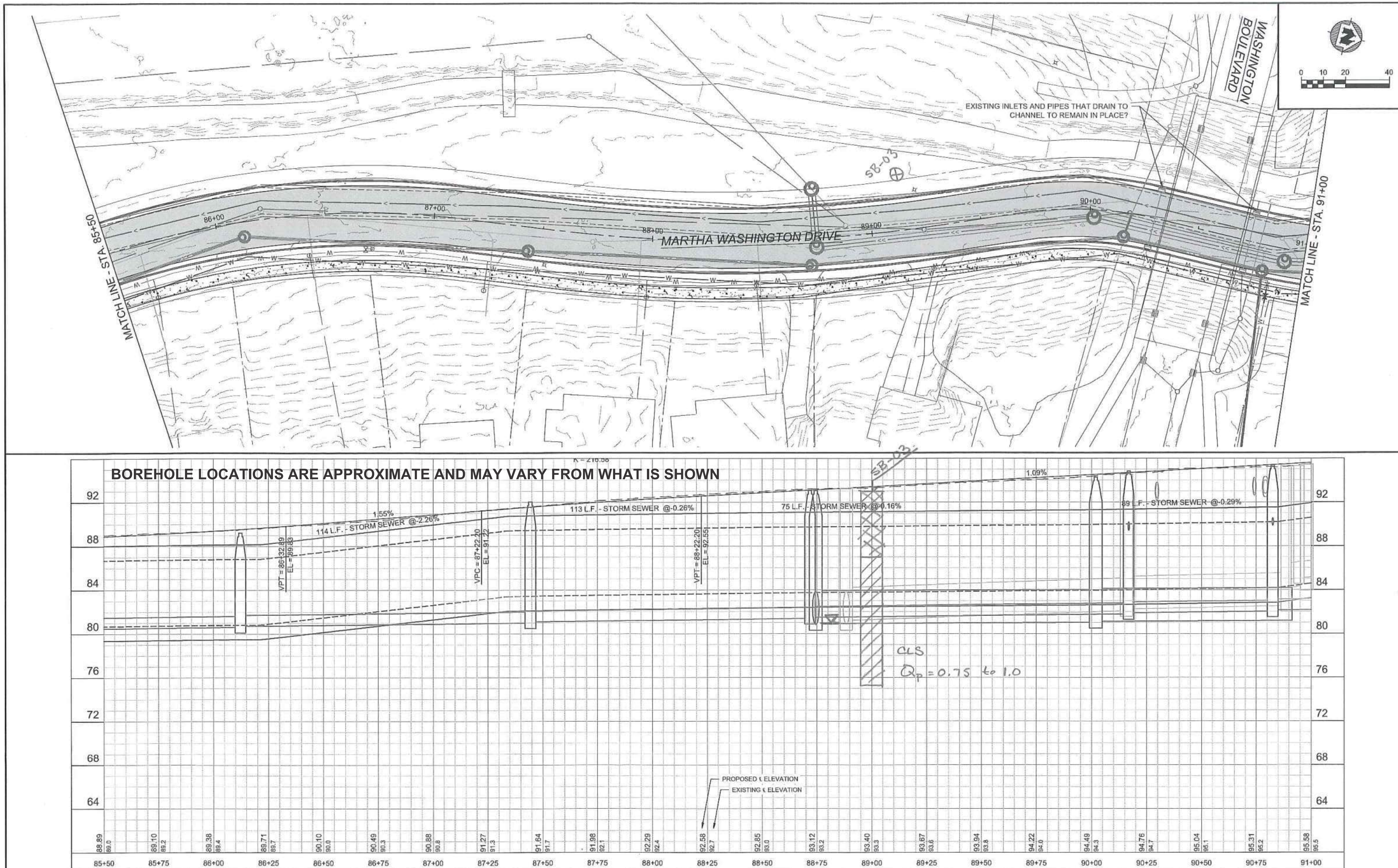

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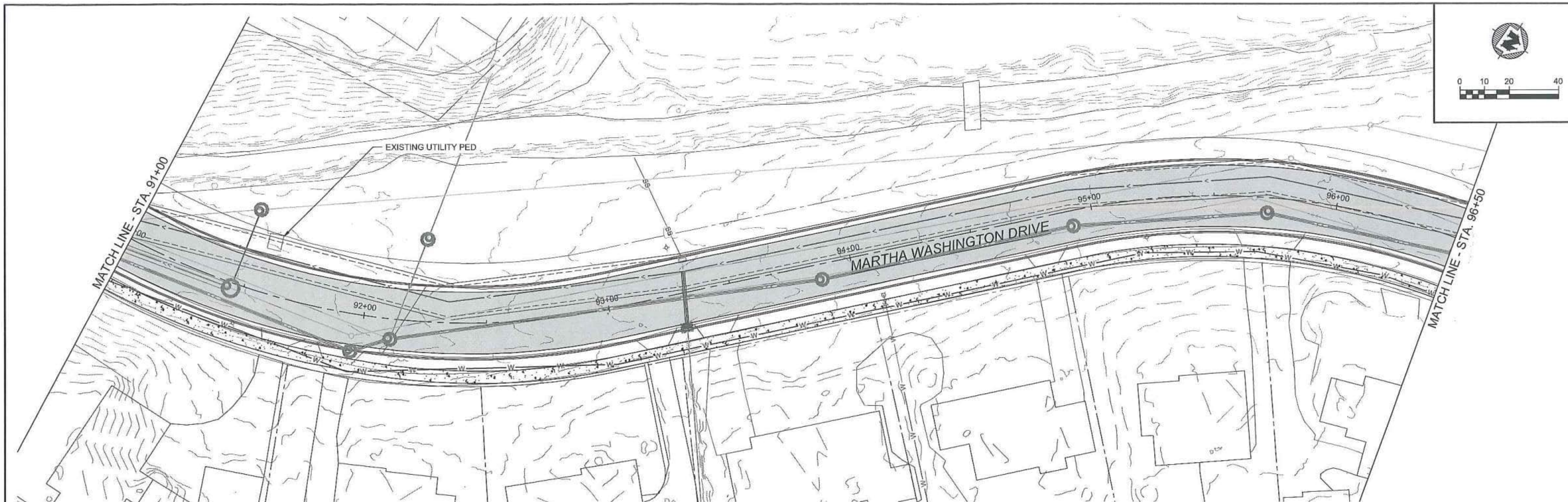
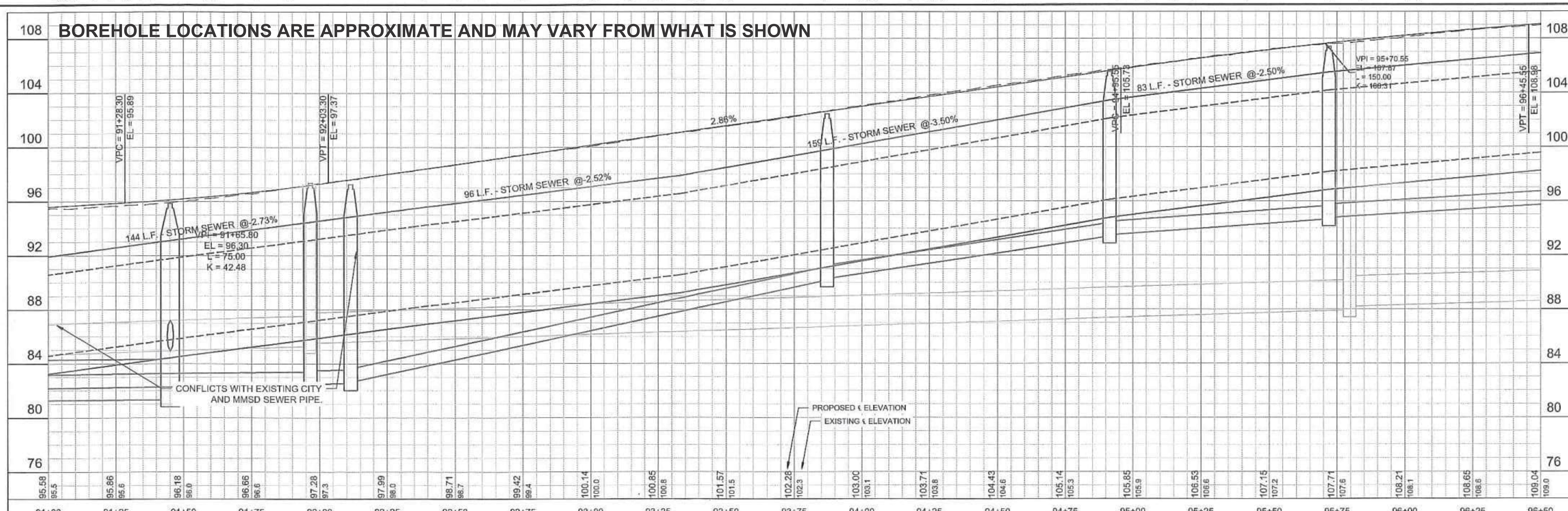
CITY OF WAUWATOSA
MILWAUKEE COUNTY, WI

ROADWAY & STORM PLANS - MARTHA WASHINGTON DRIVE

PROJECT NO. 10310004
SHEET R10





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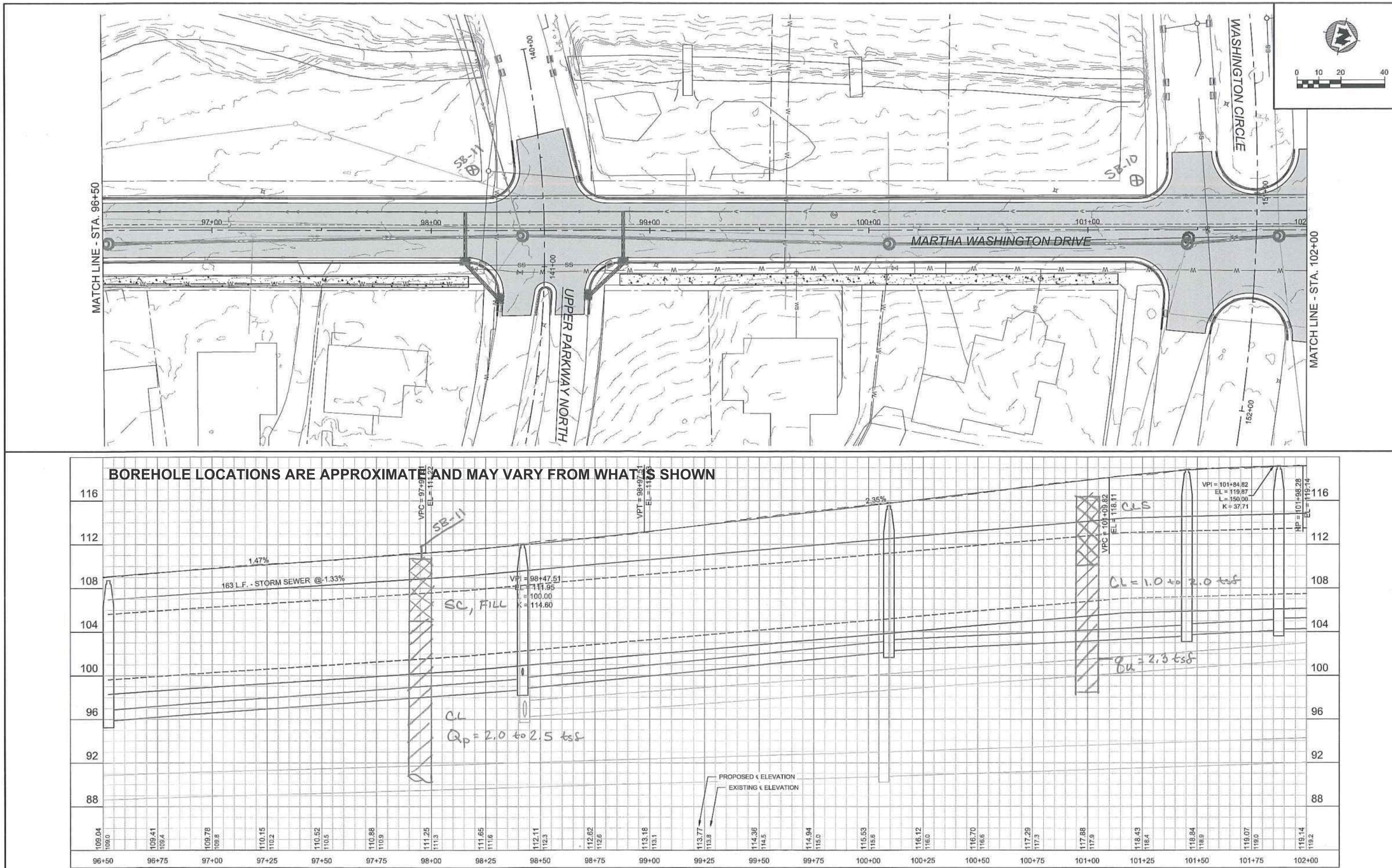
ROADWAY & STORM PLANS - MARTHA WASHINGTON DRIVE

PROJECT NO. 10310004

SHEET R11



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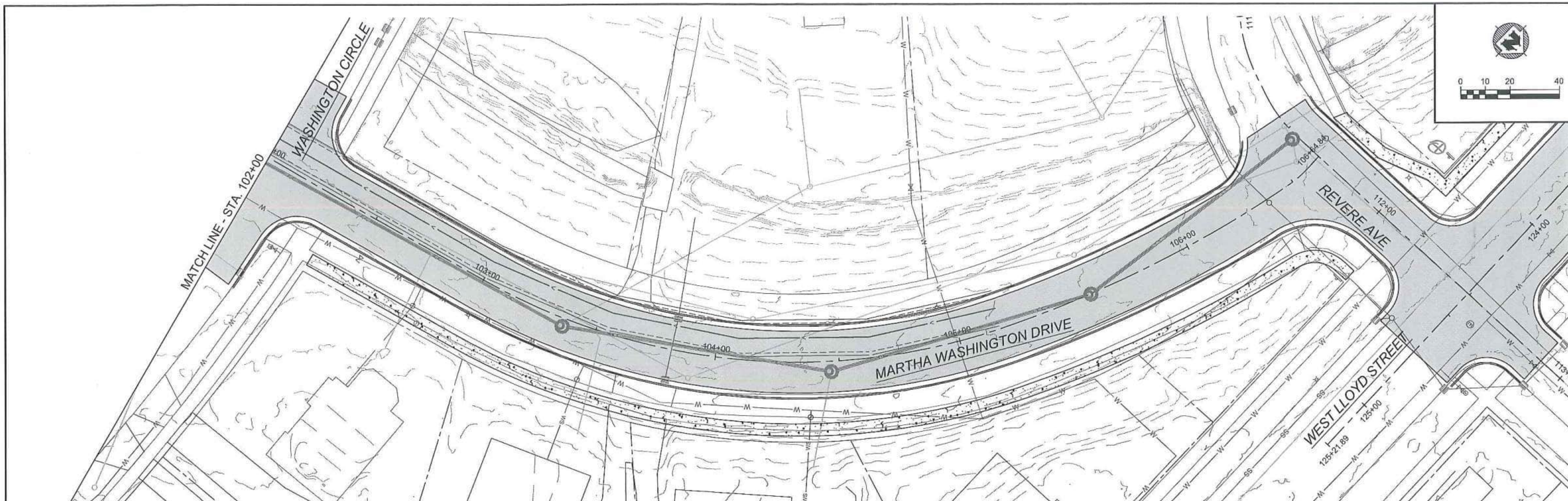
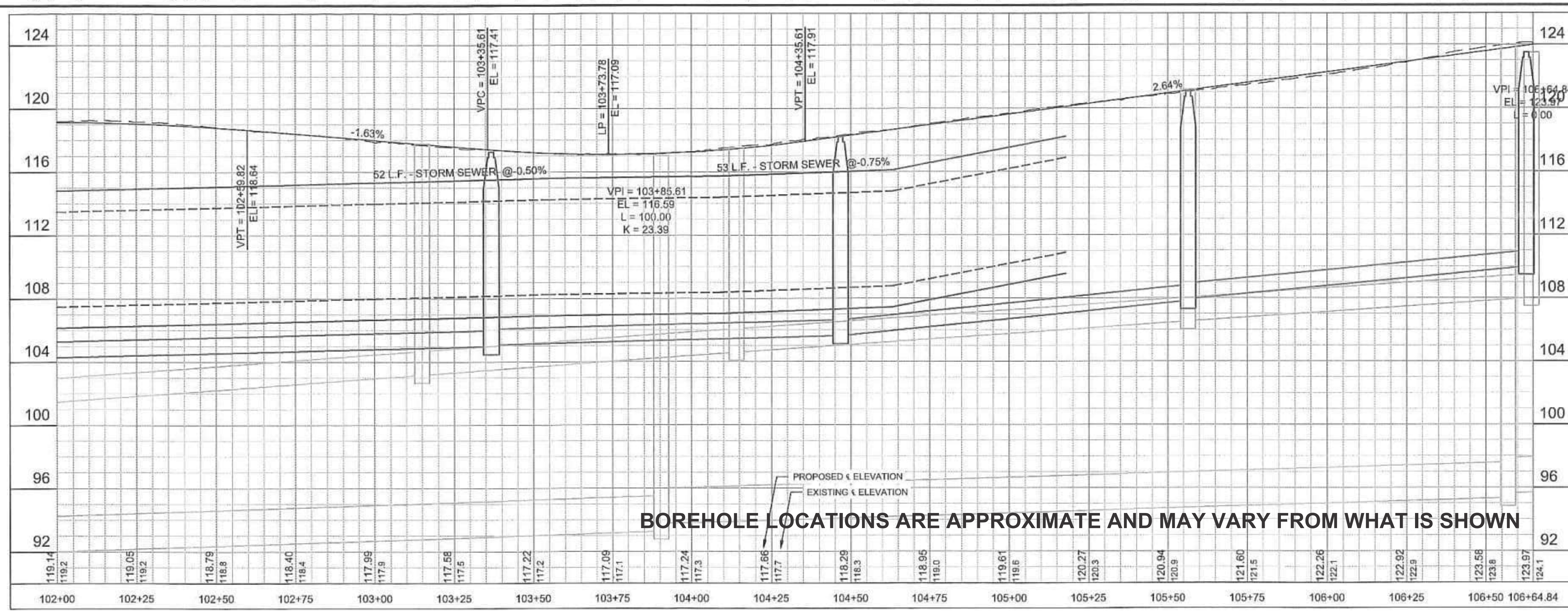
MILWAUKEE COUNTY, WI

ROADWAY & STORM PLANS - MARTHA WASHINGTON DRIVE

PROJECT NO. 10310004
SHEET R12





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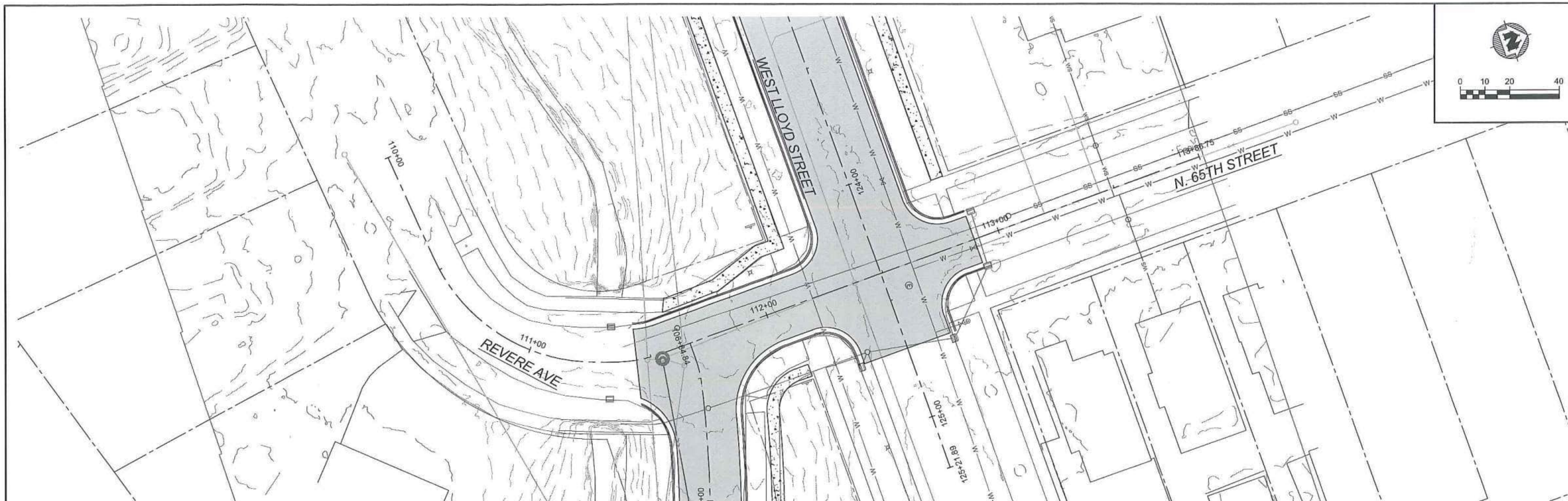
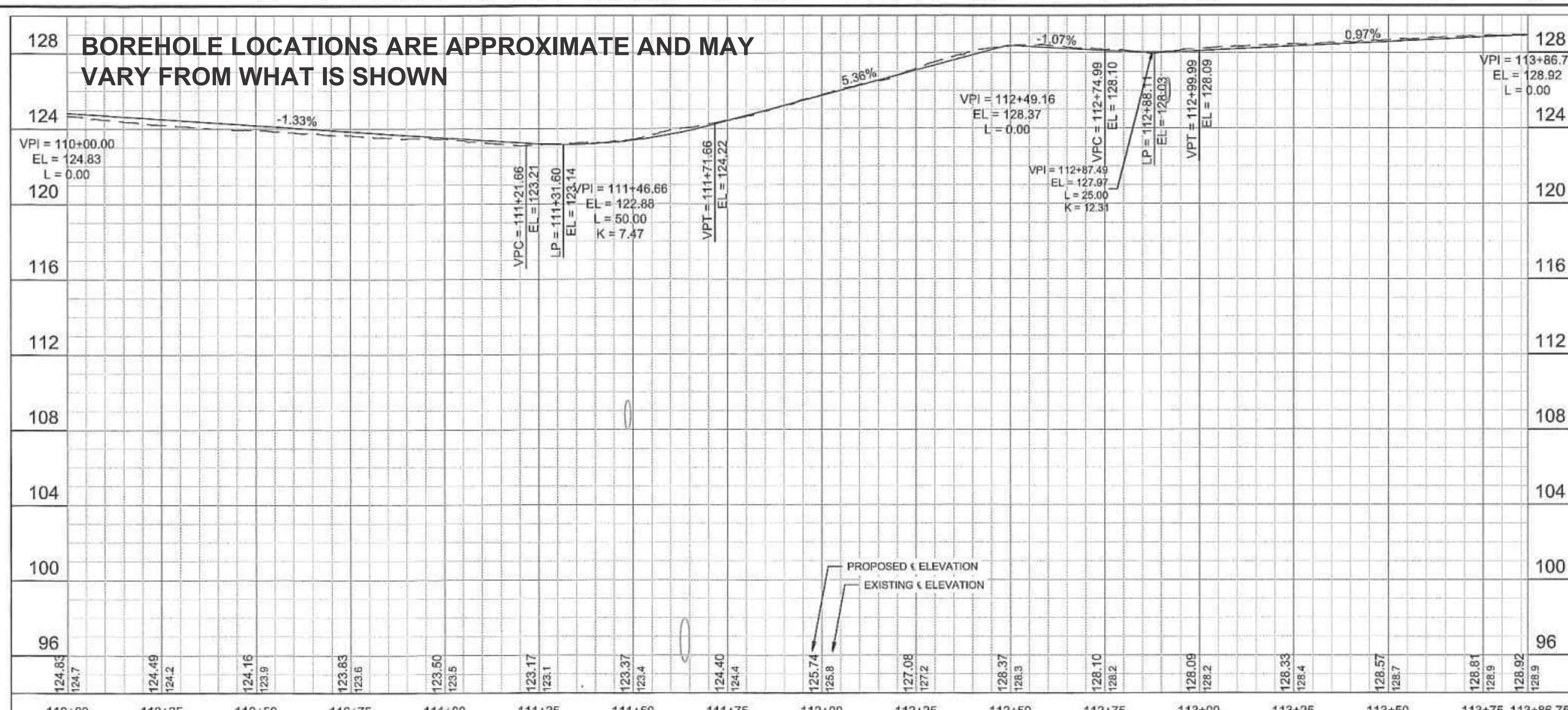
ROADWAY & STORM PLANS - MARTHA WASHINGTON DRIVE

PROJECT NO. 10310004

SHEET R13





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SCHOONMAKER CREEK PRELIMINARY PLANS
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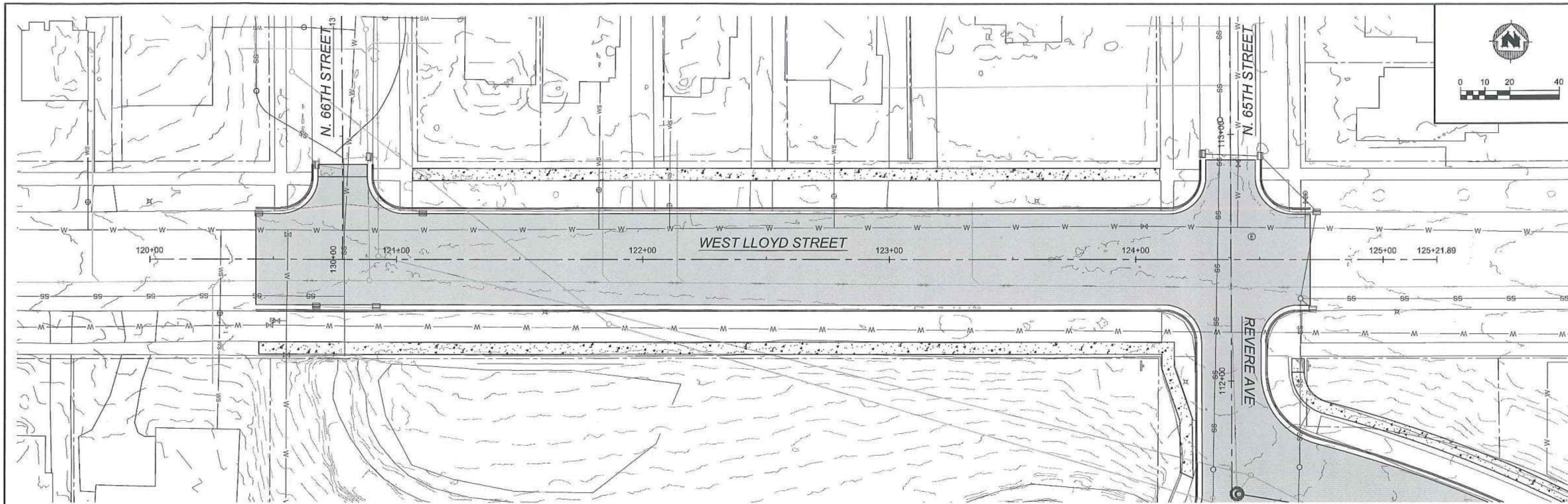
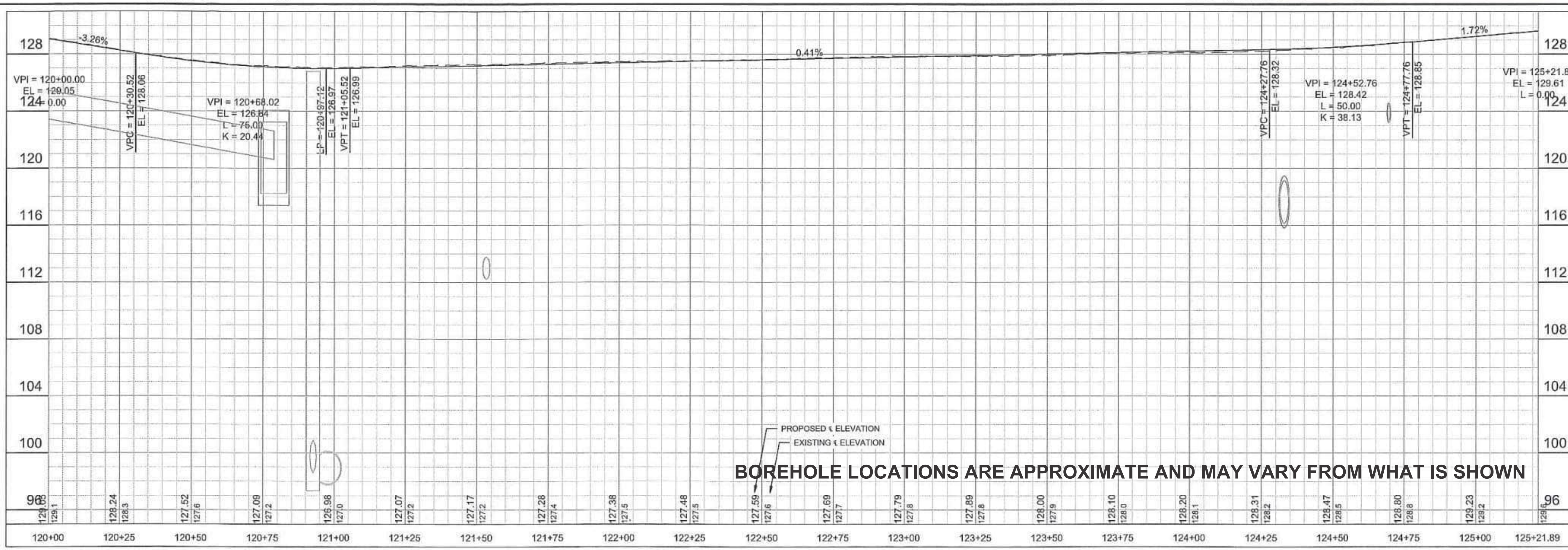
MILWAUKEE COUNTY, WI

ROADWAY & STORM PLANS - REVERE AVE & N 65TH STREET

PROJECT NO. 10310004

SHEET R14





PROJECT DATE: .	DRAWN BY: MJW	NO.	DATE	REVISION
	DESIGNED BY: Init	.	.	PRELIMINARY
	CHECKED BY: Init	.	.	BY

PLOT DATE: 3/14/2024 9:15 AM, G:\10\10310\10310004\CADD\Construction Documents\10310004 Plan & Profile - R - West Lloyd Street.dwg

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SCHOONMAKER CREEK PRELIMINARY PLANS
CITY OF WAUWATOSA
MILWAUKEE COUNTY, WI

ROADWAY & STORM PLANS - WEST LLOYD STREET

PROJECT NO. 10310004

SHEET R15

HORIZ. 0 200' 400'

VERT. 0 20' 40'

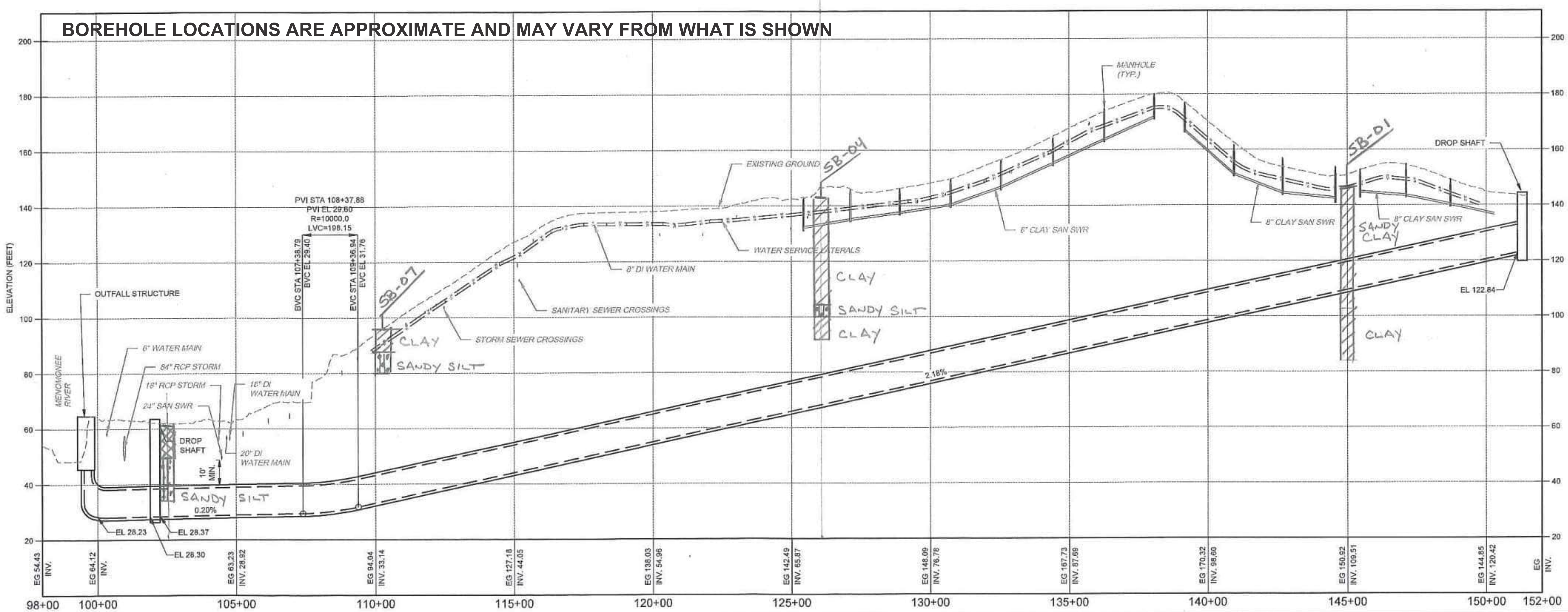
LEGEND:

—SAN—SAN—	SANITARY SEWER
—SD—SD—	STORM DRAIN
—W—W—	WATER LINE
—FO—FO—	FIBER OPTIC
	TUNNEL LINNING
	TUNNEL BASELINE
◻	MANHOLE/ INLETS
◻	FIRE HYDRANTS
	MMSD TUNNEL CENT

NOTE:

1. FIBER OPTIC AND ELECTRICAL CONDUIT N SHOWN IN PROFILE FOR CLARITY

BOREHOLE LOCATIONS ARE APPROXIMATE AND MAY VARY FROM WHAT IS SHOWN



DESIGNED BY: G. SANDERS DRAWN BY: A. BOCANEGRA SHEET CHK'D BY:	CDM Smith	CITY OF WAUWATOSA, WISCONSIN	PROJECT NO. 29184 FILE NAME: SHEET NO

ALTERNATIVE 1

Table A-1 Soil Parameters SB-01

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY LEAN CLAY, stiff to very stiff	684.5	130	135	5 to 12	1.0 to 2.0	1,000	--	--	26	500	0.007	Stiff Clay Below the Water Table
LEAN CLAY, hard	674.7	130	135	22 to 24	4.5+	4,000	--	--	26	2,000	0.004	Stiff Clay Below the Water Table
SILTY SAND, medium dense	EOB	115	120	22 to 24	--	--	32	--	32	60	--	Sand

Table A-2 Soil Parameters SB-02

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY LEAN CLAY (FILL)	701.2	125	130	5 to 14	--	1,000	--	--	26	500	0.007	Stiff Clay Above the Water Table
SAND WITH GRAVEL (FILL)	698.8	110	115	42	--	--	30	--	30	90	--	Sand
SANDY LEAN CLAY, medium stiff to stiff	684.8	130	135	5 to 14	0.75 to 2.2	1,500	--	--	26	500	0.007	Stiff Clay Below the Water Table
LEAN CLAY, very stiff to hard	EOB	130	135	15 to 36	3.0 to 4.5+	3,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table

Table A-3 Soil Parameters SB-03

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SAND WITH GRAVEL (FILL)	667.6	110	115	5 to 14	--	--	30	--	30	25	--	Sand
SANDY LEAN CLAY, stiff	655.8	130	135	6 to 8	0.75 to 1.0	1,000	--	--	26	500	0.007	Stiff Clay Below the Water Table
SANDY SILT, medium dense	650.9	110	115	10	--	--	30	--	30	60	--	Sand
SANDY LEAN CLAY, very stiff	644.9	130	135	12	2.0 to 3.0	2,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table
SANDY SILT, very dense	636.2	120	125	90	--	--	36	--	36	125	--	Sand
CLAYEY GRAVEL, very dense	633.6	120	125	refusal	--	--	36	--	36	125	--	Sand

Table A-4 Soil Parameters SB-04

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SAND (FILL)	720.5	110	115	10 to 12	--	--	30	--	30	90	--	Sand
SANDY LEAN CLAY to LEAN CLAY, stiff	711.4	130	135	9 to 12	1.5 to 3.5	1,500	--	--	26	500	0.007	Stiff Clay Above the Water Table
LEAN CLAY, very stiff	686.4	130	135	14 to 19	2.0 to 3.5	2,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table
SANDY SILT, very dense	681.4	120	125	refusal	--	--	36	--	36	125	--	Sand
SANDY LEAN CLAY, hard	EOB	130	135	48 to 54	4.0 to 4.5+	4,000	--	--	26	2,000	0.004	Stiff Clay Below the Water Table

Table A-5 Soil Parameters SB-05

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SILTY SAND WITH GRAVEL (FILL)	667	120	125	54 to 64	--	--	30	--	30	90	--	Sand
SANDY LEAN CLAY to LEAN CLAY, medium stiff	658.1	125	130	3 to 4	0.5 to 1.25	500	--	--	26	100	0.01	Stiff Clay Above the Water Table
SANDY SILT, dense	653.1	120	125	36	--	--	36	--	36	225	--	Sand
SANDY SILT, dense	643.1	120	125	32 to 40	--	--	36	--	36	125	--	Sand
SANDY LEAN CLAY, hard	EOB	130	135	30	4.5+	4,000	--	--	26	2,000	0.004	Stiff Clay Below the Water Table

Table A-6 Soil Parameters SB-07

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY LEAN CLAY (FILL)	672.6	120	125	7 to 8	--	1,000	--	--	26	500	0.007	Stiff Clay Above the Water Table
LEAN CLAY, very stiff	669.6	130	135	7	2.0	2,000	--	--	26	1,000	0.005	Stiff Clay Above the Water Table
SILTY SAND, loose to medium dense	EOB	110	115	8 to 17	--	--	30	--	30	25	--	Sand

Table A-7 Soil Parameters SB-08

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SILTY SAND to GRAVEL (FILL)	629.9	110	115	4 to 21	--	--	29	--	29	25	--	Sand
SANDY SILT, loose to medium dense	EOB	110	115	7 to 40	--	--	30	--	30	60	--	Sand

Table A-8 Soil Parameters SB-09

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY SILT to SILTY SAND, medium dense to dense	626	110	115	19 to 24	--	--	36	--	36	90	--	Sand
SANDY SILT to SILTY SAND, medium dense to dense	611.1	110	115	24 to 38	--	--	36	--	36	60	--	Sand
LEAN CLAY, hard	EOB	130	135	21	4.5+	4,000	--	--	26	2,000	0.004	Stiff Clay Below the Water Table

Table A-9 Soil Parameters SB-10

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY LEAN CLAY to LEAN CLAY, (FILL)	690.7	125	130	3 to 6	--	1,000	--	--	26	500	0.007	Stiff Clay Above the Water Table
LEAN CLAY, stiff to very stiff	679.1	130	135	6	1.0 to 2.5	1,000	--	--	26	500	0.007	Stiff Clay Below the Water Table
SILT, medium dense	674.2	110	115	20	--	--	34	--	34	60	--	Sand
LEAN CLAY, very stiff	EOB	130	135	21	3.5	3,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table

Table A-10 Soil Parameters SB-11

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY LEAN CLAY (FILL)	689.8	125	130	4	--	500	--	--	26	100	0.01	Stiff Clay Above the Water Table
CLAYEY SAND (FILL)	685.6	110	115	5 to 14	--	--	30	--	30	25	--	Sand
SANDY LEAN CLAY to LEAN CLAY, very stiff	678.7	130	135	9 to 10	2.5	2,000	--	--	26	1,000	0.005	Stiff Clay Above the Water Table
SANDY LEAN CLAY to LEAN CLAY, very stiff	673.6	130	135	13	2	2,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table
LEAN CLAY, very stiff to hard	EOB	130	135	16	3.0 to 6.6	3,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table

Table A-11 Soil Parameters SB-12

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
CLAYEY SAND WITH GRAVEL (FILL)	648.8	110	115	3 to 16	--	--	29	--	29	25	--	Sand
LEAN CLAY, very stiff	641.9	130	135	36	2.0 to 3.5	2,000	--	--	26	1,000	0.005	Stiff Clay Above the Water Table
SANDY SILT to GRAVEL WITH SAND, very dense	EOB	120	125	refusal	--	--	38	--	38	125	--	Sand

Table A-12 Soil Parameters SB-13

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
CLAYEY SAND (FILL)	639.2	110	115	11	--	--	30	--	30	90	--	Sand
SANDY SILT to SILTY SAND, loose to medium dense	630.2	110	115	6 to 11	--	--	30	--	30	25	--	Sand
LEAN CLAY, stiff	620.1	130	135	7 to 8	1.5	1,500	--	--	26	500	0.007	Stiff Clay Below the Water Table
SAND, loose	EOB	110	115	5	--	--	29	--	29	20	--	Sand

GESTRA Engineering Inc.
191 W Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 12/27/2023	BORING NUMBER: **SB-01**	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 12/27/2023	PROJECT NUMBER: 23414-10	
		DRILLING RIG: CME 75 (International)	
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: Z. Frye	FIELD LOG: C. Dietz	NORTHING: 306269	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582549	SURFACE ELEVATION: 727.2 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						ASPHALT (8.5-inches) 0.7 (726.5)								
SS - 1	12	3 3 3	6			BASE COURSE (6-inches) 1.2 (726)								
					725.0	SILT WITH SAND, brown, moist, loose 1.7 (725.5)	ML							
SS - 2	13	2 2 3	5			SANDY LEAN CLAY, gray, moist to wet, medium stiff to very stiff, trace gravel				1.00			12.1	
SS - 3	13	2 4 6	10	5		sand and silt lenses in SS-3				2.00			12.2	
					720.0									
SS - 4	17	2 4 5	9							1.00			12.2	
SS - 5	15	2 3 5	8	10						1.50			11.6	
					715.0									
SS - 6	18	1 4 6	10	15			CL			2.00			11	
					710.0									
SS - 7	18	3 4 7	11	20 ▽		wet sandy silt layer in SS-4				1.00			13.7	
					705.0									
SS - 8	18	2 4 6	10	25						1.50			11.7	
					700.0									

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 20.5 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: 45 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GESTRA

GESTRA Engineering Inc.
191 W Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 12/27/2023	BORING NUMBER: SB-01	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 12/27/2023	DRILLING RIG: CME 75 (International)	
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: Z. Frye	FIELD LOG: C. Dietz	NORTHING: 306269	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582549	SURFACE ELEVATION: 727.2 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 9	18	3 4 8	12	30		SANDY LEAN CLAY, gray, moist to wet, medium stiff to very stiff, trace gravel	CL			2.00			12.3	
					695.0									
SS - 10	18	2 3 4	7	35						0.75 (2.5)			11.4	γ_d = 128.2 pcf γ_T = 142.8 pcf
					690.0									
SS - 11	18	3 4 5	9	40		very moist, sand lens in SS-11				2.00			12.1	
					685.0	42.7 (684.5)								
						LEAN CLAY, brownish gray, moist, hard	CL							
SS - 12	18	4 10 12	22	45 ▼						4.5+			13.5	
					680.0									
SS - 13	18	8 11 13	24	50						4.5+			14.1	
					675.0	52.5 (674.7)								
						SILTY SAND, gray, moist, medium dense, trace clay laminations	SM							
SS - 14	18	5 10 12	22	55										
					670.0									

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 20.5 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: 45 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA Engineering Inc.
191 W Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PROJECT NAME: Wauwatosa Utility Planning		DATE DRILLING STARTED: 12/27/2023	BORING NUMBER: **SB-01**
PROJECT LOCATION: Wauwatosa, Wisconsin		DATE DRILLING ENDED: 12/27/2023	PROJECT NUMBER: 23414-10
			DRILLING RIG: CME 75 (International)
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: Z. Frye	FIELD LOG: C. Dietz	NORTHING: 306269	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582549	SURFACE ELEVATION: 727.2 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 15	18	6 11 13	24	60		SILTY SAND, gray, moist, medium dense, trace clay laminations; 61 (666.2)	SM							
						End of Boring at 61.0 ft.								
					665.0									
				65										
					660.0									
				70										
					655.0									
				75										
					650.0									
				80										
					645.0									
				85										
					640.0									

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: 20.5 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: 45 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/8/2024	BORING NUMBER: SB-02	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/8/2024	PROJECT NUMBER: 23414-10	DRILLING RIG: CME 75 (International)
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: D. Harris	FIELD LOG: J. Correa	NORTHING: 306233	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 583461	SURFACE ELEVATION: 707.5 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft) / Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
					LEAN CLAY WITH SAND, dark brown, moist, with roots, (TOPSOIL)								
SS - 1	14	1 2 3 2	5		1.6 (705.9)							20.1	
				705.0	SANDY LEAN CLAY, brown, moist, trace gravel, (FILL)								
SS - 2	14	2 3 2	5									18.9	
SS - 3	14	2 5 9	14	5	6.3 (701.2)							17.1	
					SAND WITH GRAVEL, brown, moist, trace silt, (FILL)								
SS - 4	10	12 23 19	42	700.0	8.7 (698.8)								
					SANDY LEAN CLAY, gray, moist, medium stiff to stiff, trace gravel								
SS - 5	12	15 10 4	14	10					1.50			10.7	
				695.0									
SS - 6	18	2 4 4	8	15		CL			0.75			14.2	
				690.0									
SS - 7	18	1 2 3	5	20					1.00 **(2.2)**	20	8	13.8	γ_d = 123.9 pcf γ_T = 141 pcf
				685.0	22.7 (684.8)								
					LEAN CLAY, brownish gray, moist to wet, very stiff to hard, trace sand and silt lenses								
SS - 8	18	4 6 9	15	25		CL			4.00			12	
				680.0									

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: 30 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GESTRA Engineering Inc.
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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/8/2024	BORING NUMBER: SB-02	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/8/2024	PROJECT NUMBER: 23414-10	DRILLING RIG: CME 75 (International)
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: D. Harris	FIELD LOG: J. Correa	NORTHING: 306233	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 583461	SURFACE ELEVATION: 707.5 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 9	18	5 8 8	16	30 ▽		LEAN CLAY, brownish gray, moist to wet, very stiff to hard, trace sand and silt lenses	CL			3.00			16.2	
					675.0									
SS - 10	18	8 10 14	24	35						4.5+			13.7	
					670.0									
SS - 11	18	6 12 18	30	40						4.5+			10	
					665.0									
SS - 12	18	8 16 20	36	45						4.5+			11.6	
					660.0									
SS - 13	18	9 10 11	21	50		trace gravel in SS-13				3.50			10.3	
					655.0									
SS - 14	18	12 11 11	22	55						4.5+			11.7	
					650.0	57.7 (649.8)								
						SANDY LEAN CLAY, gray, moist, hard, trace gravel	CL							

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 30 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME	DATE DRILLING STARTED	BORING NUMBER
Wauwatosa Utility Planning	1/8/2024	SB-02
PROJECT LOCATION	DATE DRILLING ENDED	PROJECT NUMBER: 23414-10
Wauwatosa, Wisconsin	1/8/2024	DRILLING RIG: CME 75 (International)

BORING DRILLED BY	FIELD LOG	NORTHING	DRILLING METHOD
FIRM: GESTRA CREW CHIEF: D. Harris	J. Correa	306233	3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 583461	SURFACE ELEVATION: 707.5 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 15	18	10 12 14	26	60		SANDY LEAN CLAY, gray, moist, hard, trace gravel 61 (646.5)	CL			4.5+			9	
						End of Boring at 61.0 ft.								
					645.0									
				65										
					640.0									
				70										
					635.0									
				75										
					630.0									
				80										
					625.0									
				85										
					620.0									

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 30 ft.	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

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SOIL BORING LOG

GESTRA Engineering Inc.
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PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/8/2024	BORING NUMBER: SB-03	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/8/2024	PROJECT NUMBER: 23414-10	DRILLING RIG: CME LX55 ATV
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: S. Gonyer	FIELD LOG: C. Ray; LAB LOG / QC: C. Senechalle	NORTHING: 304660; EASTING: 584217	DRILLING METHOD: 3¼" HSA; SURFACE ELEVATION: 673.6 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 1	14	1 2 3 2	5			SAND WITH GRAVEL, brown, moist, (FILL)								
SS - 2	10	3 4 5	9		670.0									
SS - 3	6	4 6 8	14	5		6 (667.6)								
						SANDY LEAN CLAY, gray, moist, medium stiff to stiff, trace gravel	CL							
SS - 4	12	3 3 3	6		665.0					0.75			13.1	
SS - 5	18	3 4 4	8	10						1.00			12.9	
				▽	660.0									
SS - 6	18	2 3 3	6	15						0.75			14.1	
						17.8 (655.8)								
					655.0	SANDY SILT, gray, wet, medium dense, clay lens	ML							
SS - 7	16	3 4 6	10	20										
						22.7 (650.9)								
					650.0	SANDY LEAN CLAY, gray, moist, very stiff	CL							
						sand lens in SS-8								
SS - 8	18	2 5 7	12	25						2.00			14.3	Gravel = 2.8% Sand = 42.7% P200 = 54.4%
					645.0	28.7 (644.9)								
						SAND, gray, moist, medium dense, trace clay layer	SP							SS-9A

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 12 ft.	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/8/2024	BORING NUMBER: SB-03	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/8/2024	DRILLING RIG: CME LX55 ATV	
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: S. Gonyer	FIELD LOG: C. Ray	NORTHING: 304660	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 584217	SURFACE ELEVATION: 673.6 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 9	18	4 7 11	18	30		SAND, gray, moist, medium dense, trace clay layer 30.2 (643.4)	SP							
						LEAN CLAY, gray, moist, very stiff 32.7 (640.9)	CL			3.00			11	
					640.0	SANDY SILT, gray, moist, very dense, trace gravel 37.4 (636.2)	ML							
SS - 10	10	15 44 46	90	35										
					635.0	CLAYEY GRAVEL, light gray, very moist, very dense, trace sand 40 (633.6)	GC							
SS - 11	5	50/5"	R	40		End of Boring at 40.0 ft.								Driller noted auger refusal at 40 feet.
					630.0									
				45										
					625.0									
				50										
					620.0									
				55										
					615.0									

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: 12 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME	Wauwatosa Utility Planning
PROJECT LOCATION	Wauwatosa, Wisconsin
DATE DRILLING STARTED	1/19/2024
DATE DRILLING ENDED	1/19/2024
BORING NUMBER	SB-04
PROJECT NUMBER	23414-10
DRILLING RIG	CME 75 (HT)
DRILLING METHOD	3¼" HSA
SURFACE ELEVATION	724.1 ft
BORING DRILLED BY	FIRM: GESTRA CREW CHIEF: C. Ray
FIELD LOG	J. Correa
LAB LOG / QC	C. Senechalle
NORTHING	304369
EASTING	582541

Soil Description and Geological Origin for Each Major Unit	Bottom Depth (Elevation)	USCS Classification
ASPHALT (4.5-inches)	0.4 (723.7)	
BASE COURSE (9-inches)	1.1 (723)	
SANDY LEAN CLAY, brown, moist, trace gravel, (FILL)	1.3 (722.8)	
SAND, brown, moist, silt lamination, (FILL)	3.6 (720.5)	
LEAN CLAY, brown, moist, very stiff, trace sand	6.5 (717.6)	CL
SANDY LEAN CLAY WITH GRAVEL, brown, moist, stiff to very stiff, with silt laminations	12.7 (711.4)	CL
LEAN CLAY, gray, moist to wet, very stiff		CL

Number and Type	Recovery (in)	Blow Counts	N - Value	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 1	8	5 5 7 7	12					
SS - 2	8	6 5 5	10					
SS - 3	18	2 4 5	9	3.50			18	
SS - 4	16	3 7 5	12	1.50			12.1	
SS - 5	16	2 3 6	9	2.50			11.2	
SS - 6	18	3 6 10	16	3.50			15.3	
SS - 7	18	5 7 10	17	3.50	23	11	15.6	
SS - 8	18	5 7 12	19	3.50			18.4	

Depth (ft): 5, 10, 15, 20, 25
Elevation: 720.0, 715.0, 710.0, 705.0, 700.0, 695.0

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: 35 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: 50 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/19/2024	BORING NUMBER: SB-04	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/19/2024	DRILLING RIG: CME 75 (HT)	
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: C. Ray	FIELD LOG: J. Correa	NORTHING: 304369	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582541	SURFACE ELEVATION: 724.1 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 9	18	4 6 9	15	30		LEAN CLAY, gray, moist to wet, very stiff	CL			2.00			16.6	
					690.0									
SS - 10	18	6 6 8	14	35 ▽						2.00			20	
				37.7	686.4	SANDY SILT, gray, wet, very dense	ML							
					685.0									
SS - 11	17	12 16 50/5"	R	40										
				42.7	681.4	SANDY LEAN CLAY, gray, moist, hard, trace gravel	CL							
					680.0									
SS - 12	18	12 18 30	48	45						4.5+				
					675.0									
SS - 13	18	15 22 32	54	50 ▼						4.00				
				51	673.1	End of Boring at 51.0 ft.								
					670.0									
				55										

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 35 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: 50 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/19/2024	BORING NUMBER: SB-05	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/19/2024	DRILLING RIG: CME 75 (HT)	
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: C. Ray	FIELD LOG: J. Correa	NORTHING: 303855	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 584490	SURFACE ELEVATION: 670.8 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
					670.0	ASPHALT (7-inches) 0.6 (670.2)								
SS - 1	10	20 42 22 22	64			BASE COURSE (7-inches) 1.2 (669.6)								
						SILTY SAND WITH GRAVEL, brown, moist, (FILL) trace clay and asphalt pieces in SS-2								
SS - 2	14	15 43 11	54			3.8 (667)								
						SANDY LEAN CLAY WITH GRAVEL, brown, moist, medium stiff								
SS - 3	8	2 1 2	3	5	665.0		CL			0.50			12.6	
SS - 4	4	2 2 2	4			8.4 (662.4)				0.50			10.1	
						LEAN CLAY WITH SAND, brown, moist, stiff								
SS - 5	16	1 1 2	3	10	660.0		CL			1.00-1.25			24.7	Gravel = 0.0% Sand = 22.1% P200 = 77.9%
						12.7 (658.1)								
						SANDY SILT, gray, moist to wet, dense, trace gravel								
SS - 6	16	9 17 19	36	15	655.0									
SS - 7	18	9 18 22	40	20 ▽	650.0	no gravel in SS-7	ML				NP	NP		
SS - 8	18	14 15 17	32	25 ▼	645.0	sand lamination in SS-8								
						27.7 (643.1)								
						SANDY LEAN CLAY, gray, moist, hard, trace gravel	CL							

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 20 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: 25 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/19/2024	BORING NUMBER: SB-05	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/19/2024	DRILLING RIG: CME 75 (HT)	
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: C. Ray	FIELD LOG: J. Correa	NORTHING: 303855	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 584490	SURFACE ELEVATION: 670.8 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 9	18	9 12 18	30	30	640.0	SANDY LEAN CLAY, gray, moist, hard, trace gravel	CL			4.5+			11.8	
SS - 10	1	50/1"	R			33.1 (637.7) rock chips in SS-10								Driller noted auger refusal at 33.1 feet. Spoon refusal with minimal recovery. Possible bedrock.
						End of Boring at 33.1 ft.								
				35	635.0									
				40	630.0									
				45	625.0									
				50	620.0									
				55	615.0									

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 20 ft.	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 25 ft.	CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/3/2024	BORING NUMBER: **SB-07**	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/3/2024	PROJECT NUMBER: 23414-10	
		DRILLING RIG: CME 75 (International)	
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: A. Woerpel	FIELD LOG: C. Dietz	NORTHING: 302842	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582657	SURFACE ELEVATION: 676.1 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						ASPHALT (6-inches) — 0.5 (675.6)								
SS - 1	4	3, 2, 5	7		675.0	BASE COURSE (11-inches) — 1.4 (674.7)								
SS - 2	7	2, 4, 4	8			SANDY LEAN CLAY, gray to light gray, moist, trace gravel, (FILL) — 3.5 (672.6)							16	
SS - 3	18	2, 3, 4	7	5	670.0	LEAN CLAY, brown, moist, very stiff, trace sand; silt lamination in SS-3 — 6.5 (669.6)	CL			2.00			27	
SS - 4	5	3, 7, 10	17			SANDY SILT, gray, moist, loose to medium dense, trace gravel	ML							
SS - 5	14	2, 3, 5	8	10	665.0									Gravel = 10.5% Sand = 49.8% P200 = 39.7%
SS - 6	0	50/3"	R	15		15 (661.1)								Driller noted no recovery on field log. Driller noted auger refusal at 15 feet.
					660.0	End of Boring at 15.0 ft.								
				20	655.0									
				25	650.0									

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: NE ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: NE	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA

GESTRA Engineering Inc.
191 W Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/26/2024	BORING NUMBER: SB-08	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/26/2024	DRILLING RIG: CME 75 (HT)	
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: A. Woerpel	FIELD LOG: C. Noll	NORTHING: 301983	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582487	SURFACE ELEVATION: 641.9 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft) / Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
					CONCRETE (8-inches) — 0.7 (641.2)								
				640.0	SILTY SAND WITH GRAVEL, brown, moist, trace clay pieces, (FILL) — 3.8 (638.1)								
SS - 1	15	5 7 5	12										
SS - 2	3	2 2 2	4	5	SILTY SAND, brown, moist, trace gravel, clay layers, (FILL)								
				635.0	large gravel piece in SS-3 — 8.4 (633.5)								
SS - 3	3	2 3 4	7										
SS - 4	7	2 11 10	21	10	GRAVEL WITH SAND, brown, moist, trace silt, (FILL) — 12 (629.9)								
				630.0	SANDY SILT, gray, moist, dense, trace gravel — 17.5 (624.4)	ML							Driller noted rig chatter at 12 feet.
SS - 5	13	8 18 22	40	15									
				625.0	SANDY SILT, gray, moist, medium dense, trace gravel, clay laminations — 22.7 (619.2)	ML							
SS - 6	18	4 6 7	13	20									
				620.0	SANDY SILT, gray, wet, loose — 26 (615.9)	ML							
SS - 7	15	2 3 4	7	25									
				615.0	End of Boring at 26.0 ft.								

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 24 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: 19.5 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA Engineering Inc.
191 W Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PROJECT NAME	Wauwatosa Utility Planning
PROJECT LOCATION	Wauwatosa, Wisconsin
DATE DRILLING STARTED	1/3/2024
DATE DRILLING ENDED	1/3/2024
BORING NUMBER	SB-09
PROJECT NUMBER	23414-10
DRILLING RIG	CME 75 (International)
BORING DRILLED BY	FIRM: GESTRA CREW CHIEF: A. Woerpel
FIELD LOG	C. Dietz
LAB LOG / QC	C. Senechalle
NORTHING	301536
EASTING	585085
DRILLING METHOD	3¼" HSA
SURFACE ELEVATION	633.5 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						ASPHALT (5.5-inches) 0.5 (633)								
						CONCRETE (4-inches) 0.8 (632.7)								
						BASE COURSE (7-inches) 1.4 (632.1)								
SS - 1	15	2 7 12	19		630.0	SANDY SILT WITH GRAVEL, brown, moist, medium dense 3.9 (629.6)	ML							
SS - 2	15	6 10 19	29	5		SILTY SAND, gray, moist, medium dense, trace gravel 6.4 (627.1)	SM							
SS - 3	14	5 9 15	24	▽	625.0	SILTY SAND, brown and gray, wet, medium dense, trace gravel 8.8 (624.7)	SM							
SS - 4	18	4 16 19	35	10		SANDY SILT, gray, moist to wet, dense, trace gravel	ML							
					620.0									
SS - 5	17	5 15 18	33	15 ▼		17.7 (615.8)								Gravel = 15.3% Sand = 37.8% P200 = 46.9%
					615.0	SAND WITH GRAVEL, gray, wet, dense								
SS - 6	10	6 16 22	38	20		22.4 (611.1)	SP							No sample retained.
					610.0	LEAN CLAY, brown, moist, hard, silt lenses								
SS - 7	14	6 10 11	21	25		26 (607.5)	CL			4.5+			27	
					605.0	End of Boring at 26.0 ft.								

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 7.5 ft.	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 15 ft.	CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GESTRA

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/10/2024	BORING NUMBER: SB-10	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/10/2024	DRILLING RIG: CME 75 (International)	
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: D. Harris	FIELD LOG: T. Engel	NORTHING: 305768	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 583777	SURFACE ELEVATION: 696.9 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						TOPSOIL (6-inches) — 0.5 (696.4)								
SS - 1	11	1 3 3 3	6		695.0	SANDY LEAN CLAY, dark brown, moist, trace gravel, trace root hairs, (FILL)							13.1	
SS - 2	6	1 2 1	3										17.8	
				5		5 (691.9)								
SS - 3	10	1 2 4	6			LEAN CLAY, brown to dark brown, moist, trace sand and gravel, (FILL) — 6.2 (690.7)							19.8	Driller noted mild rig chatter at 6 feet.
					690.0	LEAN CLAY WITH SAND, gray, moist, stiff, trace gravel								
SS - 4	18	3 2 4	6							1.00			11.7	
SS - 5	18	2 2 4	6	10						1.00			11.7	
					685.0		CL							
SS - 6	18	1 2 4	6	15						1.00 **(2.3)**			13.1	γ_d = 128.1 pcf; γ_T = 144.9 pcf
					680.0	17.8 (679.1)								
						SILT, gray, moist, medium dense								
SS - 7	18	3 9 11	20	20			ML							
					675.0	22.7 (674.2)								
						LEAN CLAY, gray, wet, very stiff, silty sand lenses	CL							
SS - 8	18	6 9 12	21	25 (▽)		26 (670.9)				3.50			16.2	
					670.0	End of Boring at 26.0 ft.								

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 24.5 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: NE	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA Engineering Inc.
191 W Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/10/2024	BORING NUMBER: SB-11	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/10/2024	PROJECT NUMBER: 23414-10	DRILLING RIG: CME 75 (International)
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: D. Harris	FIELD LOG: T. Engel	NORTHING: 305460	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 583862	SURFACE ELEVATION: 691.4 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						TOPSOIL (3-inches) — 0.2 (691.2)								
SS - 1	14	1 2 2 3	4		690.0	SANDY LEAN CLAY, dark brown, moist, trace gravel, trace root hairs, (FILL) — 1.6 (689.8)							19.2	
SS - 2	11	2 2 3	5			CLAYEY SAND, brown to dark brown, moist, trace gravel, trace root hairs, (FILL)								
														Driller noted mild rig chatter at 4 feet.
SS - 3	2	3 7 7	14	5		5.8 (685.6)								Poor recovery.
					685.0	SANDY LEAN CLAY, brown, moist, medium stiff	CL							
SS - 4	6	3 4 5	9			8.5 (682.9)							13.2	Sample disturbed. No Qp taken.
						LEAN CLAY, brown, moist, very stiff, trace gravel								
SS - 5	18	3 4 6	10	10			CL			2.50			12.2	
					680.0	12.7 (678.7)								
						LEAN CLAY, gray, moist, very stiff to hard, trace gravel								
SS - 6	18	2 5 8	13	15		sand lens in sample in SS-6				2.00			11.4	
					675.0									
SS - 7	18	2 6 10	16	20		no gravel, silt lenses	CL			4.00 **(6.7)**	28	15	15	γ_d = 121.1 pcf, γ_T = 139.4 pcf
					670.0									
SS - 8	18	4 6 10	16	25		26 (665.4)				3.00			15.4	
					665.0	End of Boring at 26.0 ft.								

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: NE ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: NE	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA Engineering Inc.
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Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PROJECT NAME	Wauwatosa Utility Planning
PROJECT LOCATION	Wauwatosa, Wisconsin
DATE DRILLING STARTED	1/23/2024
DATE DRILLING ENDED	1/23/2024
BORING NUMBER	SB-12
PROJECT NUMBER	23414-10
DRILLING RIG	Diedrich D50 ATV
BORING DRILLED BY	FIRM: GESTRA CREW CHIEF: C. Ray
FIELD LOG	C. Noll
LAB LOG / QC	C. Senechalle
NORTHING	303431
EASTING	584533
DRILLING METHOD	3¼" HSA
SURFACE ELEVATION	659.3 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 1	16	2 4 3 3	7			TOPSOIL (3.5-inches) — 0.3 (659) CLAYEY SAND WITH GRAVEL, brown, moist, (FILL)								
SS - 2	11	1 1 2	3			silt lens in SS-2								
					655.0									
SS - 3	9	1 2 2	4	5		crushed brick and asphalt pieces in SS-3								
SS - 4	14	2 5 10	15			large gravel pieces in SS-4								
					650.0									
SS - 5	12	8 10 6	16	10		10.5 (648.8) LEAN CLAY, grayish brown, moist, very stiff, trace sand and gravel	CL			3.50			14.1	Driller noted rig chatter at 12 feet.
					645.0									
SS - 6	9	23 28 8	36	15		17.4 (641.9) SANDY SILT, gray, moist, very dense, trace gravel	ML			2.00			13.8	
					640.0									
SS - 7	17	6 17 50/5"	R	20		21 (638.3) GRAVEL WITH SAND, light gray, wet, very dense	GP							Driller noted rig chatter from 20 to 24 feet.
					635.0									
SS - 8	6	16 50/2"	R	25		25.2 (634.1) End of Boring at 25.2 ft.								
					630.0									

WATER & CAVE-IN OBSERVATION DATA

∇ WATER ENCOUNTERED DURING DRILLING: 23 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: 21 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA Engineering Inc.
191 W Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/3/2024	BORING NUMBER: SB-13	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/3/2024	PROJECT NUMBER: 23414-10	DRILLING RIG: CME 75 (International)
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: A. Woerpel	FIELD LOG: C. Dietz	NORTHING: 302659	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 585043	SURFACE ELEVATION: 642.8 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (**Q**$_u$ or Q$_p$) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						ASPHALT (5.5-inches) 0.5 (642.3)								
SS - 1	9	6 5 6	11			BASE COURSE (5-inches) 0.9 (641.9)								
SS - 2	9	3 6 5	11		640.0	CLAYEY SAND, brown, moist, trace gravel, (FILL) sand and gravel layer in SS-2 3.6 (639.2)								
SS - 3	14	2 3 3	6	5		SILT, brown, moist to very moist, loose 6.3 (636.5)	ML							
SS - 4	15	2 6 5	11		635.0	SILTY SAND, brown, moist to very moist, medium dense 8.9 (633.9)	SM							
SS - 5	15	4 5 4	9	10		SANDY SILT, gray, moist, loose, trace gravel 12.6 (630.2)	ML							
					630.0	LEAN CLAY, gray, moist, stiff, trace sand, silt lenses	CL							
SS - 6	18	1 4 4	8	15						1.50			17	
					625.0									
SS - 7	18	1 3 4	7	20		decrease in silt lenses in SS-7 22.7 (620.1)				1.50 **(1.6)**	27	13	14.6	γ_d = 112.2 pcf, γ_T = 128.7 pcf
					620.0	SAND, gray, wet, loose	SP							
SS - 8	18	4 1 4	5	25 ▽		26 (616.8)								
						End of Boring at 26.0 ft.								
					615.0									

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 25 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GENERAL NOTES

DRILLING AND SAMPLING SYMBOLS

SYMBOL	DEFINITION
HSA	Hollow Stem Auger
HSA w/ RW	Hollow Stem Auger converted to Rotary Wash Boring (initiated with Mudding Fluid)
SS	2" O.D. Split Spoon Sample – (ASTM D 1586)
SH	3" Thin-Walled Tube Sample (Shelby Tube) – (ASTM D 1587)
AU	Solid Stem Auger Sample
CA	Modified California Sample – (ASTM D 3550)
RC	Rock Core Sample – (ASTM D 2113)
HA	Hand Auger Sample
GB	Grab Bag Sample
R	SPT Refusal (N-value of 50 blows for less than 6 inches of penetration)
NMR	No Measurement Recorded
NE	Not Encountered

TEST SYMBOLS

SYMBOL	DEFINITION
MC	Moisture Content (%) – (ASTM D 2216)
LOI	Organic Content (Loss on Ignition) (%) – (ASTM D 2974)
Qp	Hand Penetrometer Reading (tsf)
Qu	Unconfined Comp. Strength (tsf) – (ASTM D 2166)
γ_d	Dry Density (pcf) – (ASTM D 7263)
γ_T	Total (Moist) Density (pcf)
LL, PL	Liquid and Plastic Limit (%) – (ASTM D 4318)
PI	Plasticity Index (%)
P200	Percent passing the #200 Sieve – (ASTM D 1140)
Ts	Hand Torvane Reading (tsf)
SG	Specific Gravity – (ASTM D854)
pH	Hydrogen Ion Content – (ASTM D4972)
RQD	Rock Quality Designation (%) – (ASTM D6032)

WATER LEVEL

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In some soils, it may not be possible to determine the groundwater level within the normal time required for test borings and an extended period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol may not indicate the true level of the groundwater table. Perched water refers to water above an impervious layer, thus impeded in reaching the water table. The available water level information is given at the bottom of the respective boring log sheet.

DESCRIPTIVE TERMINOLOGY

DENSITY TERM	SPT N-VALUE
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	Over 50

CONSISTENCY TERM	Unconfined Compressive Strength, (tsf)	SPT N-VALUE
Very Soft	<0.25	0 - 2
Soft	0.25 - 0.49	2 - 4
Medium Stiff	0.50 - 0.99	4 - 8
Stiff	1.00 - 1.99	8 - 16
Very Stiff	2.00 - 3.99	16 - 30
Hard	4.0+	Over 30

Standard Penetration Test N-Value: Blows per Foot of a 140 Pound Hammer Falling 30 inches on a 2-inch OD Split Barrel Sampler

Note: If unconfined compressive strength data is not available, then N-value should be used to describe consistency term

Lamination	Up to 1/2" thick horizontal stratum
Layer	1/2" thick or greater horizontal stratum
Lens	1/2" to 6" discontinuous horizontal stratum
Varved	Alternating laminations
Dry	Powdery, dusty
Moist	Damp, below saturation
Wet	Saturated, above liquid limit

RELATIVE SIZES

U.S. Standard Sieve

12"	3"	#4	#200		
Boulders	Cobbles	Gravel	Sand	Silt	Clay
300	75	4.75	0.075	0.002	

Grain Size (mm)

SOILS CLASSIFICATION FOR ENGINEERING PURPOSES AASHTO Designation: M 145-91	SOIL ENGINEERING

Table 1—Classification of Soils and Soil–Aggregate Mixtures

General Classification	Granular Materials (35 Percent or Less Passing 75 µm)			Silt–Clay Materials (More Than 35 Percent Passing 75 µm)			
Group Classification	A-1	A-3[a]	A-2	A-4	A-5	A-6	A-7
Sieve analysis, percent passing:							
2.00 mm (No. 10)	—	—	—	—	—	—	—
0.425 mm (No. 40)	50 max	51 min	—	—	—	—	—
75 µm (No. 200)	25 max	10 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40):							
Liquid limit	—			40 max	41 min	40 max	41 min
Plasticity index	6 max	Nonplastic (NP)	[b]	10 max	10 max	11 min	11 min
General rating as subgrade	Excellent to Good			Fair to Poor			

[a] The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.
[b] See Table 2 for values.

Table 2—Classification of Soils and Soil–Aggregate Mixtures

General Classification	Granular Materials (35 Percent or Less Passing 75 µm)							Silt–Clay Materials (More Than 35 Percent Passing 75 µm)			
	A-1			A-2							A-7
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5, A-7-6
Sieve analysis, percent passing:											
2.00 mm (No. 10)	50 max	—	—	—	—	—	—	—	—	—	—
0.425 mm (No. 40)	30 max	50 max	51 min	—	—	—	—	—	—	—	—
75 µm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40):											
Liquid limit	—		—	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index	6 max		NP	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min[a]
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to Good							Fair to Poor			

[a] Plasticity index of A-7-5 subgroup is equal to or less than $LL - 30$. Plasticity index of A-7-6 subgroup is greater than $LL - 30$. (See Figure 2.)

NOTE: Charts obtained from Standard Speifications for Transportation Materials and Method of Sampling and Testing and AASHTO Provisional Standards, 2022

APPENDIX II

LABORATORY TEST RESULTS

GESTRA Engineering, Inc
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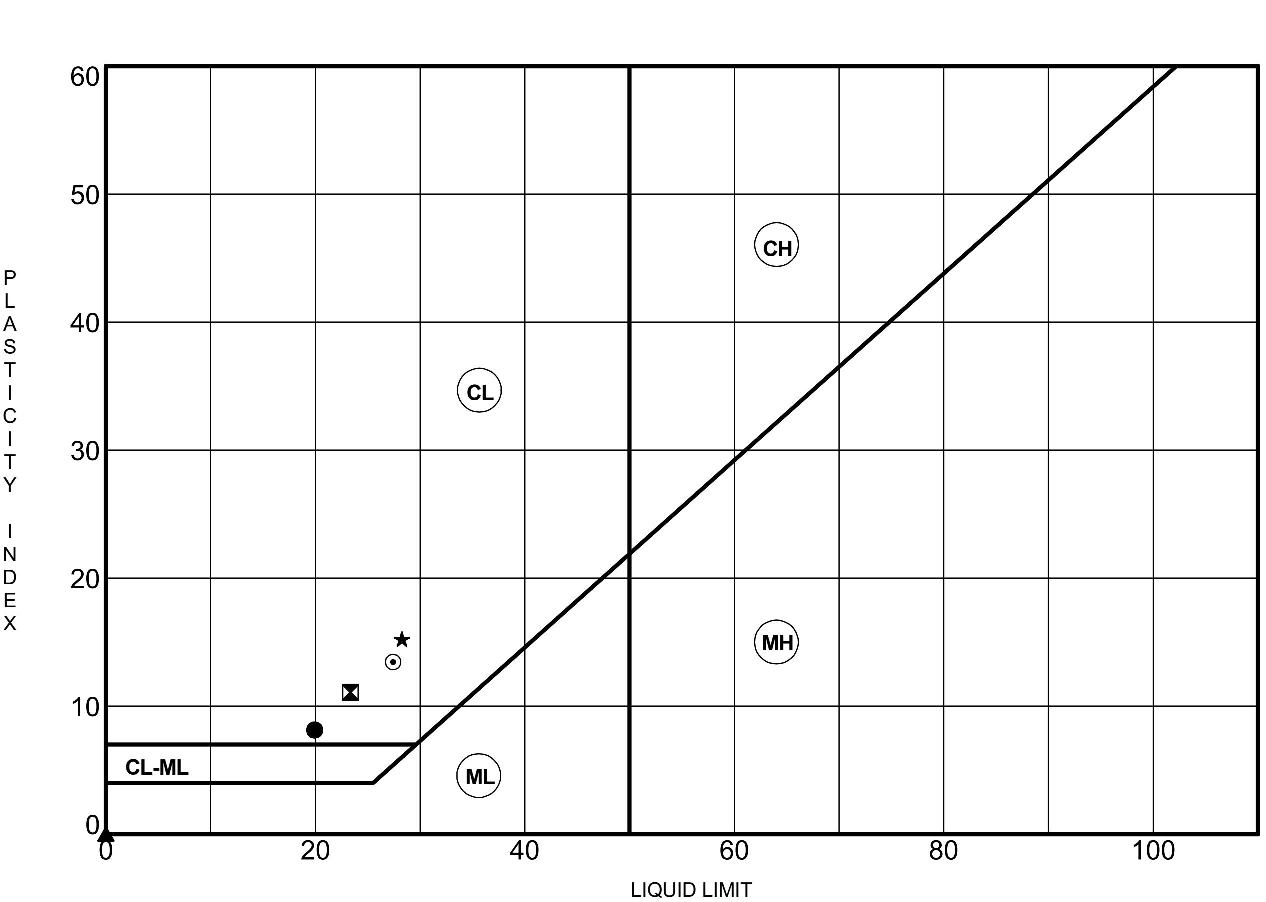
Phone: (414) 933-7444, Fax: (414) 933-7844

LABORATORY TEST RESULTS
ATTERBERG LIMITS RESULTS (ASTM D4318)

Project Name: Wauwatosa Utility Planning
Project Number: 23414-10
Project Location: Wauwatosa, Wisconsin



Unless otherwise noted, Atterberg limit sample was air-dried, Liquid limit was performed using mutiple points, and plastic limit test was hand rolled.

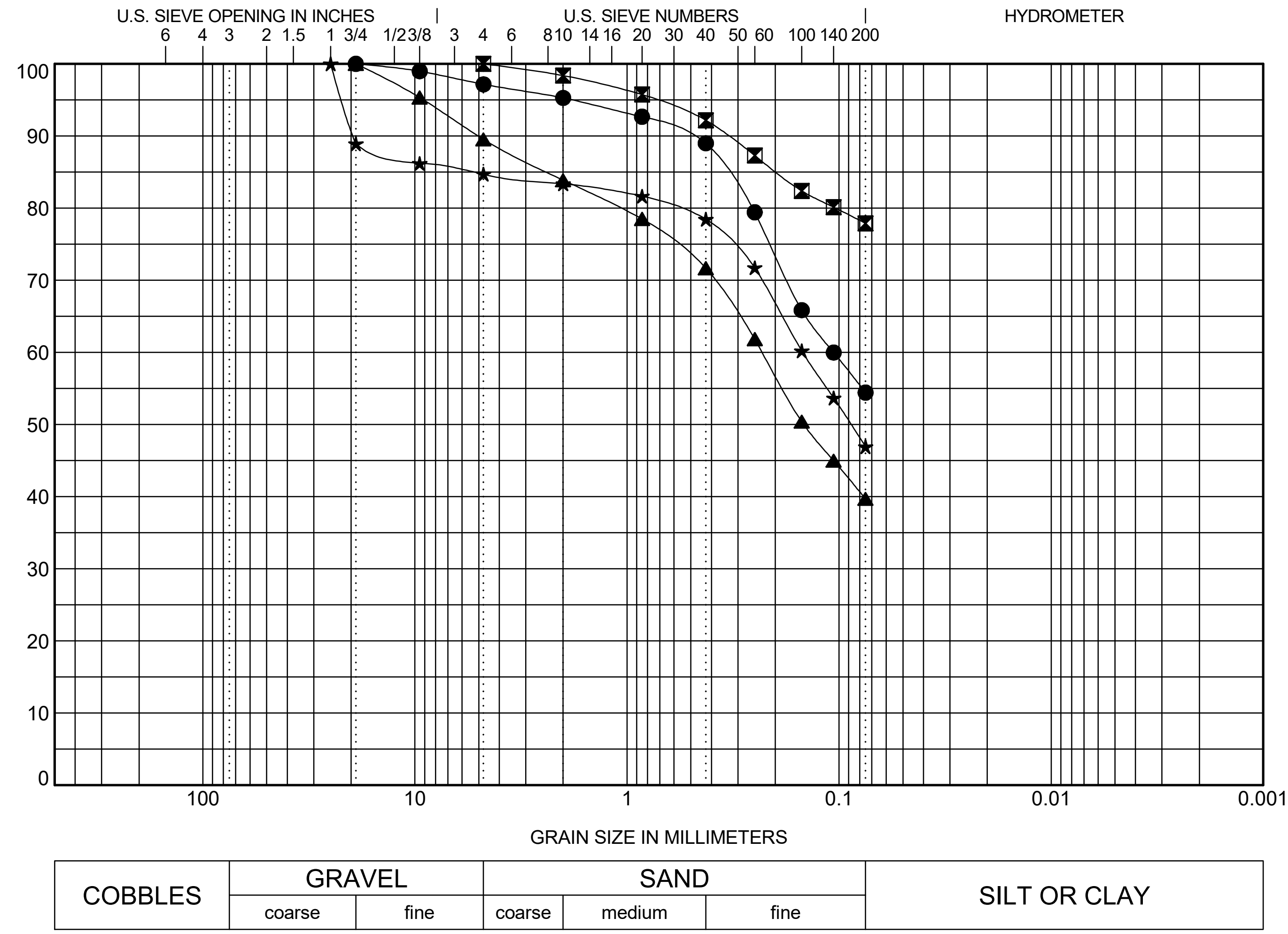
	Specimen Identification		LL	PL	PI	Fines	MC	Notes
●	**SB-02, SS-7**	**19.5'-21'**	**20**	**12**	**8**		**13.8**	
⧗	**SB-04, SS-7**	**19.5'-21'**	**23**	**12**	**11**		**15.6**	
▲	**SB-05, SS-7**	**19.5'-21'**	**NP**	**NP**	**NP**			
★	**SB-11, SS-7**	**19.5'-21'**	**28**	**13**	**15**		**15.0**	
⊙	**SB-13, SS-7**	**19.5'-21'**	**27**	**14**	**13**		**14.6**	

ATTERBERG LIMITS - GINT STD US LAB.GDT - 03/01/24 13:57 - T:\PROJECTS\2023\MILWAUKEE - 10 (GEOTECH)\23414-10EJ (TOSA UTILITY PLANNING)\LOGS\WAUWATOSA UTILITY PLANNING.GPJ

GESTRA Engineering, Inc
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: (414) 933-7444, Fax: (414) 933-7844

LABORATORY TEST RESULTS
GRAIN SIZE DISTRIBUTION (ASTM D6913 and D7928)

Project Name: Wauwatosa Utility Planning
Project Number: 23414-10
Project Location: Wauwatosa, Wisconsin



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**SB-03, SS-8**	**24.5'-26'**	**SANDY LEAN CLAY (CL)**					
⧗	**SB-05, SS-5**	**9.5'-11'**						
▲	**SB-07, SS-5**	**9.5'-11'**						
★	**SB-09, SS-5**	**14.5'-16'**						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**SB-03, SS-8**	**24.5'-26'**	**19**	**0.106**			**2.8**	**42.7**	**54.4**	
⧗	**SB-05, SS-5**	**9.5'-11'**	**4.75**				**0.0**	**22.1**	**77.9**	
▲	**SB-07, SS-5**	**9.5'-11'**	**19**	**0.23**			**10.5**	**49.8**	**39.7**	
★	**SB-09, SS-5**	**14.5'-16'**	**25**	**0.148**			**15.3**	**37.8**	**46.9**	

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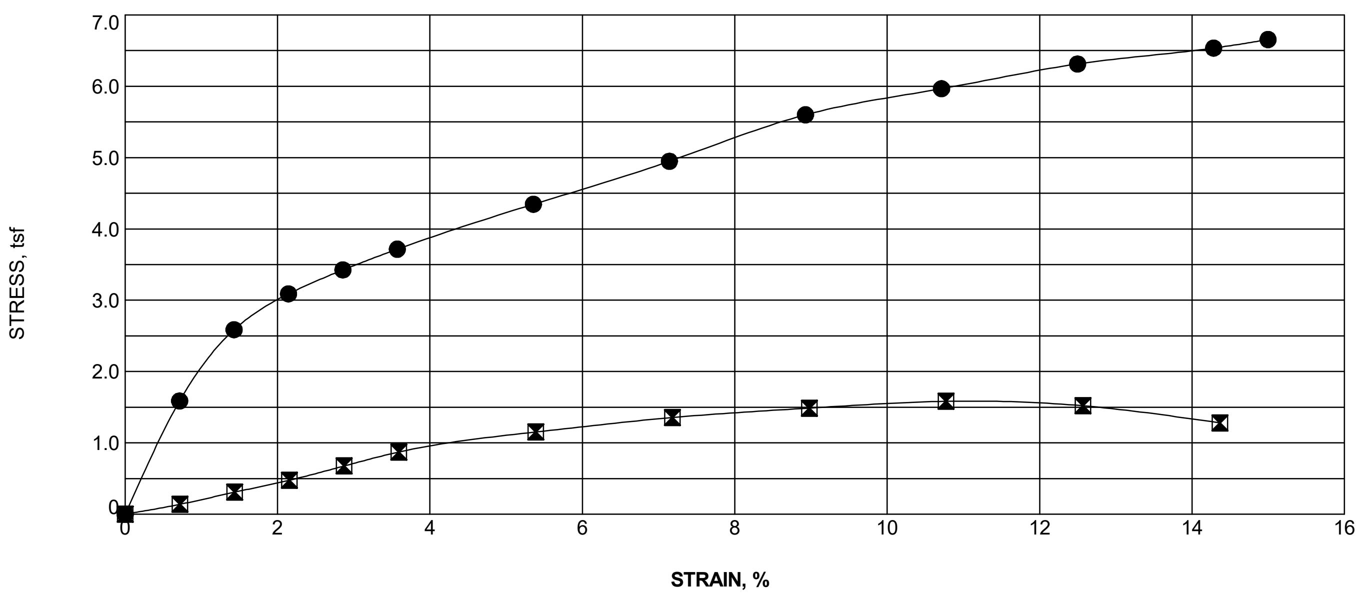
LABORATORY TEST RESULTS
UNCONFINED COMPRESSION TEST (ASTM D2166)

Project Name: Wauwatosa Utility Planning
Project Number: 23414-10
Project Location: Wauwatosa, Wisconsin



Specimen Indentification	● SB-11, SS-7	⊠ SB-13, SS-7	
Depth (feet)	**19.5'-21'**	**19.5'-21'**	
USCS Classification	**CL**	**CL**	
Sample Height (in)	2.80	2.78	
Sample Diameter (in)	1.38	1.50	
Height:Diameter Ratio	1.86	1.86	
Q_u (tsf)	**6.66**	**1.58**	
MC (%)	**15.0**	**14.6**	
γ_d (pcf)	**121.1**	**112.2**	
γ_T (pcf)	**139.4**	**128.7**	

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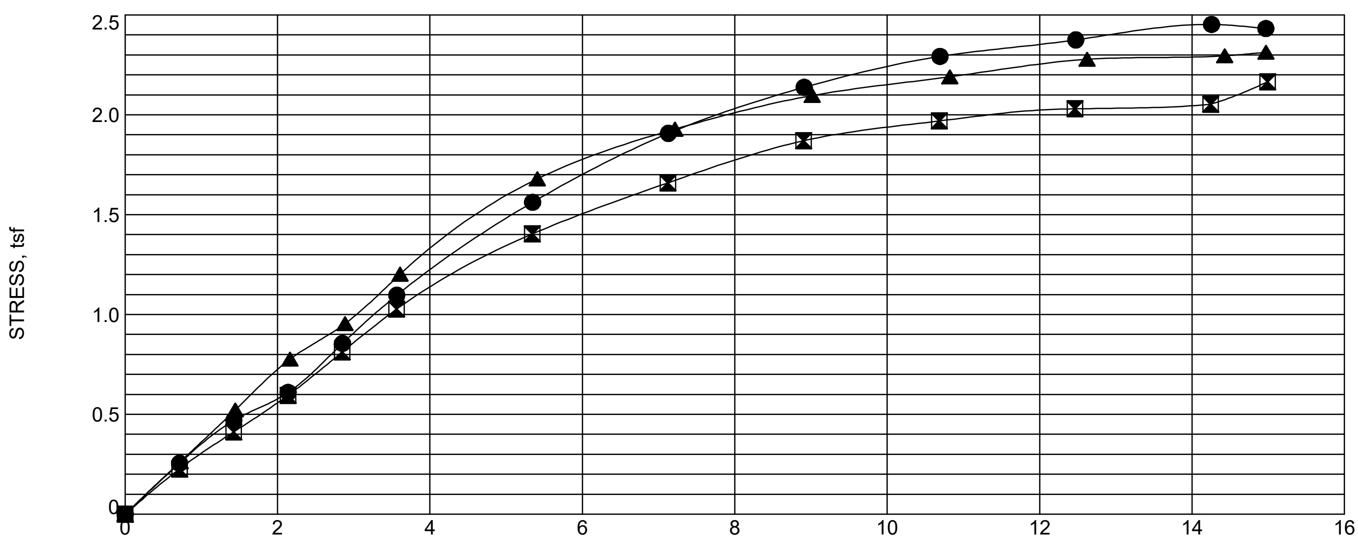
LABORATORY TEST RESULTS
UNCONFINED COMPRESSION TEST (ASTM D2166)

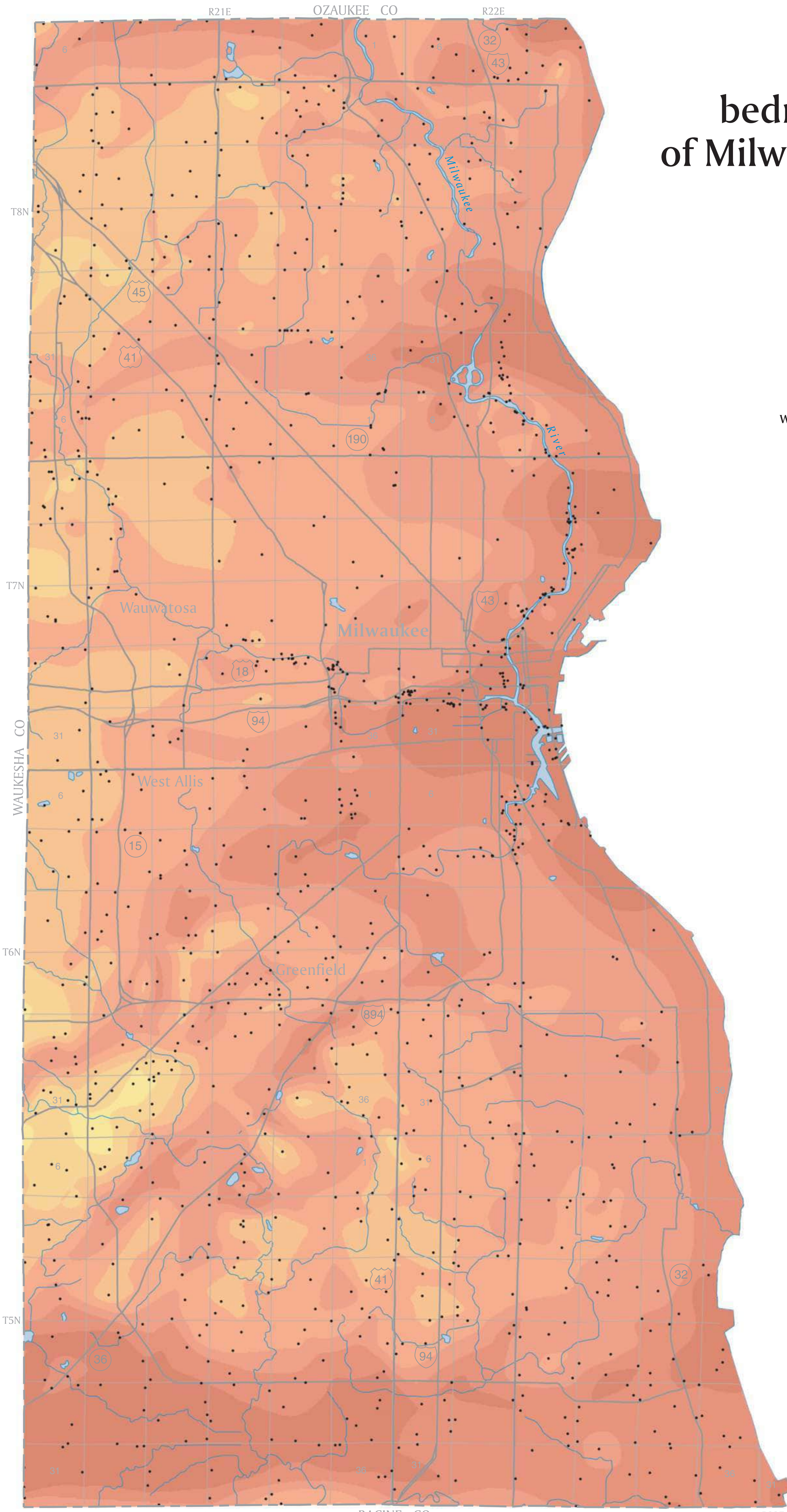
Project Name: Wauwatosa Utility Planning
Project Number: 23414-10
Project Location: Wauwatosa, Wisconsin



			
Specimen Indentification	● **SB-01, SS-10**	⧗ **SB-02, SS-7**	▲ **SB-10, SS-6**
Depth (feet)	**34.5'-36'**	**19.5'-21'**	**14.5'-16'**
USCS Classification	**CL**	**CL**	**CL**
Sample Height (in)	2.81	2.81	2.77
Sample Diameter (in)	1.46	1.43	1.44
Height:Diameter Ratio	1.93	1.93	1.93
Q_u (tsf)	**2.45**	**2.16**	**2.31**
MC (%)	**11.4**	**13.8**	**13.1**
γ_d (pcf)	**128.2**	**123.9**	**128.1**
γ_T (pcf)	**142.8**	**141.0**	**144.9**

APPENDIX III

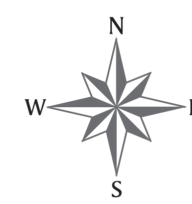
PRELIMINARY BEDROCK TOPOGRAPHY MAP OF MILWAUKEE COUNTY, WISCONSIN
BY T.J. EVANS 2004



Preliminary bedrock topography map of Milwaukee County, Wisconsin

T. J. Evans

2004



ESTIMATED ELEVATION IN FEET
(ABOVE MEAN SEA LEVEL)

- > 850
- 800 - 850
- 750 - 800
- 700 - 750
- 650 - 700
- 600 - 650
- 550 - 600
- 500 - 550
- < 500
- data point

1 0 1 2 3 4 5 6 7 8
KILOMETERS

1 0 1 2 3 4 5
MILES

Wisconsin Transverse Mercator Projection
1991 adjustment to the North American Datum of 1983 (NAD 83/91)

This map represents work performed by the Wisconsin Geological and Natural History Survey and is released to the open files in the interest of making the information readily available. This map has not been edited or reviewed for conformity with Wisconsin Geological and Natural History Survey standards and nomenclature.

This map is part of an ongoing project funded by STATEMAP, the state component of the National Cooperative Geologic Mapping Program of the U.S. Geological Survey.

UW Extension
Wisconsin Geological and Natural History Survey
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phone 608/263-7389 fax 608/262-8086 www.uwex.edu/wgnhs/

James M. Robertson, *Director and State Geologist*

Data entry and processing by K.K. Zeiler. Cartography by D.L. Patterson.

Wisconsin Geological and Natural History Survey
Open-File Report 2004-14B

Appendix B. Preliminary Geotechnical Engineering Report, Schoonmaker Creek Watershed

PRELIMINARY GEOTECHNICAL ENGINEERING REPORT

City of Wauwatosa
Schoonmaker Creek Watershed
Wauwatosa, Wisconsin

GESTRA Project No.: 23414-10
April 3, 2024

Prepared For:
MSA Professional Services, Inc.
1702 Pankratz Street
Madison, WI 53207

GESTRA

Preliminary Geotechnical Engineering Report

City of Wauwatosa
Schoonmaker Creek Watershed
Wauwatosa, Wisconsin

GESTRA Project No. 23414-10
April 3, 2024

Prepared For:

MSA Professional Services, Inc.
1702 Pankratz Street
Madison, WI 53704

Prepared By:

GESTRA

GESTRA Engineering, Inc.
191 W. Edgerton Avenue
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(414) 933-7444

Table of Contents

Preliminary Geotechnical Engineering Report
City of Wauwatosa
Schoonmaker Creek Watershed
Wauwatosa, Wisconsin

1.0 INTRODUCTION

GESTRA Engineering, Inc. (GESTRA) was authorized by MSA Professional Services, Inc. to complete a subsurface exploration and preliminary geotechnical engineering report for the City of Wauwatosa Schoonmaker Creek Watershed Preliminary Engineering Analysis project located in Wauwatosa, Wisconsin. This report presents the results from the subsurface soil exploration and describes the field exploration, laboratory test results, and provides preliminary geotechnical engineering recommendations pertaining to the design and installation of the proposed storm sewer.

The engineering recommendations and analysis contained within this report are based on the following project information which is a projection of GESTRA's understanding of the project. If for any reason the actual project information differs from what is reported below, GESTRA should be contacted so that we can review our recommendations in light of any new information.

1.1 PROJECT INFORMATION

At the time of preparing this report, the City of Wauwatosa is considering two alternatives for the relocation of a storm sewer. The two alternatives being considered are an open cut excavation option along West Llyod Street and Martha Washington Drive and a tunneling option along North 68th Street.

Based on CDM Smith Preliminary Tunnel Alignment Evaluation – Schoonmaker Creek Watershed, dated February 7, 2024, if the tunneling method is chosen, the inside diameter of the pipe is planned to be 10 feet. If open cut excavation is planned to be used, the proposed sewer will a be 6-foot by 12-foot box storm sewer. A map showing the alignment of each option has been included in Appendix I.

2.0 SCOPE OF SERVICES

GESTRA has performed the following services for the project:

- Contacted Diggers Hotline to locate the public utilities at the site.
- Located the boring locations on site using a Geomax Zenith 35 GNSS-INS (GPS) receiver. Elevation and coordinates of the boring locations determined by the GPS equipment were referenced to Wisconsin State Plane South Coordinate System (NAVD88).
- Completed a total of 12 standard penetration test (SPT) soil borings, SB-01 through SB-05 and SB-07 through SB-13. Boring SB-06 was not completed as this was cancelled by the City of Wauwatosa as it was outside of the proposed two alternatives. The SPT soil borings were completed between depths of 15 feet and 61 feet. At the completion of drilling, boreholes were abandoned per WDNR requirements. Borings completed in pavement were surfaced patched with cold patch asphalt.

- Performed laboratory soil testing to assign classification and engineering properties to the soils encountered. The laboratory testing included hand penetrometer, moisture content, Atterberg limits, grain size analysis, and unconfined compression strength tests.
- Prepared this preliminary geotechnical engineering report presenting the results from the field and laboratory testing and provide the following recommendations:
    a. Discussion related to the subsurface soil conditions, groundwater conditions, and bedrock depths.
    b. Lateral earth pressures parameters of soils at each borehole location.
    c. Construction considerations for both open cut excavation and tunneling installation.

3.0 EXPLORATION RESULTS

3.1 SITE CONDITIONS

The project site is located within the City of Wauwatosa. The project area is bounded by West Lloyd Street to the north, West State Street and River Parkway to the south, North 60th Street to the east and North 68th Street to the west. The general topography for the site slopes downward from the north to the south with grades of the site varying between 630 feet and 760 feet.

3.2 SUBSURFACE SOIL PROFILE

All of the borings were completed within City of Wauwatosa right-of-way. Borings SB-01, SB-04, SB-05, SB-07, SB-08, SB-09 and SB-13 were completed within the roadways along the proposed project alignments. Table 3-1 provides a summary of the pavement section at each of the above boring locations.

Table 3-1: Summary of Pavement Section

Boring No.	Street Name	Asphalt Thickness (inches)	Concrete Thickness (inches)	Base Course Thickness (inches)
SB-01	West Llyod Street	8.5	None	6
SB-04	Mountain Avenue	4.5	None	9
SB-05	Martha Washington Drive	7	None	7
SB-07	North 68th Street	6	None	11
SB-08	North 68th Street	None	8	Unknown [2]
SB-09	West State Street	5.5	4	7

Boring No.	Street Name	Asphalt Thickness (inches)	Concrete Thickness (inches)	Base Course Thickness (inches)
SB-13	West Martin Drive	5.5	None	5

[1] Measurements were taken to the nearest ½-inch.

[2] An accurate base course thickness was unable to be determined due to the similarity between the base course material and the underlying subgrade soils.

The remaining borings, SB-02, SB-03, SB-10, SB-11 and SB-12, were completed in the landscaped grass area within City of Wauwatosa right-of-way. The topsoil thickness at the above locations was measured to be less than 6 inches, with the exception in boring SB-02. In boring SB-02 the topsoil thickness was measured to be approximately 20 inches.

The project site is located in an urban area. Fill material was encountered in multiple borings and varied in soil type, consistency and depth. The soil types ranged from lean clay with various amount of sand and gravel to granular soil with various amounts of fines. In boring SB-05 trace pieces of asphalt was observed within the fill.

The native soil profile varied along each of the proposed alignments. North of Milwaukee Avenue the generalize native soil profile primarily consisted of medium stiff to very stiff lean clay soil which transitioned to very stiff to hard lean clay soil. In borings SB-01 and SB-03 which were completed deeper, granular soil was encountered below the very stiff to hard lean clay soils. The depth to granular soil was observed to be below a depth of 50 feet in SB-01 and below a depth of 25 feet in SB-03. Borings performed south of Milwaukee Avenue the depth to granular soil was observed to be shallower in borings SB-05, SB-12 and SB-13 typically within less than 15 feet to 20 feet below the ground surface (bgs) and even shallower in borings SB-07, SB-08 and SB-09 along West State Street, within less than 5 feet to 10 feet bgs.

Results of the field and laboratory tests, observations, transition and thicknesses of each stratum are depicted on the individual boring logs included in Appendix I. In addition, strength values for each stratum are presented on the soil parameter tables also included in Appendix I. Soils were grouped together based on similar observed properties. The stratification lines were estimated by the reviewing engineer based on available data and experience. The actual in-situ changes between layers may differ slightly and may be more gradual than depicted on the boring logs. Subsurface and groundwater conditions can vary between borehole locations and in areas not explored.

It is important to note that the soil observations, fill depths, topsoil, and pavement thickness estimates were made in small diameter boreholes. Therefore, it should be understood that thicker or thinner deposits of the individual strata are likely to be encountered within other portions of the project. Furthermore, the estimation of strata thickness at a particular location can differ from person to person due to a sometimes-indistinct transition between the soils encountered. Additionally, it must be recognized that in the absence of foreign substances and/or debris within the soil samples obtained, it is sometimes difficult to distinguish between natural soils and clean soil fill.

3.3 BEDROCK INDICATORS

Bedrock coring was not completed in any of the borings as this was out of GESTRA's scope of services for the project and if needed, will likely be completed once the design has been further developed. Another indication of potential bedrock may be auger refusal or slow tri-cone advancement during drilling operations. Auger refusal was observed in three of the borings completed. Table 3-2 summarizes the boring locations where auger refusal was encountered prior to reaching the assigned termination depth.

Table 3-2: Potential Depth and Elevation of Bedrock at Borehole Locations

Boring Number	Depth to Auger Refusal or Slow Tri-cone Advancement (feet)	Elevation of Auger Refusal or Slow Tri-cone Advancement (feet)
SB-03	39.9	633.6
SB-05	33.1	637.7
SB-07	15.0	661.1

Based on the Preliminary Bedrock Topography Map of Milwaukee County Wisconsin by T.J. Evan dated 2004, bedrock within the project area primarily varies between an elevation of 600 feet and 650 feet. The exception is noted in a small area that appears to be located near North 68th Street just north of West State Street. At this location the bedrock is mapped slightly higher between an elevation of 650 feet and 700 feet, which seems to compare to where auger refusal was noted in boring SB-07.

It should be noted that the estimated bedrock depths noted in the above table are estimates. To determine if auger refusal was caused due to bedrock, additional borings with rock core should be performed at these locations and/ or geophysical topography study should be performed.

3.4 GROUNDWATER OBSERVATIONS

Groundwater observations were made during and at the completion of drilling operations. Table 3-3 provides a summary of groundwater observations made during and at the completion of drilling operations.

Table 3-3: Observed Water Levels During and at the Completion of Drilling Operations

Boring Number	Observed Water Table During Drilling Operations		Observed Water Table at the Completion of Drilling Opeartions	
	Depth (feet)	Elevation (feet)	Depth (feet)	Elevation (feet)
SB-01	20.5	706.7	45	682.2

Boring Number	Observed Water Table During Drilling Operations		Observed Water Table at the Completion of Drilling Opeartions	
	Depth (feet)	Elevation (feet)	Depth (feet)	Elevation (feet)
SB-02	30	677.5	No Measurement Recorded	
SB-03	12	661.6	No Measurement Recorded	
SB-04	35	689.1	50	674.1
SB-05	20	650.8	25	645.8
SB-07	Water Not Present		Water Not Present	
SB-08	24	617.9	19.5	622.4
SB-09	7.5	626.0	15	618.5
SB-10	24.5	672.4	Water Not Present	
SB-11	Water Not Present		Water Not Present	
SB-12	23	636.3	21	638.3
SB-13	25	617.8	Water Not Present	

The groundwater measurements made in the boreholes may not be a true representation of the actual groundwater table. Therefore, the measurements taken in the boreholes should be considered a temporary condition. It should be noted that the groundwater table within clay and silt soils may require several days to recharge and stabilize due to the low permeability rate of clay and silt soils. Therefore, it is recommended installation and monitoring of observation wells be installed to assess the true groundwater along the project alignment.

Groundwater level fluctuations may occur with time and seasonal changes due to variations in precipitation, evaporation, surface water runoff and local dewatering. Perched water pockets and a higher water table may also be encountered during wet weather periods, particularly in more permeable silt and sand seams or granular fill material overlying less permeable clays.

4.0 ANALYSIS AND RECOMMENDATIONS

It is unknown if the project will install the new storm sewer by either open cut excavations or by using tunneling methods. The below sections provide considerations for both options and any concerns that may arise during construction. The recommendations provided in this section should be taken as preliminary as the final design details have not been provided and additional information may be needed once the design has been further developed.

4.1 Recommended Soil Parameters

Subsurface exploration and laboratory test data was used to approximate the subsurface profile at each borehole location. The actual transition of soil stratum between sample intervals and borehole locations may be different in-situ than inferred from the boring logs. Some of the engineering properties were directly measured from laboratory tests, and other properties were interpreted based on published correlations with SPT blow counts and soil index properties, or generally accepted engineering judgment. The recommended soil parameters are included in Appendix I.

4.2 Open Cut Excavation Considerations

Along the proposed open cut excavation alternative, a total of nine soil borings were completed, SB-01, SB-02, SB-03, SB-05, SB-09, SB-10, SB-11, SB-12 and SB-13. Based on the Plan and Profile drawings, dated March 3, 2024 provided by MSA the alignment using open cut methods will follow along West Llyod Street starting from North 68th Street to Matha Washington Drive, at Martha Washington Drive the storm sewer will follow the roadway south to West Martin Drive and North 60th Street, where it will cross below West State Street and discharge in the Menomonee River.

Based on the soil borings completed it appears that there is a change in the native soil profile where excavations will primarily occur in native granular soil (sand and gravel) and native clay soil. The transition appears to occur between borings SB-05 and SB-13. Boring SB-12 was complete between the two borings but had deeper fill, therefore it is difficult to determine if excavations at this location will primarily occur through native granular or clay soil. Additional borings may be warranted between borings B-05 and B-13 to help determine more accurately the transition where excavations will occur primarily through native granular soil or clay soil.

Based on the soil borings it appears that excavations north of B-05 will primarily occur through the native clay soil, and excavations south of B-13 will primarily occur through the native granular soils. It should be noted that fill was encountered in majority of the borings and that the project is located in an urbanized area. Based on the fill material observed in the borings it is likely that the fill material will consist of a mixture of granular and fine-grained soils.

Based on the Plan and Profile drawings and borings performed, the new storm sewer will likely be supported directly on the native soils. The native soils encountered in the borings at the base of the proposed storm sewer soils should be suitable to support the new pipe or box.

Reuse of Excavated Soil for Backfill Material

Proper selection and compaction of the storm sewer bedding and cover materials is essential to reduce the amount of storm sewer deflection and settlement of the trench backfill in open cut areas. Bedding material should be placed in accordance with normally accepted procedures for the class of pipe being used. Placement of bedding should be done in such a way as to provide relatively uniform lateral support to the storm sewer until the backfill extends over the pipe. This can be done by alternating fill placement at approximately one-foot intervals to both sides of the storm sewer.

The majority of soils encountered in the borings contained a significant percentage of fine-grained soils (clay and silt). Fine grained soil can be difficult to compact or moisture condition in trench backfill situations. Improper placement of fine-grained soil can result in excess settlement or consolidation of the fill material if not placed and compacted in a controlled manner. Therefore, to limit the risk of improper placement we do not recommended using excavated soil as backfill material within pavement areas. Excavations performed within pavement areas should be backfilled using either granular fill or low strength flowable fill.

The project may consider the reuse of excavated soil in green space area. However, it should be noted that there is still the concern for settlement and consolidation of the fill material. This could result in creating a ditch or an area for potential ponding to occur during storm events. As an alternate to reuse of excavated material the design could also consider using either granular fill or low strength flowable fill as backfill in green space areas.

Dewatering

Based on the soil borings performed, substantial water is not anticipated to be encountered during majority of the excavations with the exception of the southern end of the project where the pipe will cross below West State Street to the outfall structure.

If water is encountered during shallow excavations north of Station 31+75, we anticipate the appropriate number of temporary sump pits and pumps should be sufficient to remove anticipated volume of water in the excavation. The contractor should be prepared to control groundwater and surface water and prevent it from accumulating in excavations or otherwise affecting construction.

South of Station 31+75 the profile of the pipe will be lowered to cross under existing utilities in West State Street, and it is anticipated that excavations will then need to be performed below the static groundwater table. The contractor should be prepared to install a construction dewatering system in this area. It is recommended that the water level during construction be kept a minimum of 2 feet below the deepest excavation during construction and until the final structure and backfill material is placed a minimum of 2 feet above the static water table.

Based on soil borings B-09 and B-13 the static groundwater table is anticipated to be between an elevation of 617 feet and 620 feet. Topographic map on the Milwaukee County LIO website also indicated that the Menomonee River is around an elevation of 620 feet, which correlates with the observed water level measurements in the borings. It should be noted that in boring B-09 water was observed to be at an elevation of 626.8 feet during drilling. Since the measured water level at the completion of drilling was noted to be lower this may be indication that perched water seams may also be encountered in excavation in this area.

A specialty dewatering contractor should be consulted for appropriate dewatering methods during construction as well as to evaluate potential impact on the proposed construction and surrounding structures. If the dewatering system is not properly designed, a boiling and/or heaving subgrade could occur possibly resulting in loss of ground support and detrimental effect to the nearby existing structures.

4.3 TUNNELING CONSIDERATIONS

Based on CDM Smith Preliminary Tunnel Alignment Evaluation – Schoonmaker Creek Watershed, dated February 7, 2024, the most favorable alignment alternative is Alignment 1. The alignment has less curves and will be easier to construct for the contractor. Additionally, unlike alignment 2 and 3 there are fewer utilities directly above the tunnel alignment and less risk of tunnel induced settlement resulting in damage to adjacent infrastructure. The recommendations presented in this section are based on the assumption that Alternative 1 will be the selected alternative, provided that tunneling is selected over open cut excavation.

Along Alignment 1, a total of four soil borings were completed, SB-01, SB-04, SB-07 and SB-08. The plan and profile drawing included in the Preliminary Tunnel Alignment Evaluation – Schoonmaker Creek Watershed was used to evaluate the soil conditions along the alignment and provide any concerns that may arise during construction. Based on soil borings performed, it is likely that tunneling operations may occur through clay and/ or granular soils or mixed faces, such as soil and bedrock.

At boring location SB-01, on the north end of the site, the tunneling operations may likely occur through clay soils. At boring location SB-07 (approximate STA 110+00) the tunneling operations may then likely occur through bedrock, indicated by auger refusal, and at boring location SB-08, on the south end of the site, tunneling operations may occur through granular soils.

Where tunneling operations will occur through the clay soils, it is anticipated that the soils will exhibit a “firm” behavior. Based on Figure 1-8 Soil Expansion Prediction (after Holtz et al. 2011) and results from the Atterberg limit test the clay soil is considered to have low to non-swelling potential. Where tunneling operations will likely occur through sandy silt soils, and will likely occur below the water table, it is anticipated that the soils will exhibit more of a “fast raveling” to potential “flowing” behavior.

Where tunneling operations will occur below the water table, the project should consider a dewatering plan or the use of shield tunnel to prevent the running or flowing of wet sand, silt and gravel soil. In addition, to the additional borings above, we recommend that the design team and owner considers installing monitoring wells along the southern portion of the alignment and performed slug testing to determine the permeability rate of the in-situ soils to design a proper dewatering system. The dewatering plan should also consider the effects of lower the water level may have on nearby utilities and structures.

It should be noted that the above assumptions were based on limited soil information collected in the borings. At some locations the borings did not extend below the proposed bottom of the pipe elevation. Therefore, if Alternative 1 and tunneling installation is selected as the preferred method of installation, additional borings must be completed along the alignment to confirm soil and bedrock conditions. Rock coring must be done to determine the condition and type of bedrock in the area. A geophysics study could be completed to better define the horizontal and vertical limits of bedrock.

4.4 GEOTECHNICAL CONSIDERATIONS

Excavation Stability

Caving is a common issue for excavation side walls during construction, especially if fill material, granular soils, and/or water seepage are observed. An excavation plan should be developed and the length of excavation left open should be limited to prevent caving soil from covering the suitable bearing soils.

A temporary soil retention system may also be necessary in order to prevent caving or provide support of surrounding structures or utilities during construction. Providing recommendations or designing the retention system is out of the scope for GESTRA. The contractor must comply with the federal, state, local and updated OSHA regulations during excavation and in retention system design to ensure excavation safety.

Occupational Safety and Health Act (OSHA) has instituted strict standards for temporary construction excavations. These standards are outlined in 29 CFR Part 1926 Subpart P. Excavations within unstable soil conditions or extending five feet or more in depth should be adequately sloped or braced according to these standards. Excavation safety is the responsibility of the contractor. Material stockpiles or heavy equipment should not be placed near the edge of the excavation slopes. The actual stable slope angle should be determined during construction and will depend upon the loading, soil, and groundwater conditions encountered.

Weather Implications

The subgrade soil or the soil at foundation level might become unstable with exposure to adverse weather such as rain, snow and freezing temperatures. The unstable areas due to weather exposure may require an additional undercut or stabilization and the representative geotechnical engineer should assist with the determination of the depth of additional undercut or stabilization procedure based on observation of the field condition.

Soil Sensitivity

Soil at the construction site will be exposed to moisture and disturbance from construction traffic, construction equipment and human factors. If the soil is disturbed, it may become more moisture sensitive. The contractor should try to lessen the exposure of the soil at the construction site to moisture and disturbances. Therefore, the manhole and pipes or box sections should be installed immediately after the review of the representative geotechnical engineer.

5.0 EXPLORATION AND TESTING PROCEDURES

5.1 LAYOUT AND ELEVATION PROCEDURES

A total of twelve (12) SPT soil borings were completed at the approximate locations shown on the attached Borehole Location Map in Appendix I. The location of the borings were selected and located in the field by the City of Wauwatosa. The borings were offset from the original staked located if there was a conflict due to access or utilities.

Elevation of the boreholes were obtained by GESTRA using a Geomax Zenith 35 GNSS-INS receiver. Elevations shown on the boring logs are reference to the Wisconsin County Coordinate System-Milwaukee County (NAVD 88). Coordinates and elevation were not obtained by a licensed surveyor.

5.2 FIELD TESTING PROCEDURES

The boreholes were drilled using either a track or truck mounted drill rig. The boreholes were initiated and advanced by using hollow stem augers. Split spoon samples were collected at 2-1/2 foot intervals to a depth of 11 feet, and then at 5 foot intervals to the assigned termination depth, unless auger refusal was encountered prior. At the completion of drilling the boreholes were backfill per WDNR requirements and surfaced patched with cold patch asphalt.

All representative soil samples were taken in general accordance with the “Standard Method for Penetration Test and Split-Barrel Sampling of Soils” (ASTM D1586) or “Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes” (ASTM D1587). After each sampling, a soil sample was retained and placed in a jar and recorded for type, color, consistency, and moisture, sealed and then transported to the laboratory for further review and testing, if required. The specific drilling method used including the depths, rig type, crew chief, are included on each of the individual boring logs as it may change for each borehole.

5.3 LABORATORY TESTING PROCEDURES

After completion of drilling operations, all of the retained soil samples were transported to GESTRA’s laboratory and classified by a geotechnical engineer using the Unified Soil Classification System (USCS). A chart describing the classification system used is included in Appendix I. The engineer assigned laboratory testing suited to extract important index properties of the soil layers. These tests included hand penetrometer, moisture content, Atterberg limits, grain size analysis, and unconfined compression strength test.

STANDARD OF CARE

Our exploration was limited to evaluating subsurface soil and groundwater conditions pertaining to the proposed project. GESTRA did not perform any environmental, chemical, or hydrogeologic testing as these were not part of our work scope.

This report should be made available in its entirety to bidding contractors for information purposes. The soil boring logs and borehole location map should not be detached from this report. Our report is not valid if used for purposes other than what is described in the report.

All OSHA regulations such as those regarding proper sloping and temporary shoring of excavations should be followed during the entire construction process.

GESTRA has presented our professional opinions in this report in the form of recommendations. Our opinions are based on our understanding of current project information and related accepted engineering practices at the time of this report. Other than this, no warranty is implied or intended.

Sincerely,

GESTRA Engineering, Inc.

Report Prepared By:

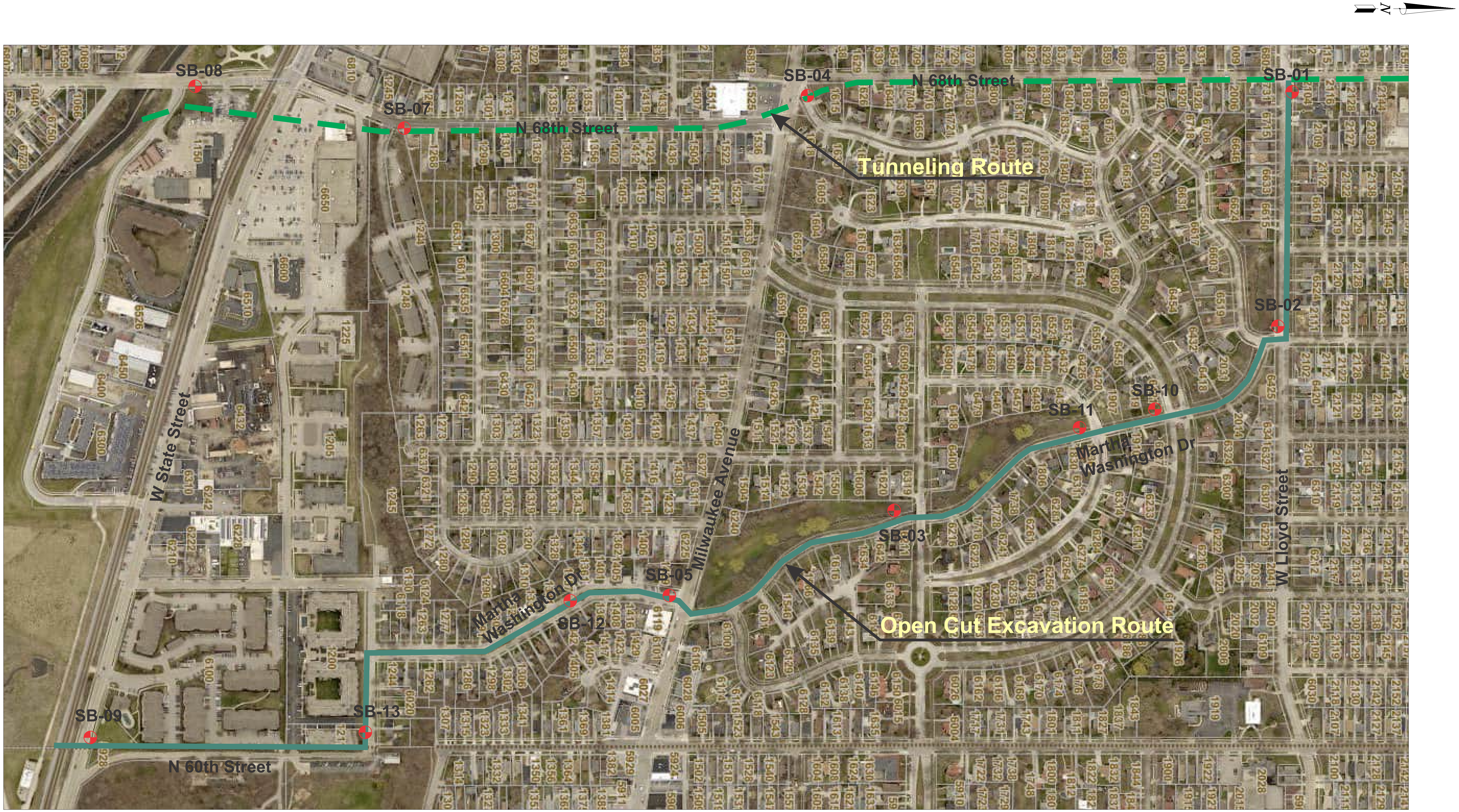
Eric Jeske, P.E.
Senior Engineer

Report Reviewed By:

Doug Bath, P.E.
Senior Engineer

APPENDIX I

BOREHOLE LOCATION MAP, PLAN AND PROFILE DRAWINGS, SOIL BORING LOGS, RECOMMENDED SOIL PARAMETERS, GENERAL NOTES AND SOILS CLASSIFICATION



Base map obtained from Milwaukee County LIO website

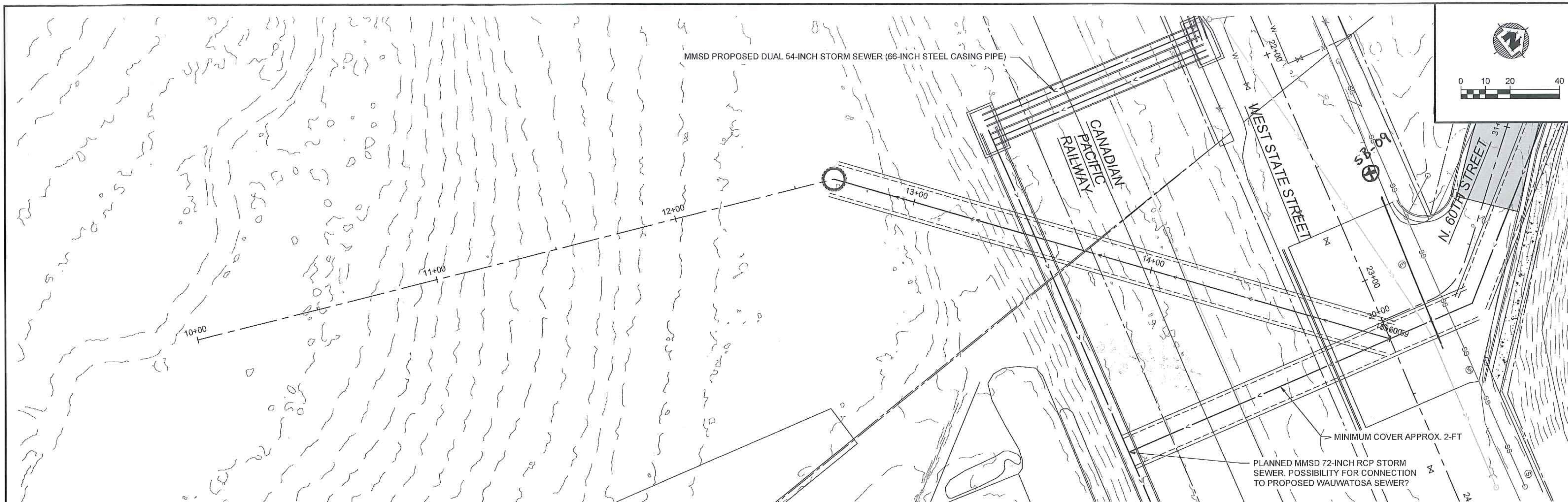
ROUTES ARE APPROXIMATE. ACTUAL ROUTE MAY VARY SLIGHTLY FROM WHAT IS SHOWN

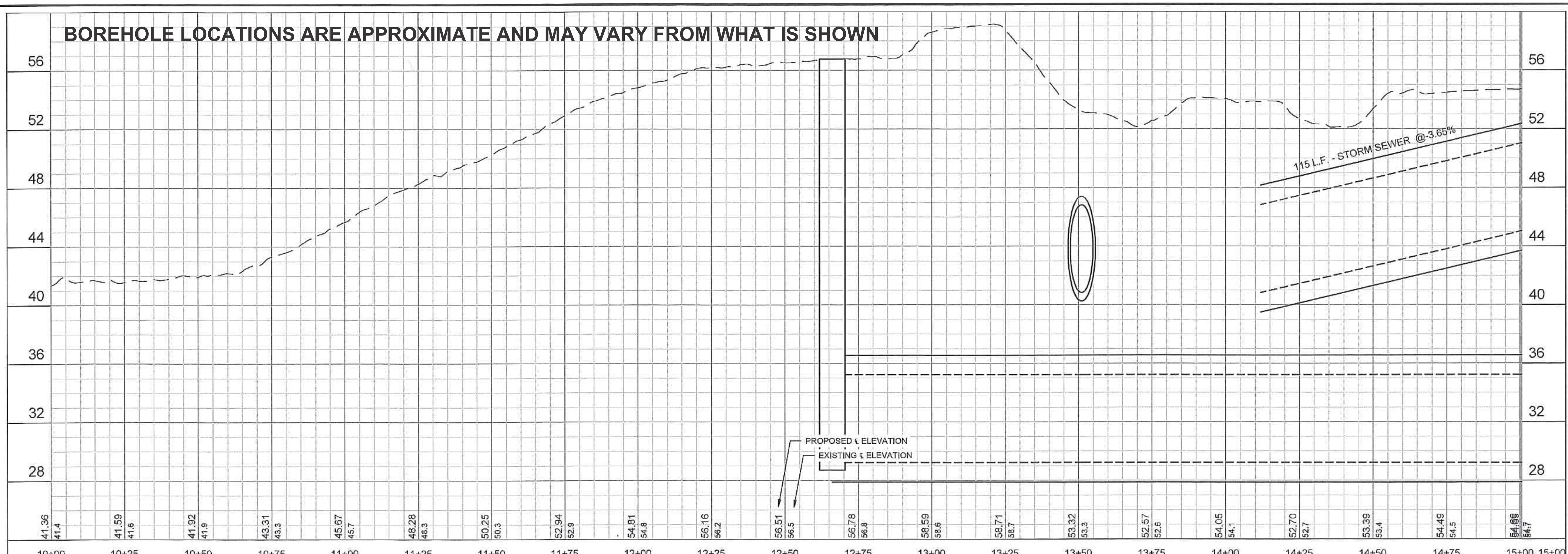
= APPROXIMATE BOREHOLE LOCATION

GESTRA

GESTRA Engineering, Inc.
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: (414) 933-7444
Fax: (414) 933-7844

Project Name & Location: City of Wauwatosa, Schoonmaker Creek Watershed, Wauwatosa, Wisconsin	Scale: 1" = 6,500'
	Drawing No.: 1 of 1
	Prepared by: ESJ
Drawing Title: Borehole Location Map	Checked by: DB
Project No.: 23414-10	Date: March 25, 2024





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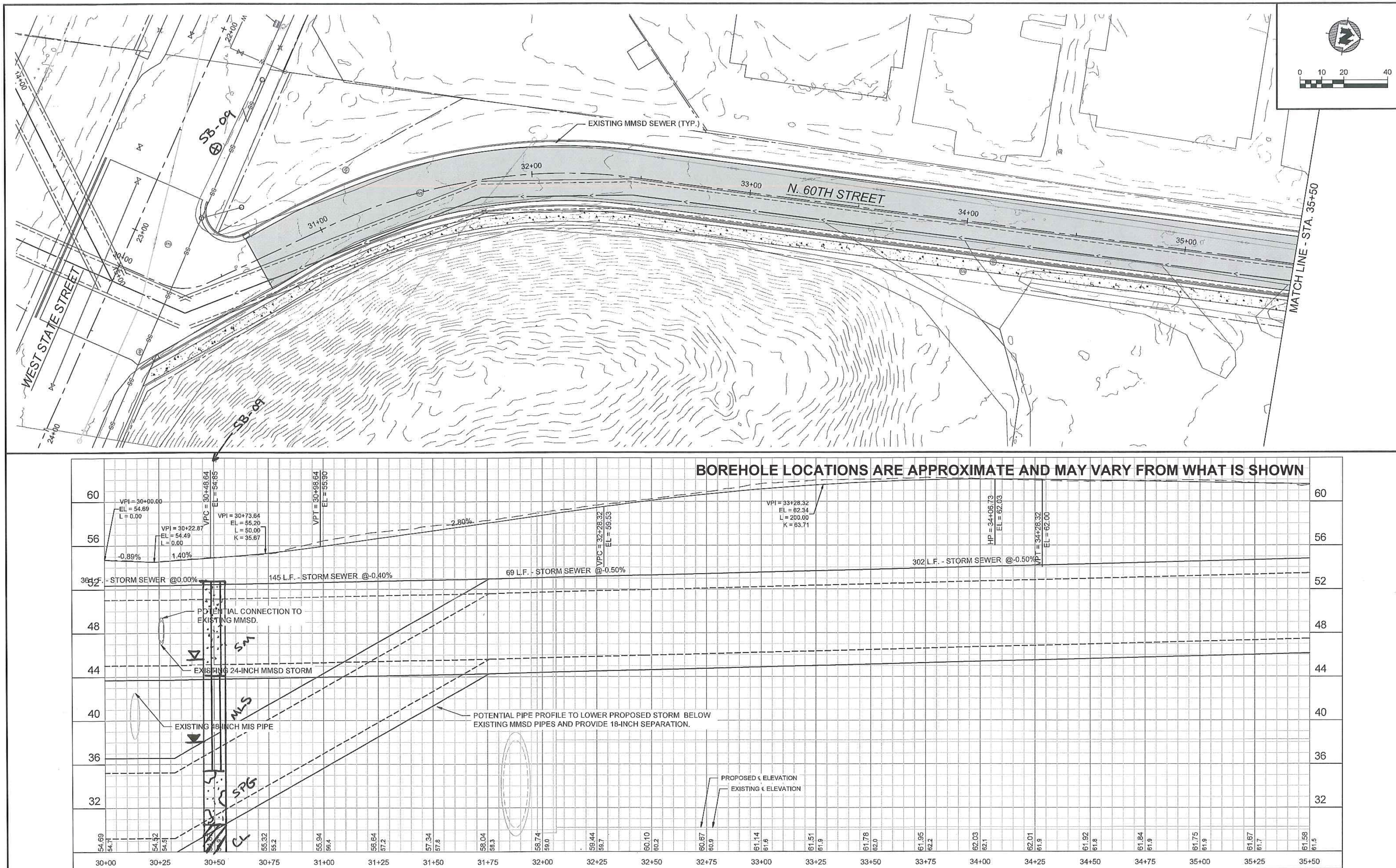

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SHEET R2

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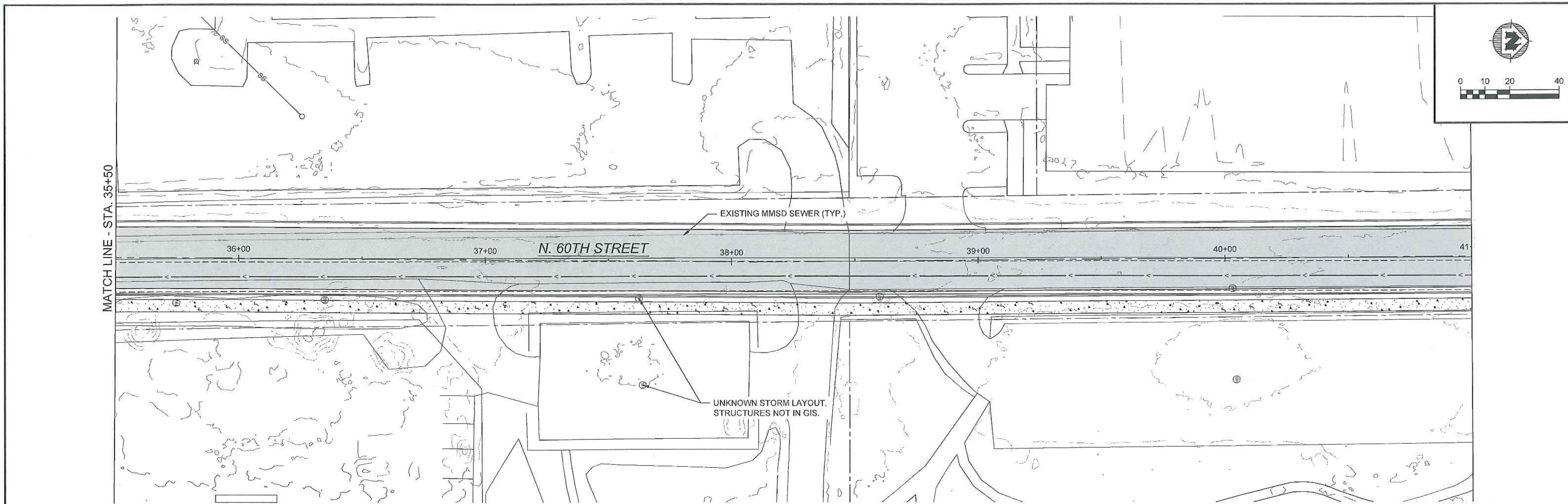

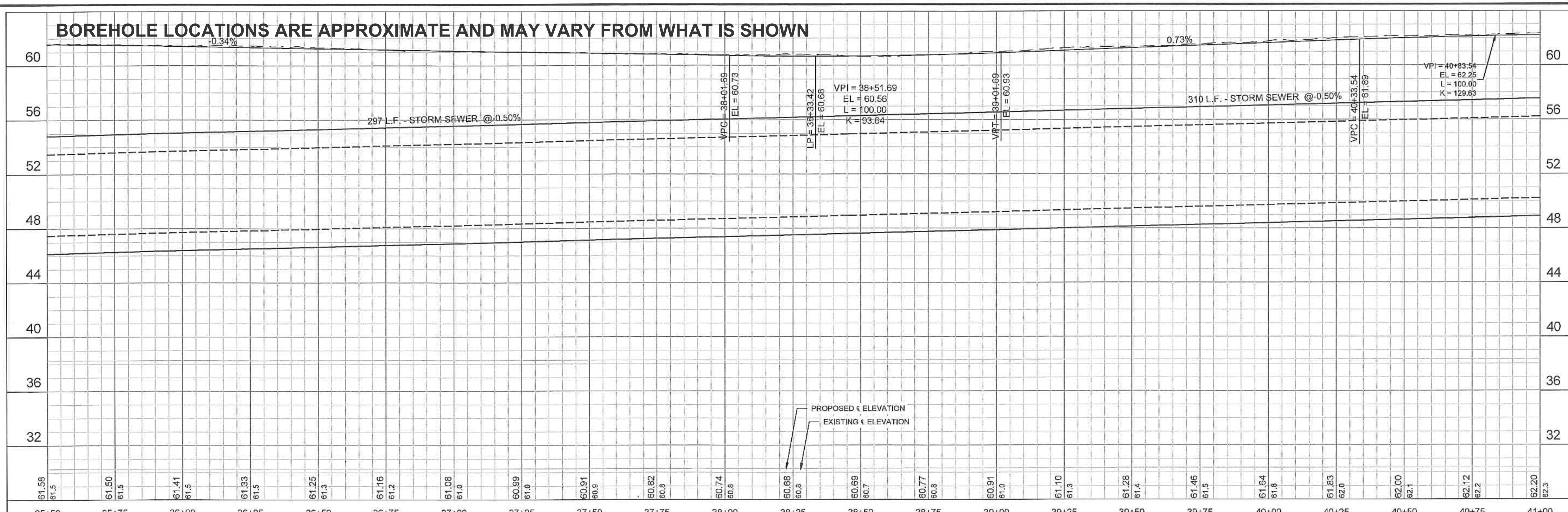

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PROJECT NO. 10310004
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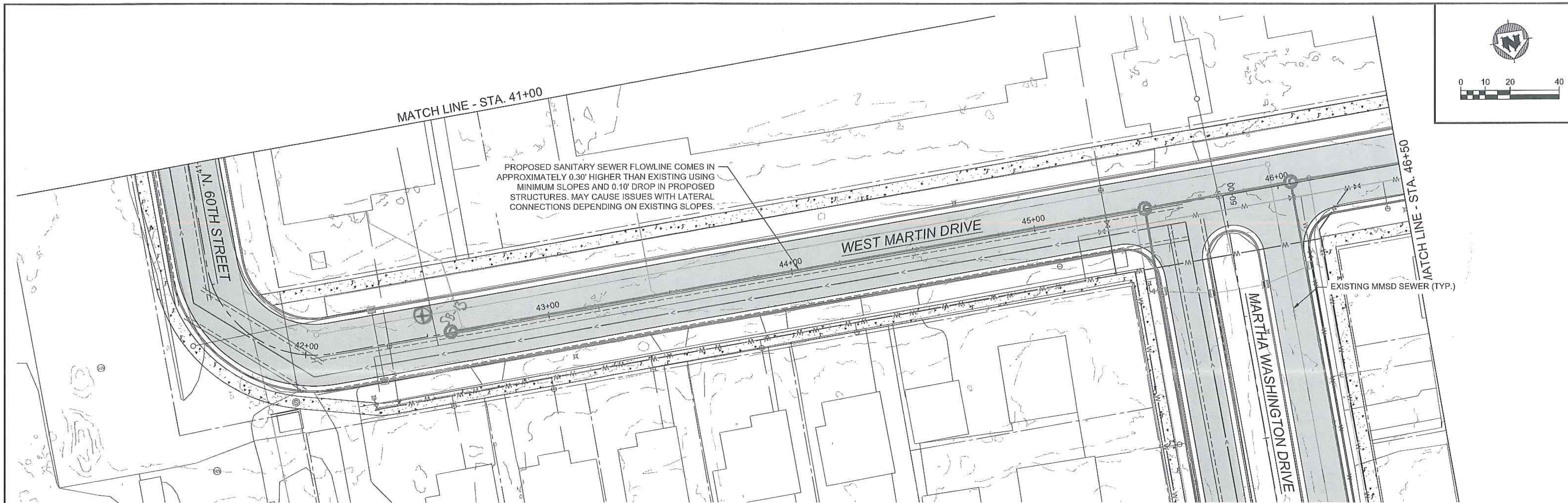

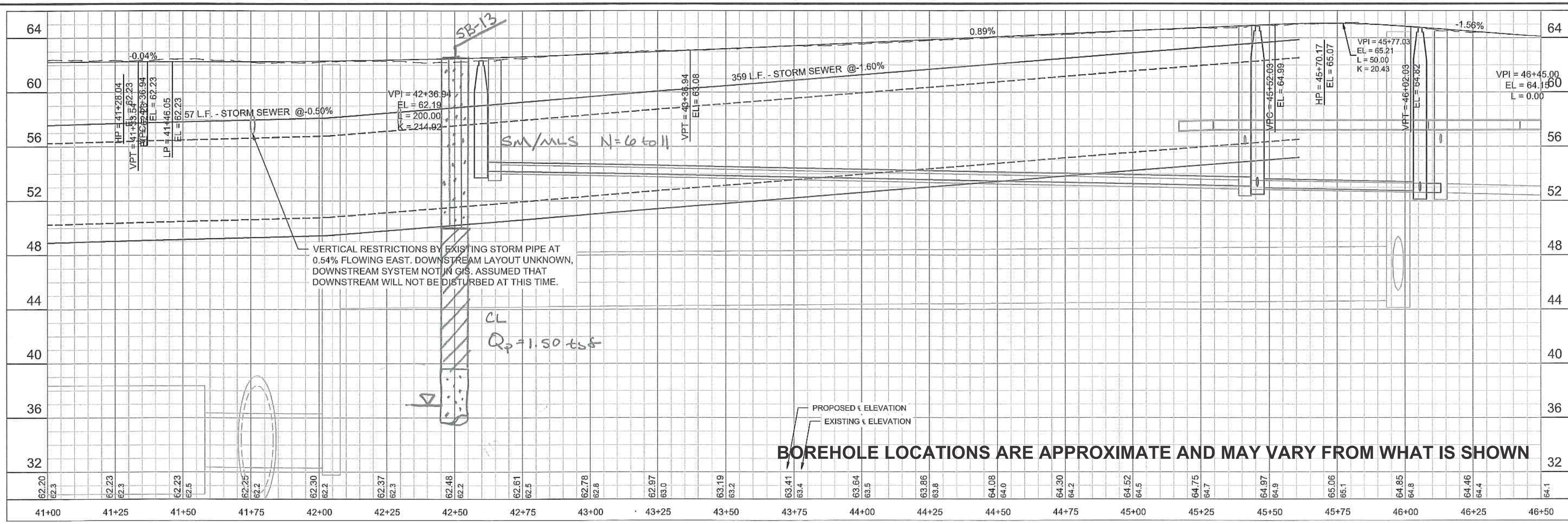

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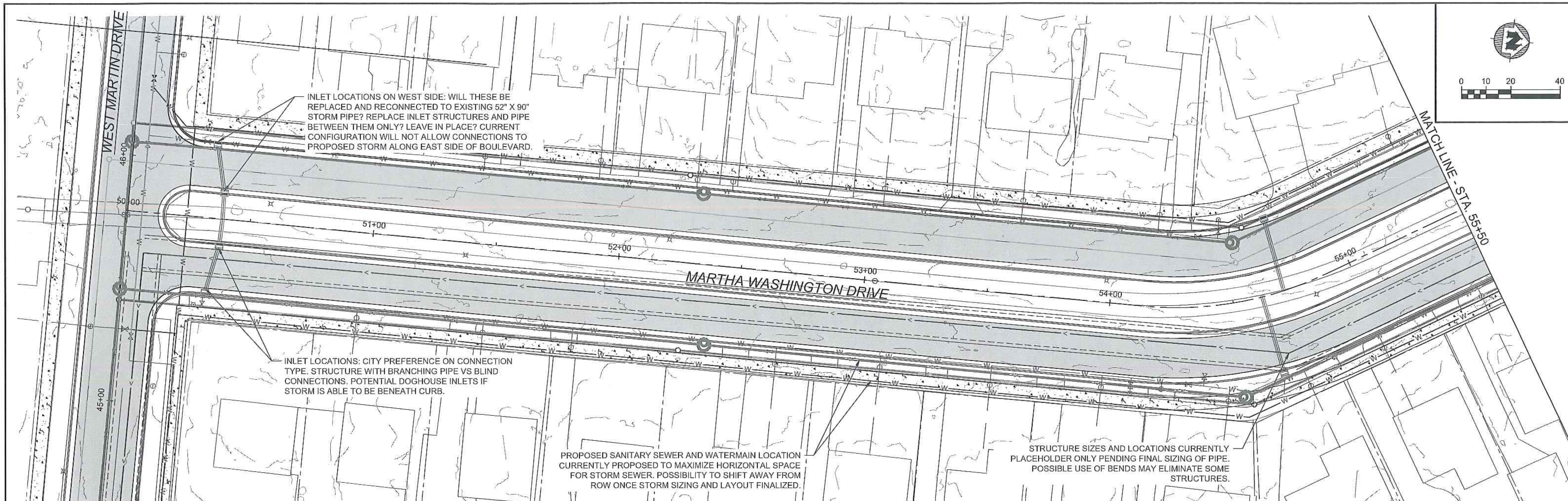

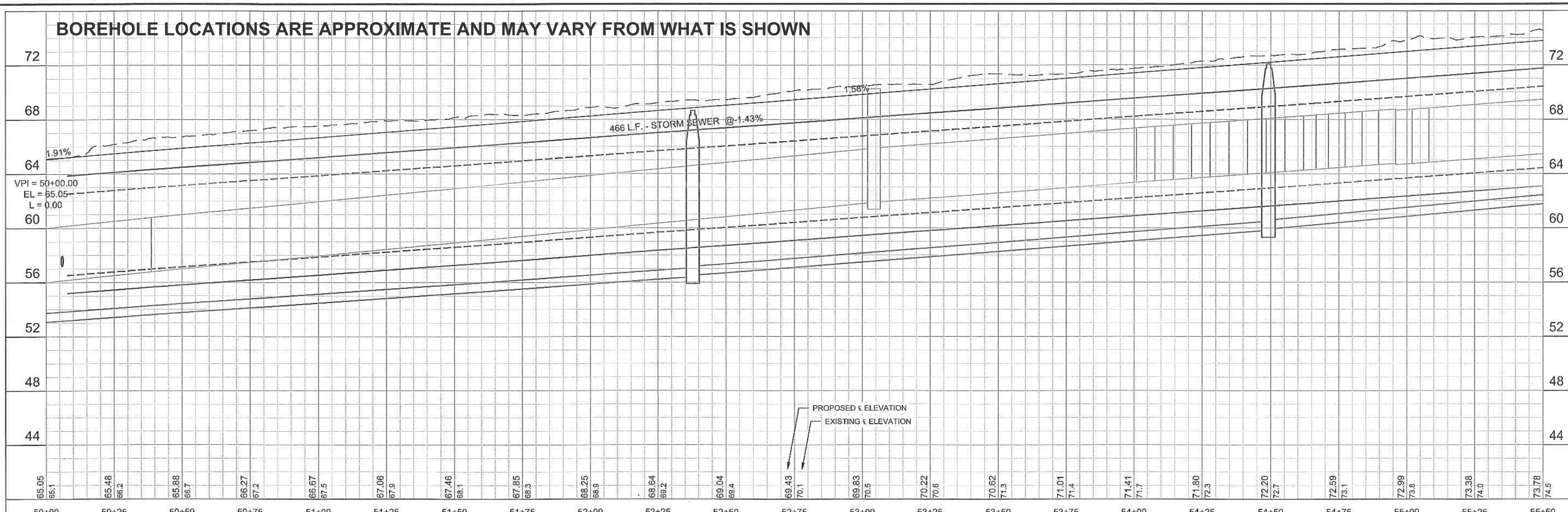

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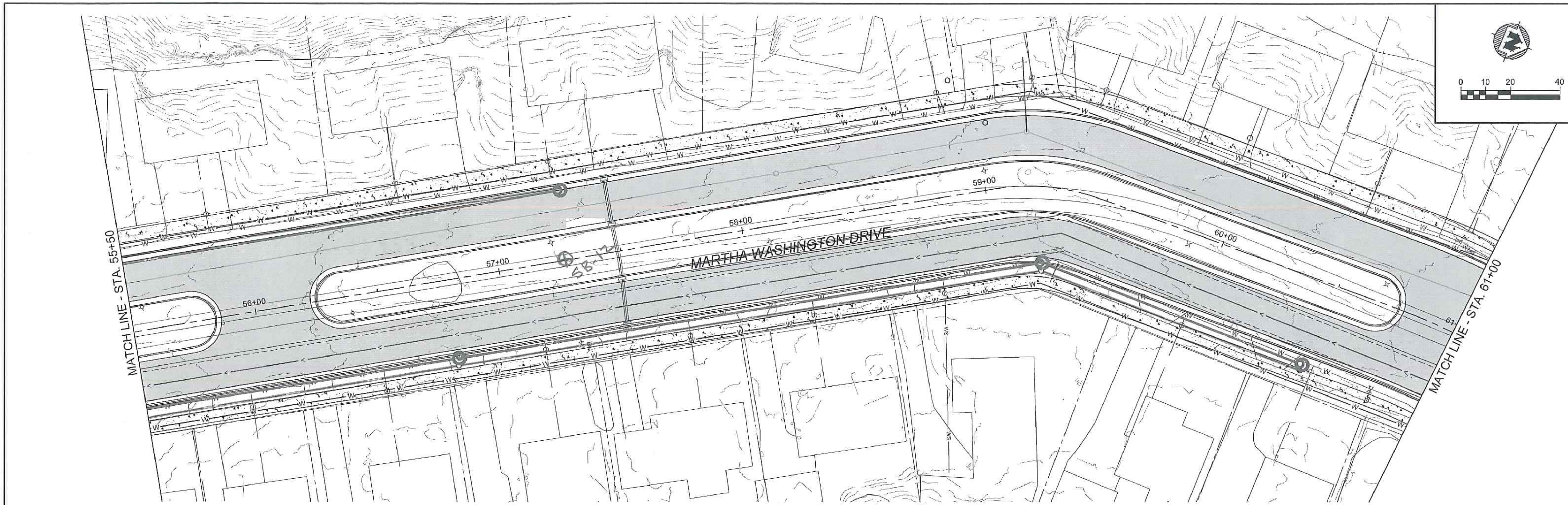

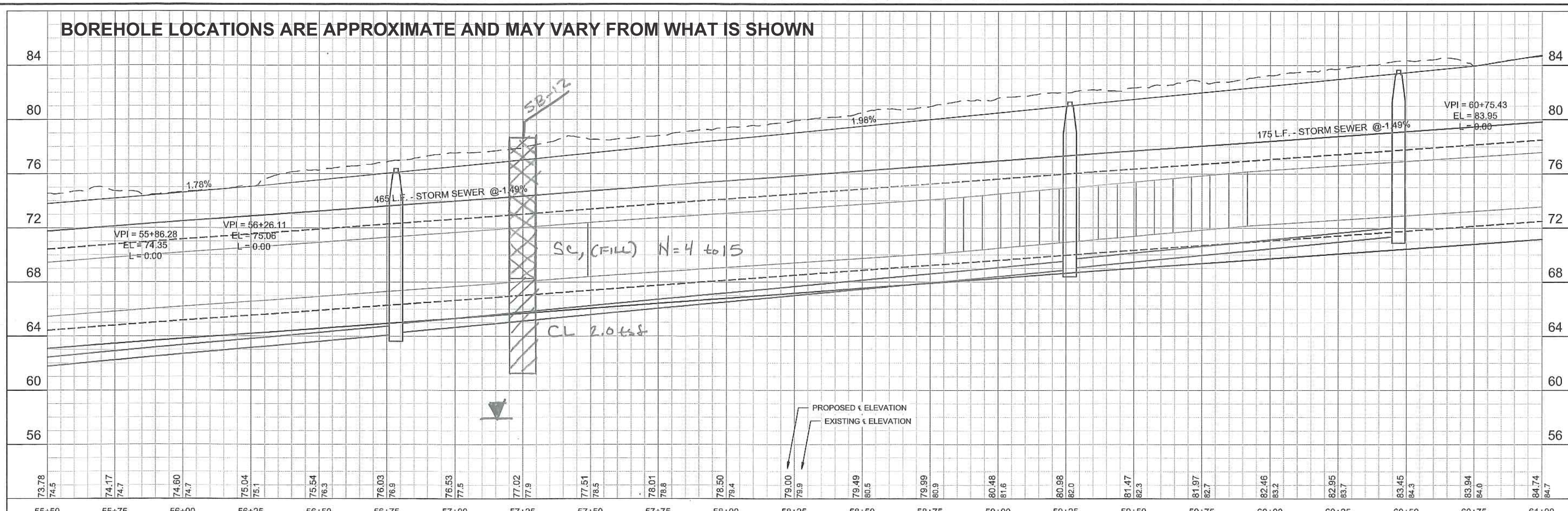

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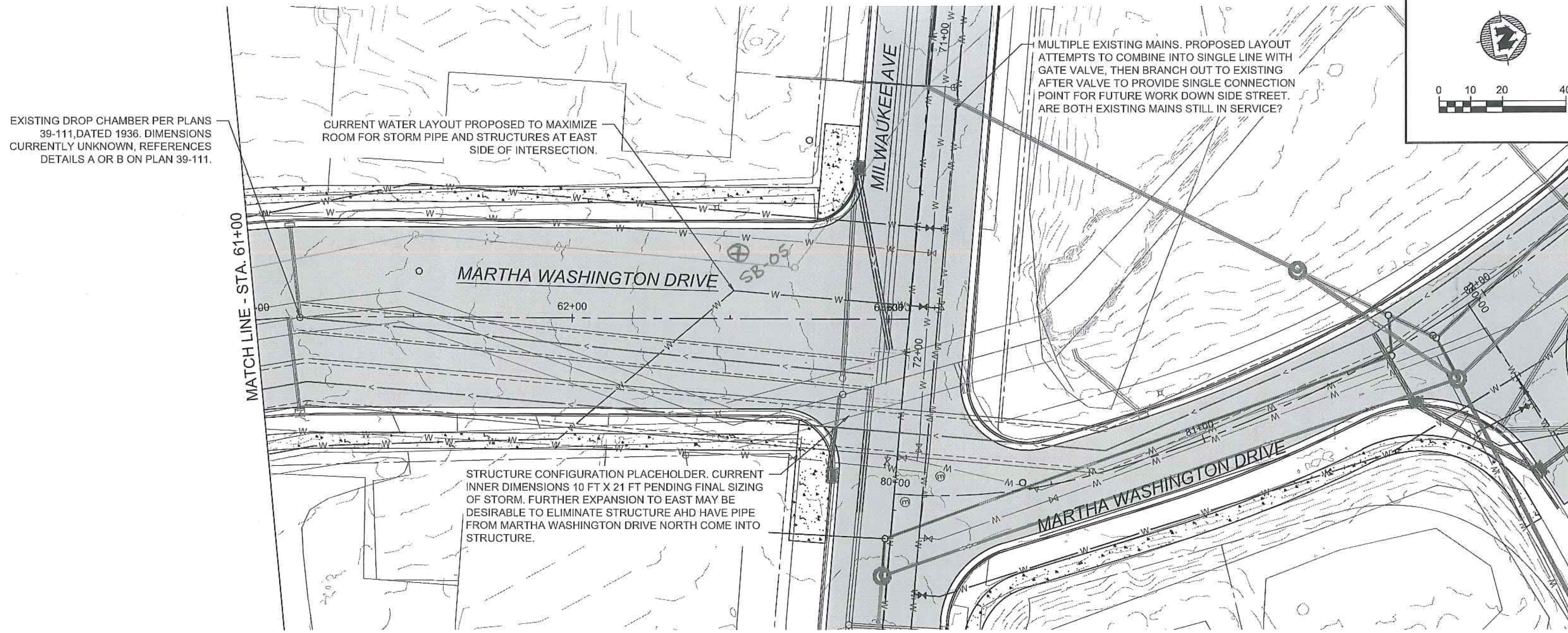

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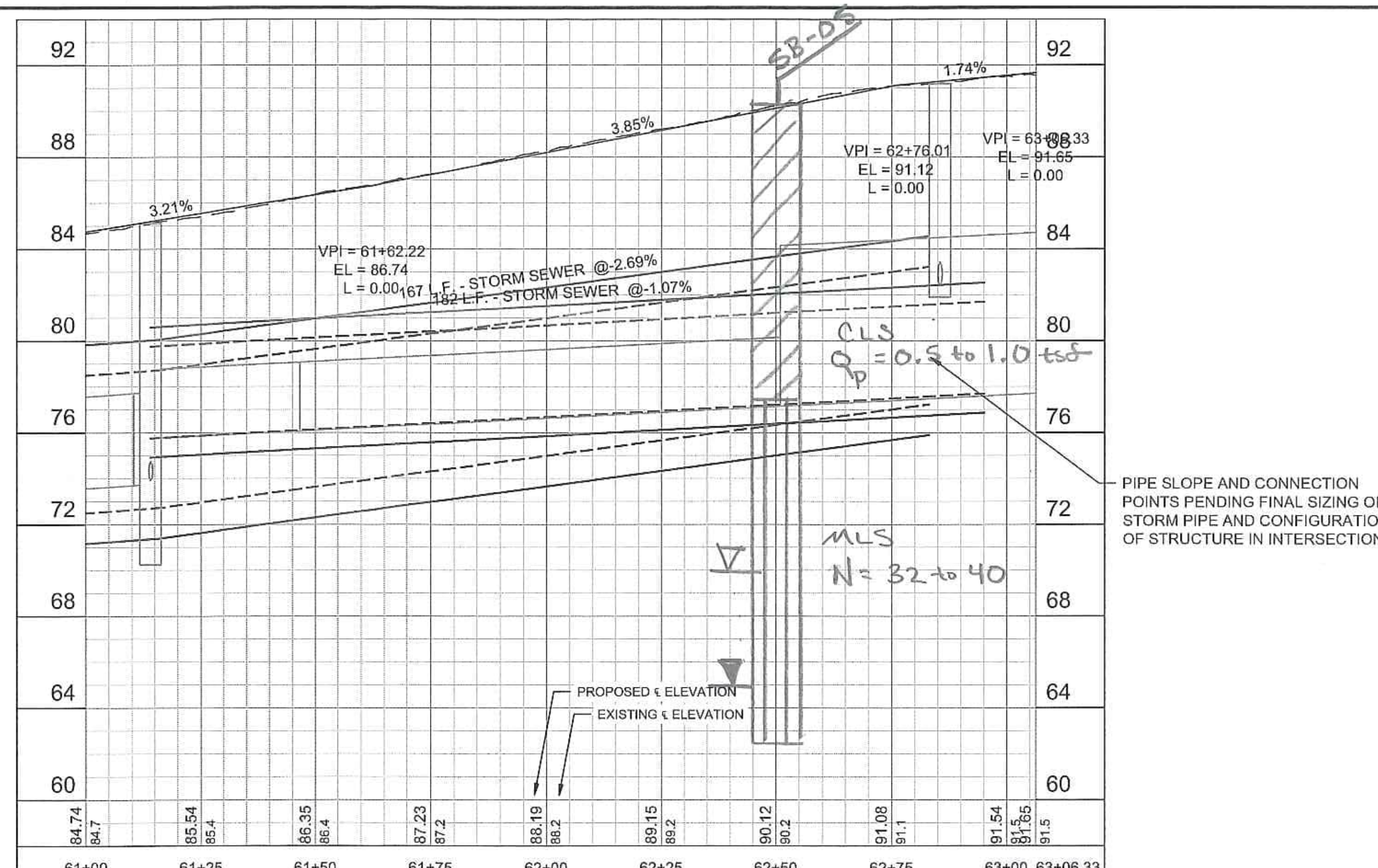

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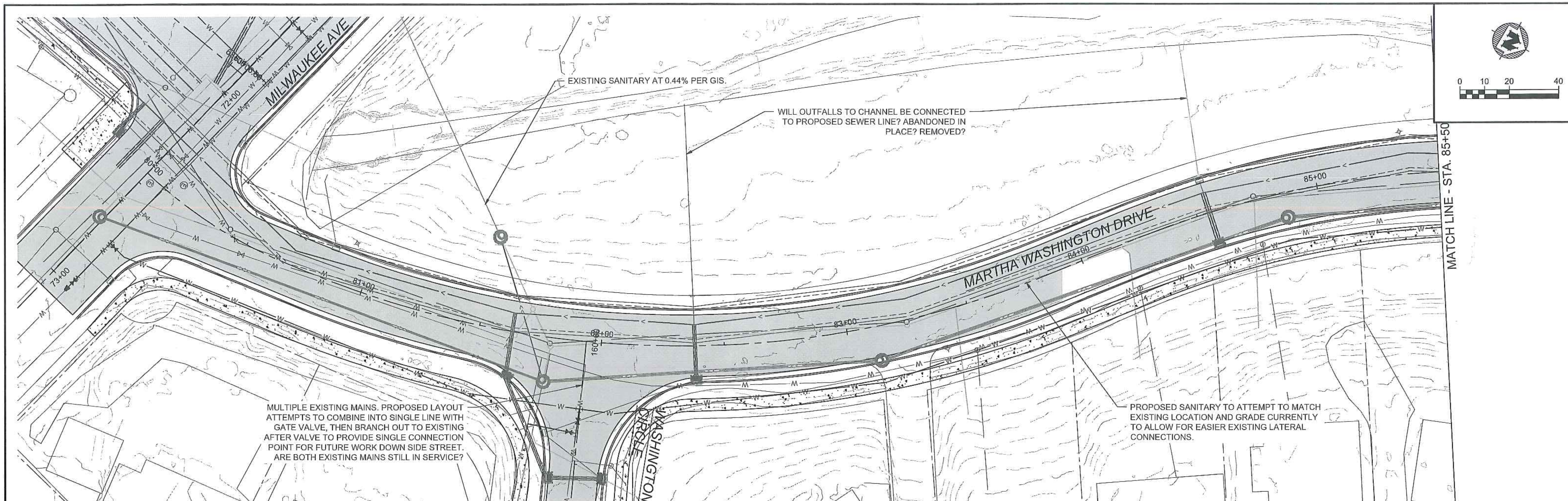

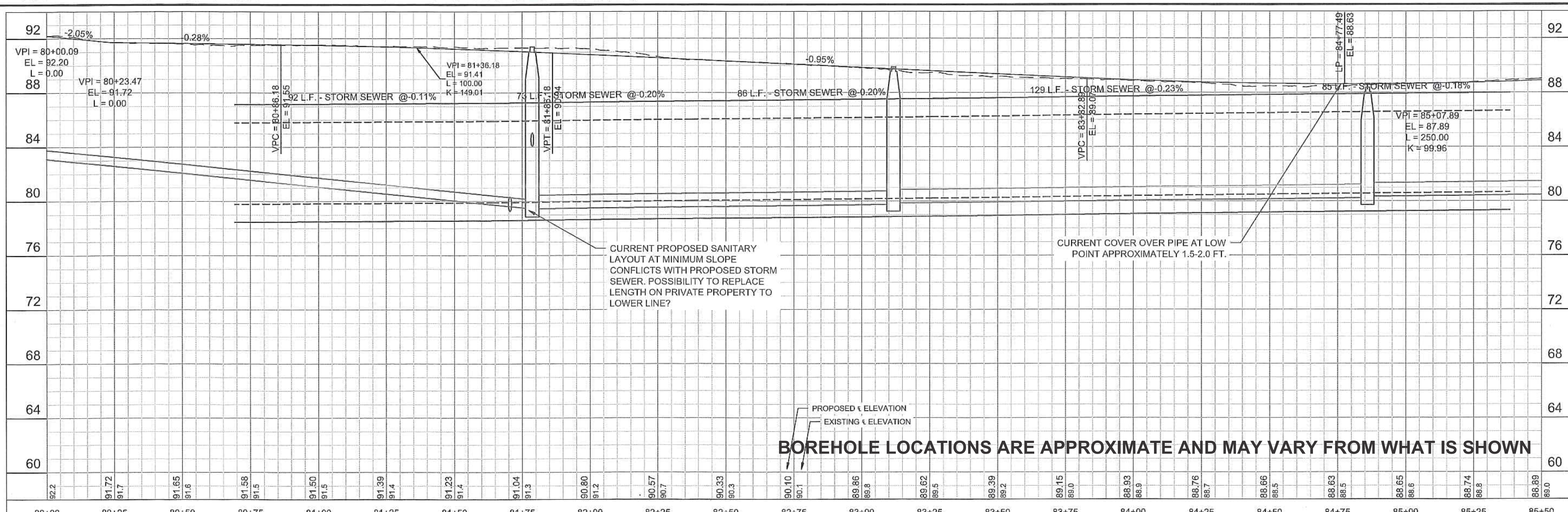

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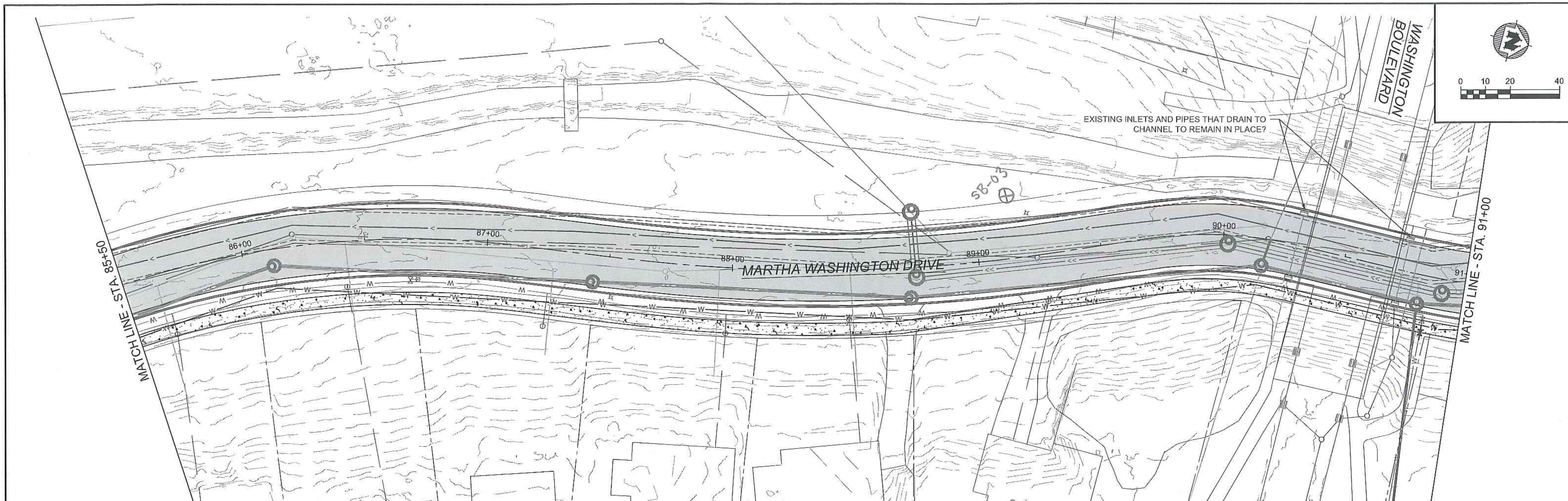

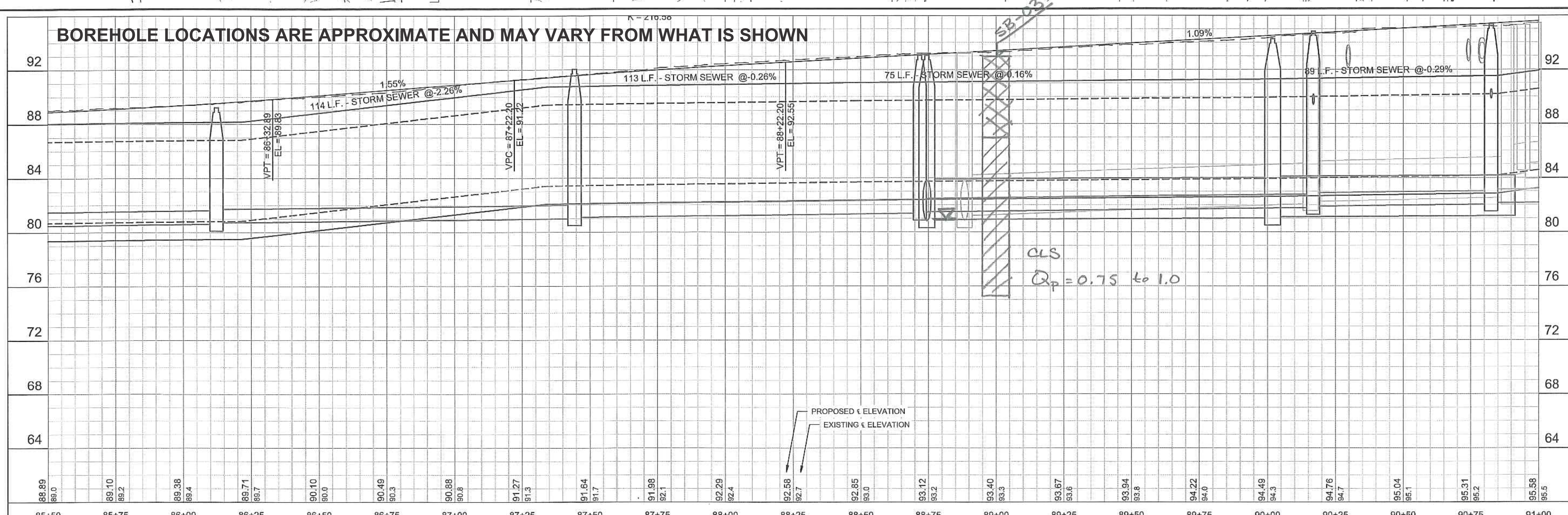

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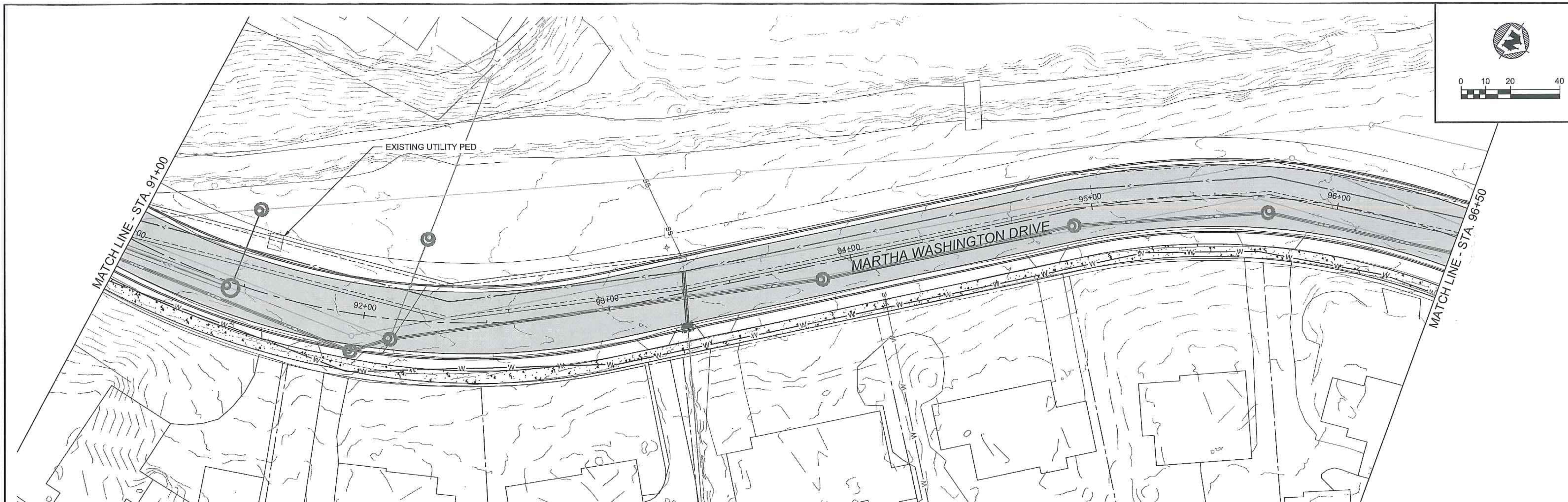

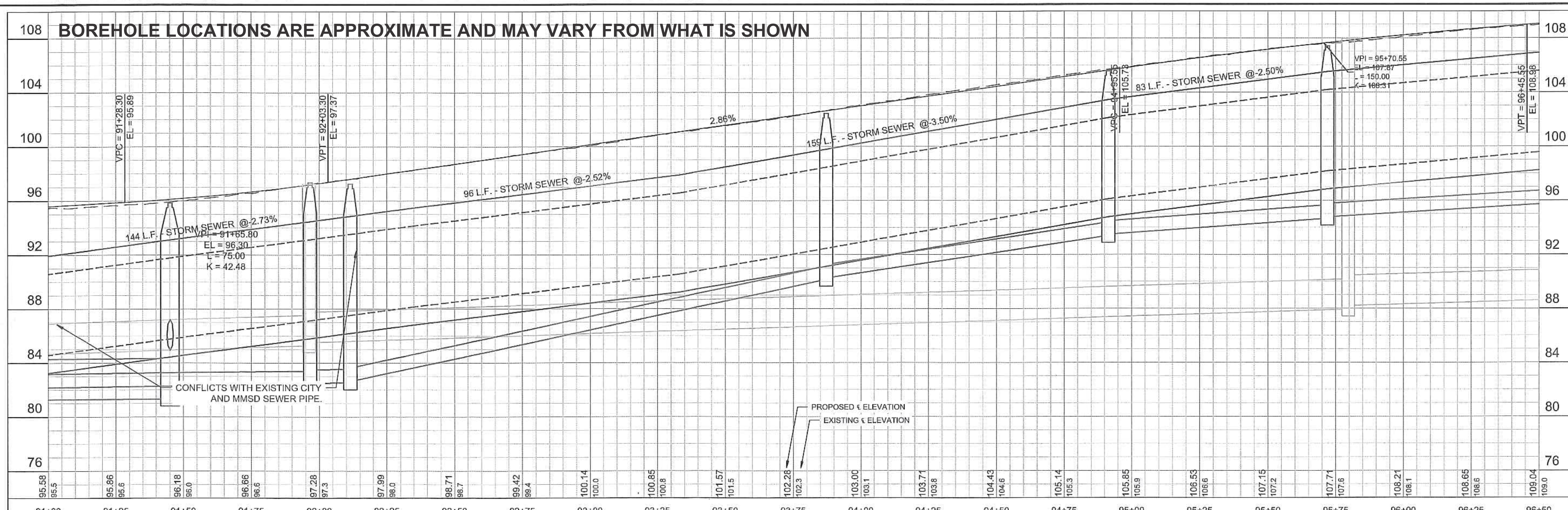

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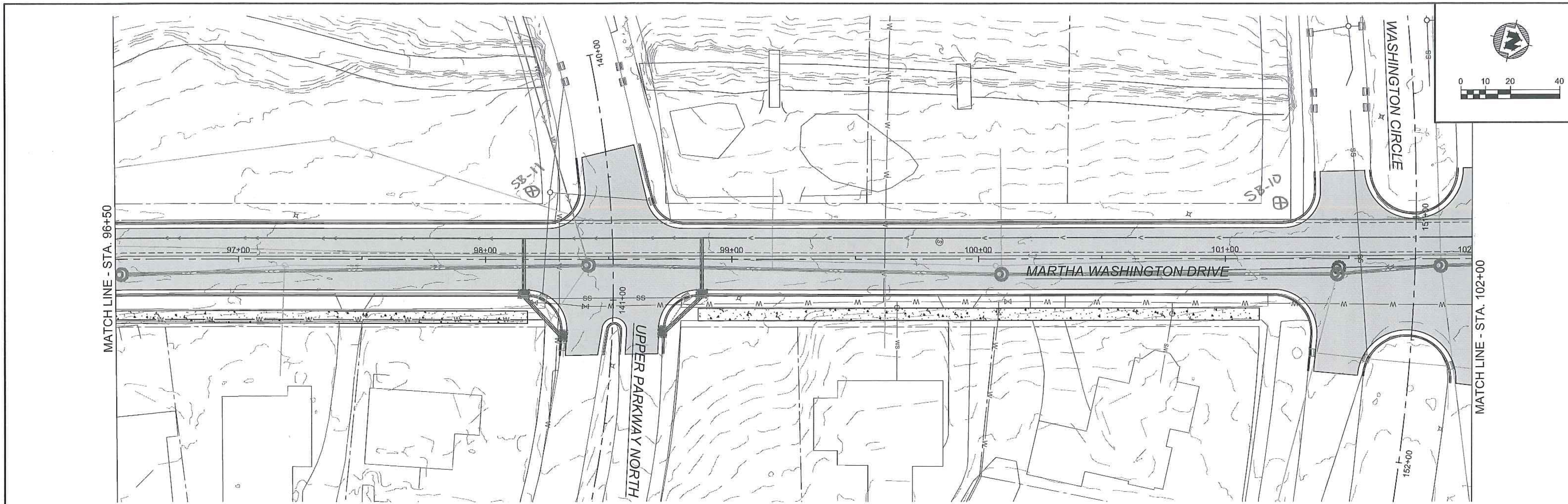

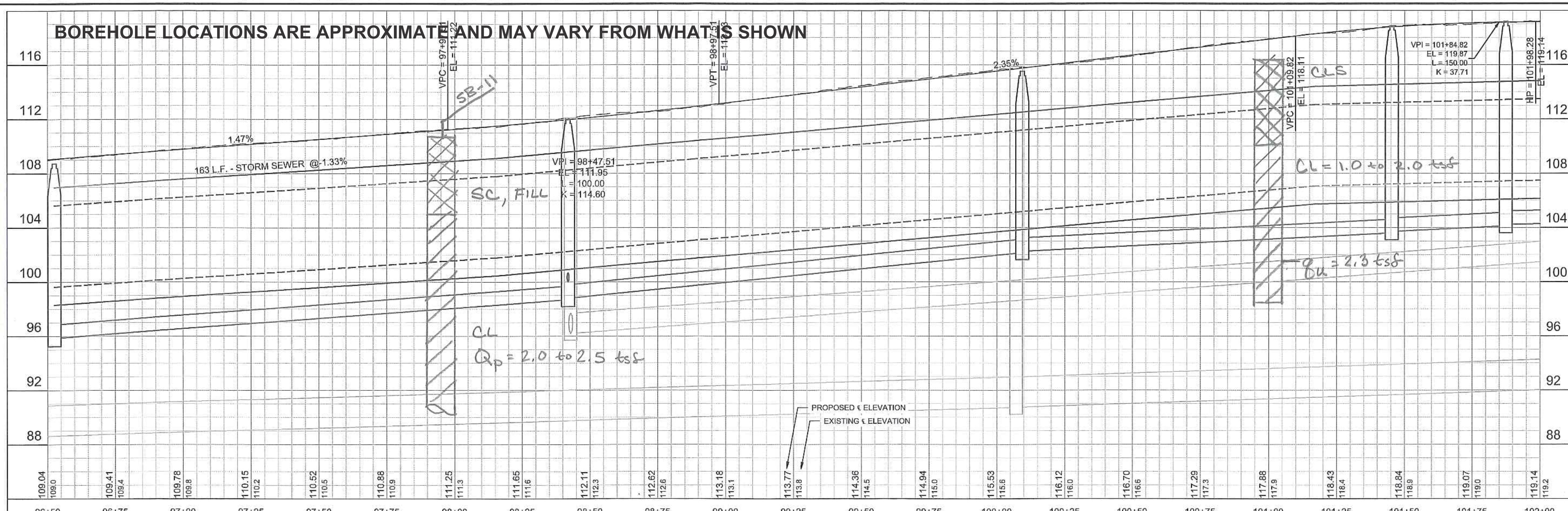

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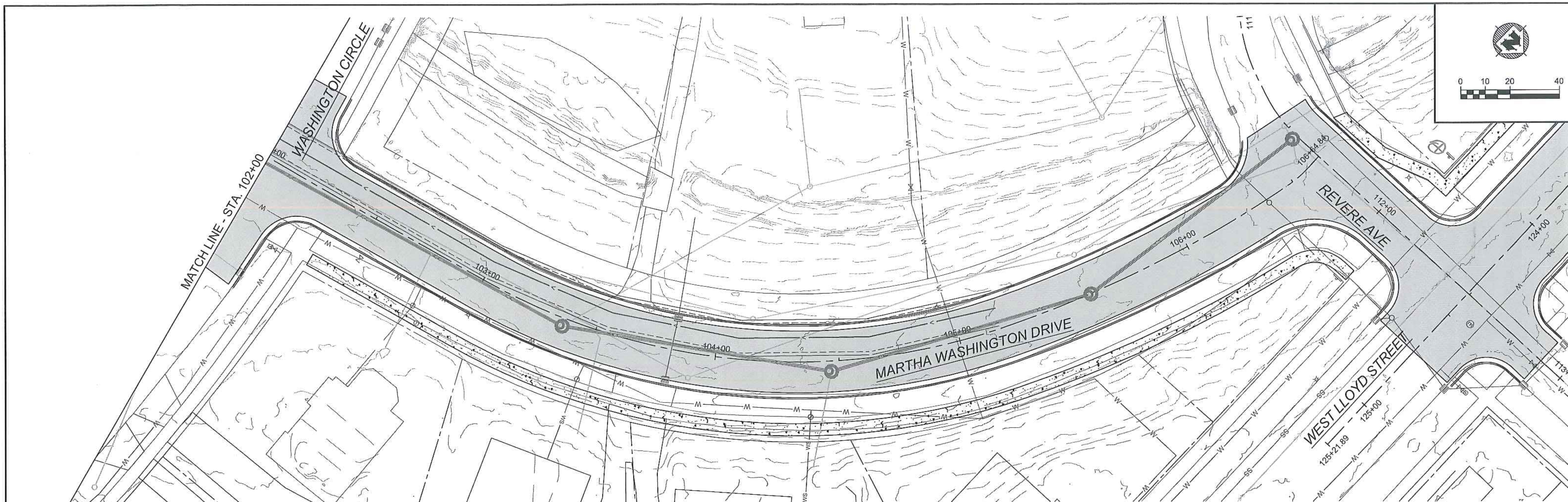

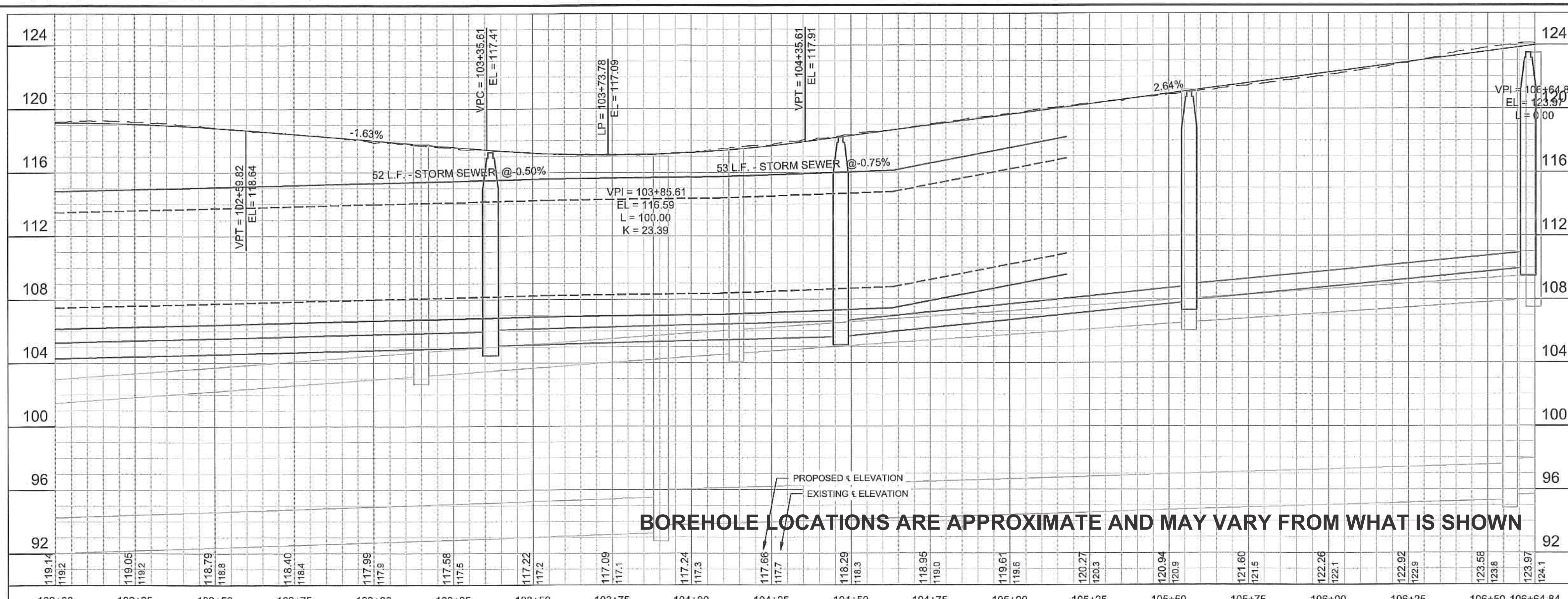

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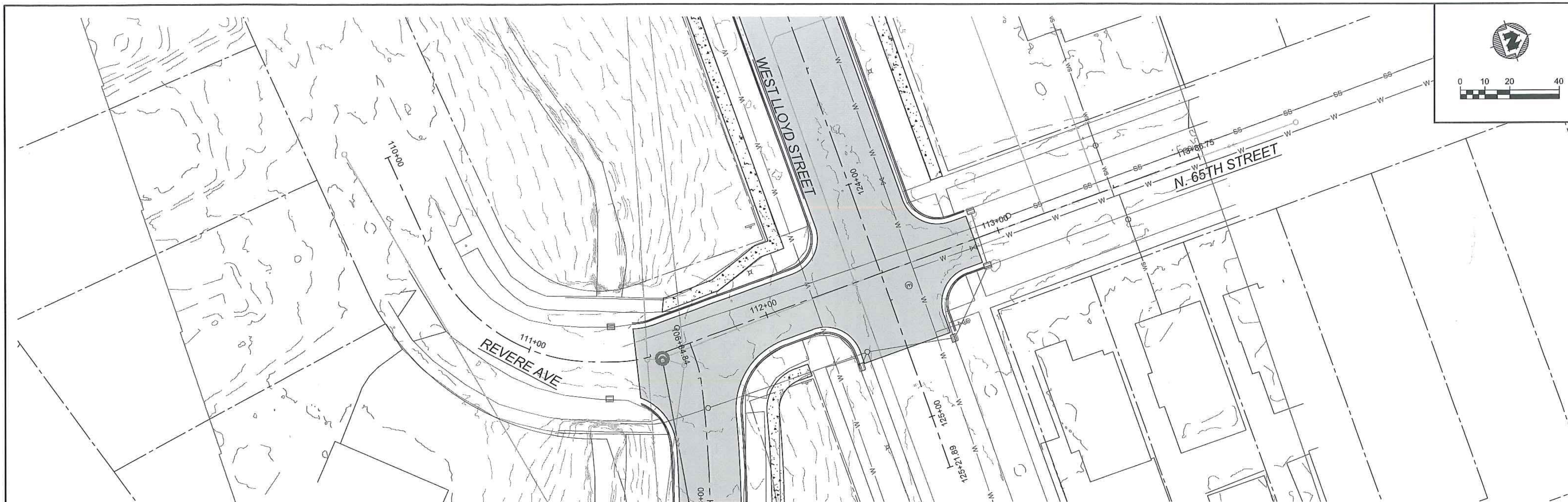

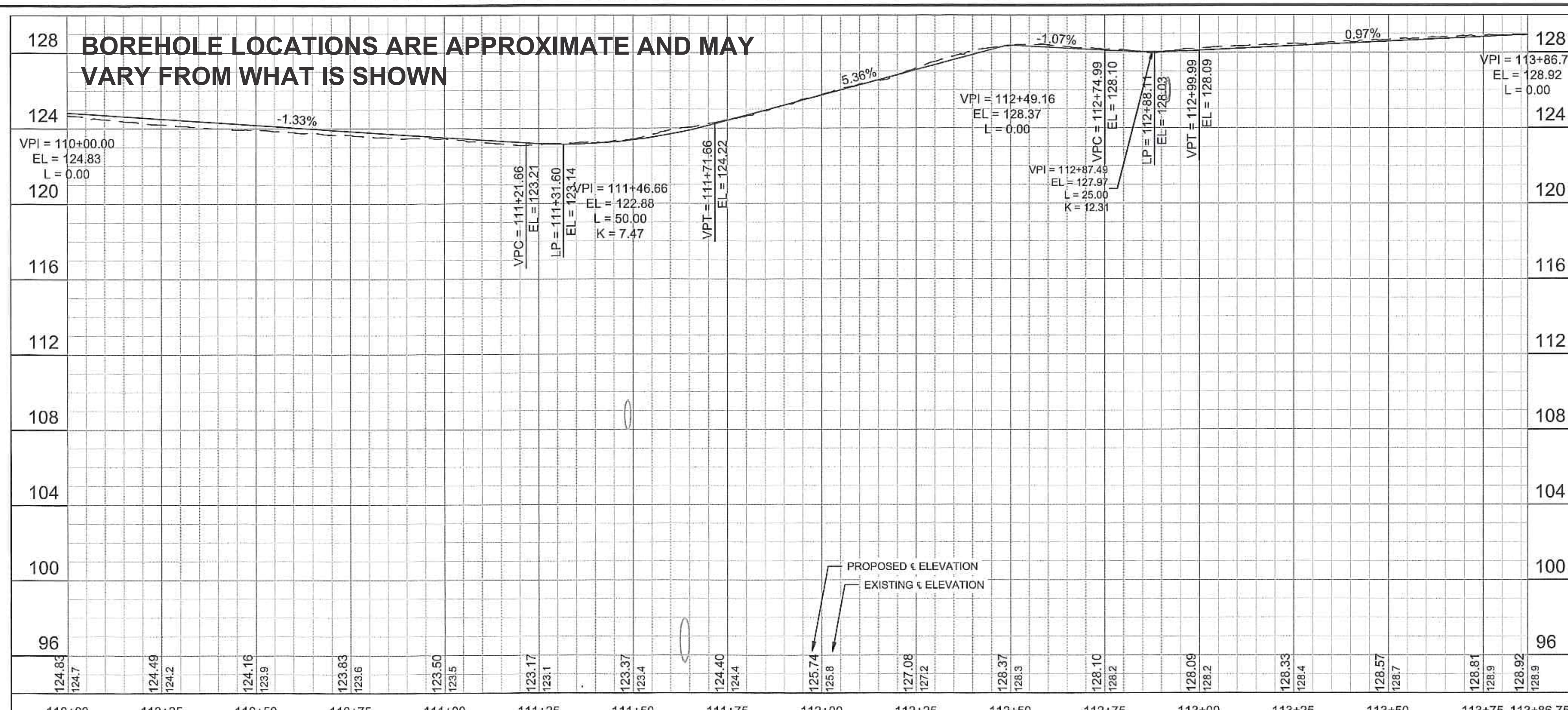

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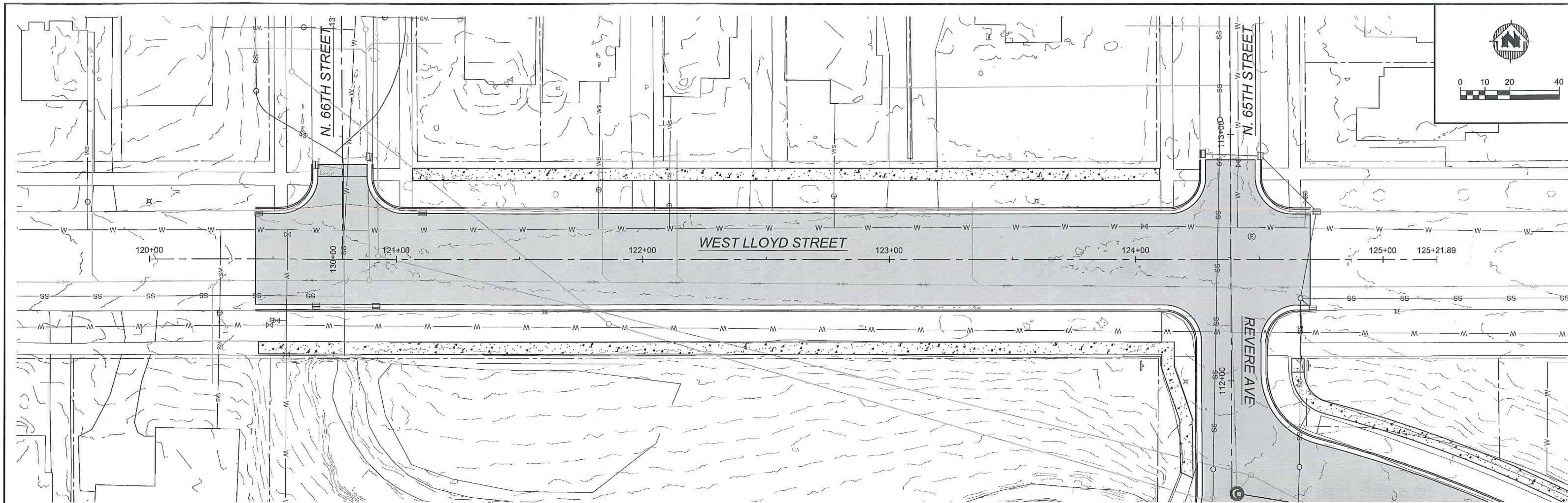

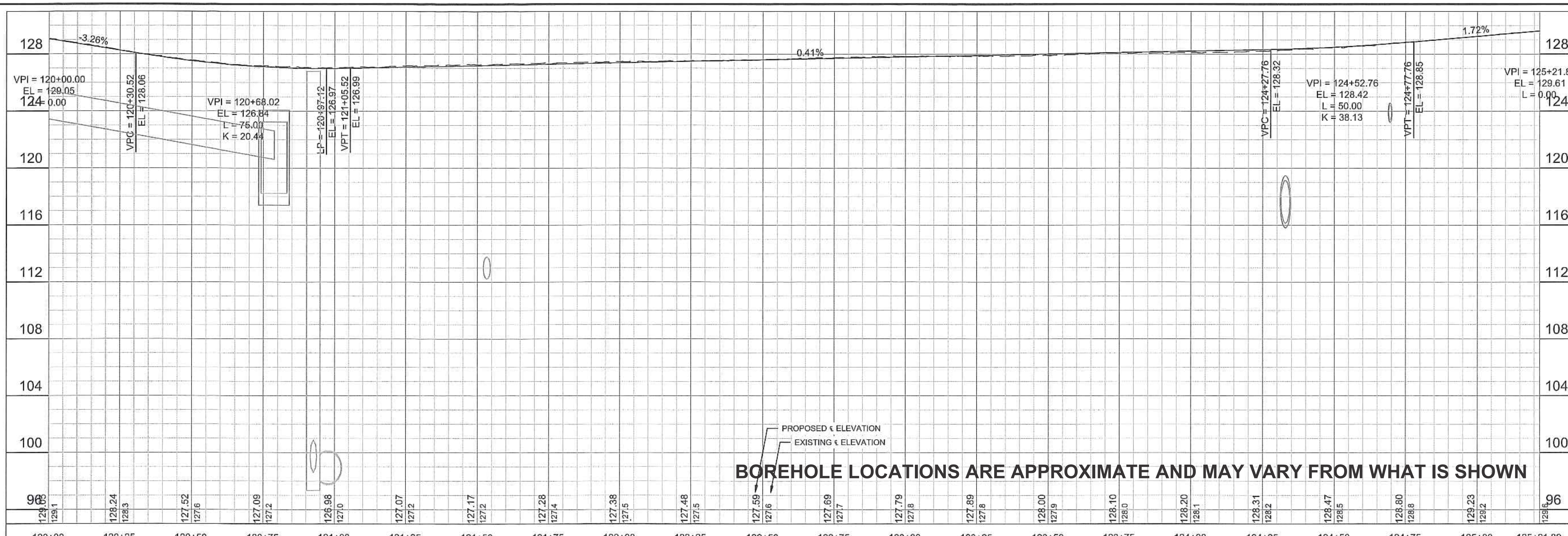

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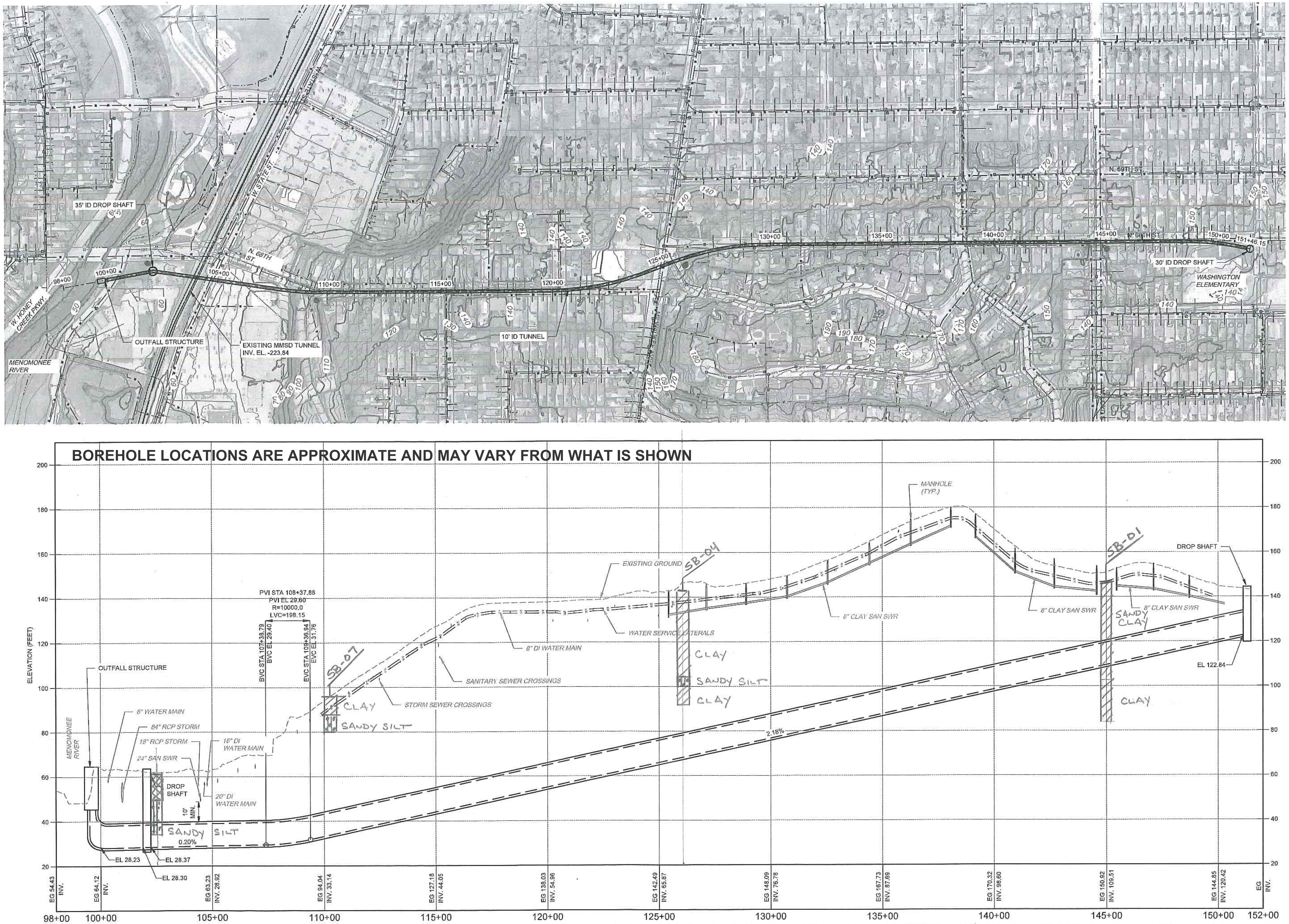
MILWAUKEE COUNTY, WI

ROADWAY & STORM PLANS - WEST LLOYD STREET

PROJECT NO. 10310004
SHEET R15



HORIZ. 0 200' 400'

VERT. 0 20' 40'

LEGEND:

- SANITARY SEWER
- STORM DRAIN
- WATER LINE
- FIBER OPTIC
- TUNNEL LINNING
- TUNNEL BASELINE
- MANHOLE/ INLETS
- FIRE HYDRANTS
- MMSD TUNNEL CENT

NOTE:

1. FIBER OPTIC AND ELECTRICAL CONDUIT N SHOWN IN PROFILE FOR CLARITY

DESIGNED BY: G. SANDERS
DRAWN BY: A. BOCANEGRA
SHEET CHK'D BY:

CDM Smith

CITY OF WAUWATOSA, WISCONSIN

ALTERNATIVE 1

PROJECT NO. 29184
FILE NAME:
SHEET NO

Table A-1 Soil Parameters SB-01

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY LEAN CLAY, stiff to very stiff	684.5	130	135	5 to 12	1.0 to 2.0	1,000	--	--	26	500	0.007	Stiff Clay Below the Water Table
LEAN CLAY, hard	674.7	130	135	22 to 24	4.5+	4,000	--	--	26	2,000	0.004	Stiff Clay Below the Water Table
SILTY SAND, medium dense	EOB	115	120	22 to 24	--	--	32	--	32	60	--	Sand

Table A-2 Soil Parameters SB-02

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY LEAN CLAY (FILL)	701.2	125	130	5 to 14	--	1,000	--	--	26	500	0.007	Stiff Clay Above the Water Table
SAND WITH GRAVEL (FILL)	698.8	110	115	42	--	--	30	--	30	90	--	Sand
SANDY LEAN CLAY, medium stiff to stiff	684.8	130	135	5 to 14	0.75 to 2.2	1,500	--	--	26	500	0.007	Stiff Clay Below the Water Table
LEAN CLAY, very stiff to hard	EOB	130	135	15 to 36	3.0 to 4.5+	3,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table

Table A-3 Soil Parameters SB-03

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SAND WITH GRAVEL (FILL)	667.6	110	115	5 to 14	--	--	30	--	30	25	--	Sand
SANDY LEAN CLAY, stiff	655.8	130	135	6 to 8	0.75 to 1.0	1,000	--	--	26	500	0.007	Stiff Clay Below the Water Table
SANDY SILT, medium dense	650.9	110	115	10	--	--	30	--	30	60	--	Sand
SANDY LEAN CLAY, very stiff	644.9	130	135	12	2.0 to 3.0	2,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table
SANDY SILT, very dense	636.2	120	125	90	--	--	36	--	36	125	--	Sand
CLAYEY GRAVEL, very dense	633.6	120	125	refusal	--	--	36	--	36	125	--	Sand

Table A-4 Soil Parameters SB-04

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SAND (FILL)	720.5	110	115	10 to 12	--	--	30	--	30	90	--	Sand
SANDY LEAN CLAY to LEAN CLAY, stiff	711.4	130	135	9 to 12	1.5 to 3.5	1,500	--	--	26	500	0.007	Stiff Clay Above the Water Table
LEAN CLAY, very stiff	686.4	130	135	14 to 19	2.0 to 3.5	2,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table
SANDY SILT, very dense	681.4	120	125	refusal	--	--	36	--	36	125	--	Sand
SANDY LEAN CLAY, hard	EOB	130	135	48 to 54	4.0 to 4.5+	4,000	--	--	26	2,000	0.004	Stiff Clay Below the Water Table

Table A-5 Soil Parameters SB-05

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SILTY SAND WITH GRAVEL (FILL)	667	120	125	54 to 64	--	--	30	--	30	90	--	Sand
SANDY LEAN CLAY to LEAN CLAY, medium stiff	658.1	125	130	3 to 4	0.5 to 1.25	500	--	--	26	100	0.01	Stiff Clay Above the Water Table
SANDY SILT, dense	653.1	120	125	36	--	--	36	--	36	225	--	Sand
SANDY SILT, dense	643.1	120	125	32 to 40	--	--	36	--	36	125	--	Sand
SANDY LEAN CLAY, hard	EOB	130	135	30	4.5+	4,000	--	--	26	2,000	0.004	Stiff Clay Below the Water Table

Table A-6 Soil Parameters SB-07

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY LEAN CLAY (FILL)	672.6	120	125	7 to 8	--	1,000	--	--	26	500	0.007	Stiff Clay Above the Water Table
LEAN CLAY, very stiff	669.6	130	135	7	2.0	2,000	--	--	26	1,000	0.005	Stiff Clay Above the Water Table
SILTY SAND, loose to medium dense	EOB	110	115	8 to 17	--	--	30	--	30	25	--	Sand

Table A-7 Soil Parameters SB-08

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SILTY SAND to GRAVEL (FILL)	629.9	110	115	4 to 21	--	--	29	--	29	25	--	Sand
SANDY SILT, loose to medium dense	EOB	110	115	7 to 40	--	--	30	--	30	60	--	Sand

Table A-8 Soil Parameters SB-09

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY SILT to SILTY SAND, medium dense to dense	626	110	115	19 to 24	--	--	36	--	36	90	--	Sand
SANDY SILT to SILTY SAND, medium dense to dense	611.1	110	115	24 to 38	--	--	36	--	36	60	--	Sand
LEAN CLAY, hard	EOB	130	135	21	4.5+	4,000	--	--	26	2,000	0.004	Stiff Clay Below the Water Table

Table A-9 Soil Parameters SB-10

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY LEAN CLAY to LEAN CLAY, (FILL)	690.7	125	130	3 to 6	--	1,000	--	--	26	500	0.007	Stiff Clay Above the Water Table
LEAN CLAY, stiff to very stiff	679.1	130	135	6	1.0 to 2.5	1,000	--	--	26	500	0.007	Stiff Clay Below the Water Table
SILT, medium dense	674.2	110	115	20	--	--	34	--	34	60	--	Sand
LEAN CLAY, very stiff	EOB	130	135	21	3.5	3,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table

Table A-10 Soil Parameters SB-11

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
SANDY LEAN CLAY (FILL)	689.8	125	130	4	--	500	--	--	26	100	0.01	Stiff Clay Above the Water Table
CLAYEY SAND (FILL)	685.6	110	115	5 to 14	--	--	30	--	30	25	--	Sand
SANDY LEAN CLAY to LEAN CLAY, very stiff	678.7	130	135	9 to 10	2.5	2,000	--	--	26	1,000	0.005	Stiff Clay Above the Water Table
SANDY LEAN CLAY to LEAN CLAY, very stiff	673.6	130	135	13	2	2,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table
LEAN CLAY, very stiff to hard	EOB	130	135	16	3.0 to 6.6	3,000	--	--	26	1,000	0.005	Stiff Clay Below the Water Table

Table A-11 Soil Parameters SB-12

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
CLAYEY SAND WITH GRAVEL (FILL)	648.8	110	115	3 to 16	--	--	29	--	29	25	--	Sand
LEAN CLAY, very stiff	641.9	130	135	36	2.0 to 3.5	2,000	--	--	26	1,000	0.005	Stiff Clay Above the Water Table
SANDY SILT to GRAVEL WITH SAND, very dense	EOB	120	125	refusal	--	--	38	--	38	125	--	Sand

Table A-12 Soil Parameters SB-13

Soil Unit	Approx. Bottom Elevation (feet)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)	N-values (blows per foot)	Unconfined Compression Strength (tsf)	Undrained Soil Condition		Drained Soil Condition		Static Loading Soil Modulus, k_c (pci)	ε_{50} (in/in)	p-y Curve Soil Model
						Cohesion, c (psf)	Friction Angle (degree)	Cohesion, c (psf)	Friction Angle (degree)			
CLAYEY SAND (FILL)	639.2	110	115	11	--	--	30	--	30	90	--	Sand
SANDY SILT to SILTY SAND, loose to medium dense	630.2	110	115	6 to 11	--	--	30	--	30	25	--	Sand
LEAN CLAY, stiff	620.1	130	135	7 to 8	1.5	1,500	--	--	26	500	0.007	Stiff Clay Below the Water Table
SAND, loose	EOB	110	115	5	--	--	29	--	29	20	--	Sand

GESTRA

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 12/27/2023	BORING NUMBER: **SB-01**	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 12/27/2023	PROJECT NUMBER: 23414-10	DRILLING RIG: CME 75 (International)
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: Z. Frye	FIELD LOG: C. Dietz	NORTHING: 306269	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582549	SURFACE ELEVATION: 727.2 ft

Soil Description and Geological Origin for Each Major Unit

Depth (ft) / Elevation	Soil Description	USCS Classification
0 – 0.7 (726.5)	ASPHALT (8.5-inches)	
0.7 – 1.2 (726)	BASE COURSE (6-inches)	
1.2 – 1.7 (725.5)	SILT WITH SAND, brown, moist, loose	ML
1.7 –	SANDY LEAN CLAY, gray, moist to wet, medium stiff to very stiff, trace gravel sand and silt lenses in SS-3 wet sandy silt layer in SS-4	CL

Number and Type	Recovery (in)	Blow Counts	N - Value	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 1	12	3 3 3	6					
SS - 2	13	2 2 3	5	1.00			12.1	
SS - 3	13	2 4 6	10	2.00			12.2	
SS - 4	17	2 4 5	9	1.00			12.2	
SS - 5	15	2 3 5	8	1.50			11.6	
SS - 6	18	1 4 6	10	2.00			11	
SS - 7	18	3 4 7	11	1.00			13.7	
SS - 8	18	2 4 6	10	1.50			11.7	

Depth (ft): 5, 10, 15, 20, 25
Elevation: 725.0, 720.0, 715.0, 710.0, 705.0, 700.0

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 20.5 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: 45 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 12/27/2023	BORING NUMBER: SB-01	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 12/27/2023	DRILLING RIG: CME 75 (International)	
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: Z. Frye	FIELD LOG: C. Dietz	NORTHING: 306269	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582549	SURFACE ELEVATION: 727.2 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 9	18	3 4 8	12	30		SANDY LEAN CLAY, gray, moist to wet, medium stiff to very stiff, trace gravel	CL			2.00			12.3	
					695.0									
SS - 10	18	2 3 4	7	35						0.75 **(2.5)**			11.4	γ_d = 128.2 pcf γ_T = 142.8 pcf
					690.0									
SS - 11	18	3 4 5	9	40		very moist, sand lens in SS-11				2.00			12.1	
					685.0	42.7 (684.5)								
						LEAN CLAY, brownish gray, moist, hard	CL							
SS - 12	18	4 10 12	22	45 ▽						4.5+			13.5	
					680.0									
SS - 13	18	8 11 13	24	50						4.5+			14.1	
					675.0	52.5 (674.7)								
						SILTY SAND, gray, moist, medium dense, trace clay laminations	SM							
SS - 14	18	5 10 12	22	55										
					670.0									

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 20.5 ft.	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 45 ft.	CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

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SOIL BORING LOG

PROJECT NAME	DATE DRILLING STARTED	BORING NUMBER
Wauwatosa Utility Planning	12/27/2023	SB-01
PROJECT LOCATION	DATE DRILLING ENDED	PROJECT NUMBER: 23414-10
Wauwatosa, Wisconsin	12/27/2023	DRILLING RIG: CME 75 (International)

BORING DRILLED BY	FIELD LOG	NORTHING	DRILLING METHOD
FIRM: GESTRA	C. Dietz	306269	3¼" HSA
CREW CHIEF: Z. Frye	LAB LOG / QC: C. Senechalle	EASTING: 582549	SURFACE ELEVATION: 727.2 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 15	18	6 11 13	24	60		SILTY SAND, gray, moist, medium dense, trace clay laminations 61 (666.2)	SM							
						End of Boring at 61.0 ft.								
					665.0									
				65										
					660.0									
				70										
					655.0									
				75										
					650.0									
				80										
					645.0									
				85										
					640.0									

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 20.5 ft.		CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 45 ft.		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME	DATE DRILLING STARTED	BORING NUMBER
Wauwatosa Utility Planning	1/8/2024	SB-02
PROJECT LOCATION	DATE DRILLING ENDED	PROJECT NUMBER: 23414-10
Wauwatosa, Wisconsin	1/8/2024	DRILLING RIG: CME 75 (International)

BORING DRILLED BY	FIELD LOG	NORTHING	DRILLING METHOD
FIRM: GESTRA CREW CHIEF: D. Harris	J. Correa	306233	3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 583461	SURFACE ELEVATION: 707.5 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 1	14	1 2 3 2	5			LEAN CLAY WITH SAND, dark brown, moist, with roots, (TOPSOIL) — 1.6 (705.9)							20.1	
SS - 2	14	2 3 2	5		705.0	SANDY LEAN CLAY, brown, moist, trace gravel, (FILL)							18.9	
SS - 3	14	2 5 9	14	5		6.3 (701.2)							17.1	
SS - 4	10	12 23 19	42		700.0	SAND WITH GRAVEL, brown, moist, trace silt, (FILL) — 8.7 (698.8)								
SS - 5	12	15 10 4	14	10		SANDY LEAN CLAY, gray, moist, medium stiff to stiff, trace gravel				1.50			10.7	
					695.0									
SS - 6	18	2 4 4	8	15			CL			0.75			14.2	
					690.0									
SS - 7	18	1 2 3	5	20						1.00 **(2.2)**	20	8	13.8	γ_d = 123.9 pcf γ_T = 141 pcf
					685.0	22.7 (684.8)								
SS - 8	18	4 6 9	15	25		LEAN CLAY, brownish gray, moist to wet, very stiff to hard, trace sand and silt lenses	CL			4.00			12	
					680.0									

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 30 ft.	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME	DATE DRILLING STARTED	BORING NUMBER
Wauwatosa Utility Planning	1/8/2024	SB-02
PROJECT LOCATION	DATE DRILLING ENDED	PROJECT NUMBER: 23414-10
Wauwatosa, Wisconsin	1/8/2024	DRILLING RIG: CME 75 (International)

BORING DRILLED BY	FIELD LOG	NORTHING	DRILLING METHOD
FIRM: GESTRA CREW CHIEF: D. Harris	J. Correa	306233	3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 583461	SURFACE ELEVATION: 707.5 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 9	18	5 8 8	16	30 ▽		LEAN CLAY, brownish gray, moist to wet, very stiff to hard, trace sand and silt lenses	CL			3.00			16.2	
					675.0									
SS - 10	18	8 10 14	24	35						4.5+			13.7	
					670.0									
SS - 11	18	6 12 18	30	40						4.5+			10	
					665.0									
SS - 12	18	8 16 20	36	45						4.5+			11.6	
					660.0									
SS - 13	18	9 10 11	21	50		trace gravel in SS-13				3.50			10.3	
					655.0									
SS - 14	18	12 11 11	22	55						4.5+			11.7	
					650.0	57.7 (649.8)								
						SANDY LEAN CLAY, gray, moist, hard, trace gravel	CL							

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 30 ft.	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

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PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/8/2024	BORING NUMBER: SB-02	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/8/2024	DRILLING RIG: CME 75 (International)	
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: D. Harris	FIELD LOG: J. Correa	NORTHING: 306233	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 583461	SURFACE ELEVATION: 707.5 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 15	18	10 12 14	26	60		SANDY LEAN CLAY, gray, moist, hard, trace gravel 61 (646.5)	CL			4.5+			9	
					645.0	End of Boring at 61.0 ft.								
				65	640.0									
				70	635.0									
				75	630.0									
				80	625.0									
				85	620.0									

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: 30 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GESTRA

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/8/2024	BORING NUMBER: SB-03	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/8/2024	DRILLING RIG: CME LX55 ATV	
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: S. Gonyer	FIELD LOG: C. Ray	NORTHING: 304660	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 584217	SURFACE ELEVATION: 673.6 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 1	14	1 2 3 2	5			SAND WITH GRAVEL, brown, moist, (FILL)								
SS - 2	10	3 4 5	9		670.0									
SS - 3	6	4 6 8	14	5		6 (667.6)								
						SANDY LEAN CLAY, gray, moist, medium stiff to stiff, trace gravel	CL							
SS - 4	12	3 3 3	6		665.0					0.75			13.1	
SS - 5	18	3 4 4	8	10						1.00			12.9	
				∇ (12 ft)	660.0									
SS - 6	18	2 3 3	6	15						0.75			14.1	
						17.8 (655.8)								
					655.0	SANDY SILT, gray, wet, medium dense, clay lens	ML							
SS - 7	16	3 4 6	10	20										
						22.7 (650.9)								
					650.0	SANDY LEAN CLAY, gray, moist, very stiff	CL							
SS - 8	18	2 5 7	12	25		sand lens in SS-8				2.00			14.3	Gravel = 2.8% Sand = 42.7% P200 = 54.4%
					645.0	28.7 (644.9)								
						SAND, gray, moist, medium dense, trace clay layer	SP							SS-9A

WATER & CAVE-IN OBSERVATION DATA

∇ WATER ENCOUNTERED DURING DRILLING: 12 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/8/2024	BORING NUMBER: SB-03	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/8/2024	DRILLING RIG: CME LX55 ATV	
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: S. Gonyer	FIELD LOG: C. Ray	NORTHING: 304660	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 584217	SURFACE ELEVATION: 673.6 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 9	18	4 7 11	18	30		SAND, gray, moist, medium dense, trace clay layer — 30.2 (643.4)	SP							
						LEAN CLAY, gray, moist, very stiff — 32.7 (640.9)	CL			3.00			11	
					640.0	SANDY SILT, gray, moist, very dense, trace gravel — 37.4 (636.2)	ML							
SS - 10	10	15 44 46	90	35										
					635.0	CLAYEY GRAVEL, light gray, very moist, very dense, trace sand — 40 (633.6)	GC							
SS - 11	5	50/5"	R	40		End of Boring at 40.0 ft.								Driller noted auger refusal at 40 feet.
					630.0									
				45										
					625.0									
				50										
					620.0									
				55										
					615.0									

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: 12 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: NMR	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

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SOIL BORING LOG

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PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/19/2024	BORING NUMBER: **SB-04**	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/19/2024	DRILLING RIG: CME 75 (HT)	
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: C. Ray	FIELD LOG: J. Correa	NORTHING: 304369	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582541	SURFACE ELEVATION: 724.1 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	USCS Classification	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 1	8	5 5 7 7	12									
SS - 2	8	6 5 5	10		720.0							
SS - 3	18	2 4 5	9	5		CL		3.50			18	
SS - 4	16	3 7 5	12		715.0	CL		1.50			12.1	
SS - 5	16	2 3 6	9	10				2.50			11.2	
					710.0							
SS - 6	18	3 6 10	16	15				3.50			15.3	
					705.0							
SS - 7	18	5 7 10	17	20		CL		3.50	23	11	15.6	
					700.0							
SS - 8	18	5 7 12	19	25				3.50			18.4	
					695.0							

Soil Description and Geological Origin for Each Major Unit:

Soil Description	Bottom Depth (Elevation)
ASPHALT (4.5-inches)	0.4 (723.7)
BASE COURSE (9-inches)	1.1 (723)
SANDY LEAN CLAY, brown, moist, trace gravel, (FILL)	1.3 (722.8)
SAND, brown, moist, silt lamination, (FILL)	3.6 (720.5)
LEAN CLAY, brown, moist, very stiff, trace sand	6.5 (717.6)
SANDY LEAN CLAY WITH GRAVEL, brown, moist, stiff to very stiff, with silt laminations	12.7 (711.4)
LEAN CLAY, gray, moist to wet, very stiff	

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: 35 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: 50 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

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SOIL BORING LOG

PROJECT NAME	DATE DRILLING STARTED	BORING NUMBER
Wauwatosa Utility Planning	1/19/2024	SB-04
PROJECT LOCATION	DATE DRILLING ENDED	PROJECT NUMBER
Wauwatosa, Wisconsin	1/19/2024	23414-10
		DRILLING RIG: CME 75 (HT)

BORING DRILLED BY	FIELD LOG	NORTHING	DRILLING METHOD
FIRM: GESTRA CREW CHIEF: C. Ray	J. Correa	304369	3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582541	SURFACE ELEVATION: 724.1 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 9	18	4 6 9	15	30		LEAN CLAY, gray, moist to wet, very stiff	CL			2.00			16.6	
					690.0									
SS - 10	18	6 6 8	14	35 ▽						2.00			20	
				37.7	686.4	SANDY SILT, gray, wet, very dense	ML							
					685.0									
SS - 11	17	12 16 50/5"	R	40										
				42.7	681.4	SANDY LEAN CLAY, gray, moist, hard, trace gravel	CL							
					680.0									
SS - 12	18	12 18 30	48	45						4.5+				
					675.0									
SS - 13	18	15 22 32	54	50 ▼						4.00				
				51	673.1	End of Boring at 51.0 ft.								
					670.0									
				55										

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 35 ft.		CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 50 ft.		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

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SOIL BORING LOG

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PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/19/2024	BORING NUMBER: **SB-05**	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/19/2024	DRILLING RIG: CME 75 (HT)	
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: C. Ray	FIELD LOG: J. Correa	NORTHING: 303855	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 584490	SURFACE ELEVATION: 670.8 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
					670.0	ASPHALT (7-inches) 0.6 (670.2)								
SS - 1	10	20 42 22 22	64			BASE COURSE (7-inches) 1.2 (669.6)								
						SILTY SAND WITH GRAVEL, brown, moist, (FILL) trace clay and asphalt pieces in SS-2								
SS - 2	14	15 43 11	54			3.8 (667)								
						SANDY LEAN CLAY WITH GRAVEL, brown, moist, medium stiff								
SS - 3	8	2 1 2	3	5	665.0		CL			0.50			12.6	
SS - 4	4	2 2 2	4			8.4 (662.4)				0.50			10.1	
						LEAN CLAY WITH SAND, brown, moist, stiff								
SS - 5	16	1 1 2	3	10	660.0		CL			1.00-1.25			24.7	Gravel = 0.0% Sand = 22.1% P200 = 77.9%
						12.7 (658.1)								
						SANDY SILT, gray, moist to wet, dense, trace gravel								
SS - 6	16	9 17 19	36	15	655.0									
SS - 7	18	9 18 22	40	20 ∇	650.0	no gravel in SS-7	ML				NP	NP		
SS - 8	18	14 15 17	32	25 ▼	645.0	sand lamination in SS-8								
						27.7 (643.1)								
						SANDY LEAN CLAY, gray, moist, hard, trace gravel	CL							

WATER & CAVE-IN OBSERVATION DATA

∇ WATER ENCOUNTERED DURING DRILLING: 20 ft.	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼ WATER LEVEL AT COMPLETION: 25 ft.	CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼ WATER LEVEL AFTER 0 HOURS: NMR		

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/19/2024	BORING NUMBER: SB-05	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/19/2024	PROJECT NUMBER: 23414-10	DRILLING RIG: CME 75 (HT)
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: C. Ray	FIELD LOG: J. Correa	NORTHING: 303855	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 584490	SURFACE ELEVATION: 670.8 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 9	18	9 12 18	30	30	640.0	SANDY LEAN CLAY, gray, moist, hard, trace gravel	CL			4.5+			11.8	
SS - 10	1	50/1"	R			33.1 (637.7) rock chips in SS-10								Driller noted auger refusal at 33.1 feet. Spoon refusal with minimal recovery. Possible bedrock.
						End of Boring at 33.1 ft.								
				35	635.0									
				40	630.0									
				45	625.0									
				50	620.0									
				55	615.0									

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 20 ft.		CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 25 ft.		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

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SOIL BORING LOG

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/3/2024	BORING NUMBER: SB-07	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/3/2024	DRILLING RIG: CME 75 (International)	
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: A. Woerpel	FIELD LOG: C. Dietz	NORTHING: 302842	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 582657	SURFACE ELEVATION: 676.1 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						ASPHALT (6-inches) — 0.5 (675.6)								
SS - 1	4	3 2 5	7		675.0	BASE COURSE (11-inches) — 1.4 (674.7)								
SS - 2	7	2 4 4	8			SANDY LEAN CLAY, gray to light gray, moist, trace gravel, (FILL) — 3.5 (672.6)							16	
						LEAN CLAY, brown, moist, very stiff, trace sand								
SS - 3	18	2 3 4	7	5	670.0	silt lamination in SS-3 — 6.5 (669.6)	CL			2.00			27	
SS - 4	5	3 7 10	17			SANDY SILT, gray, moist, loose to medium dense, trace gravel								
SS - 5	14	2 3 5	8	10	665.0		ML							Gravel = 10.5% Sand = 49.8% P200 = 39.7%
SS - 6	0	50/3"	R	15		15 (661.1)								Driller noted no recovery on field log. Driller noted auger refusal at 15 feet.
					660.0	End of Boring at 15.0 ft.								
				20	655.0									
				25	650.0									

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: NE ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: NE	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

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SOIL BORING LOG

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PROJECT NAME: Wauwatosa Utility Planning
DATE DRILLING STARTED: 1/26/2024
BORING NUMBER: SB-08
PROJECT LOCATION: Wauwatosa, Wisconsin
DATE DRILLING ENDED: 1/26/2024
PROJECT NUMBER: 23414-10
DRILLING RIG: CME 75 (HT)
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: A. Woerpel
FIELD LOG: C. Noll
LAB LOG / QC: C. Senechalle
NORTHING: 301983
EASTING: 582487
DRILLING METHOD: 3¼" HSA
SURFACE ELEVATION: 641.9 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						CONCRETE (8-inches)								
				0.7	641.2	SILTY SAND WITH GRAVEL, brown, moist, trace clay pieces, (FILL)								
					640.0									
SS - 1	15	5 7 5	12											
				3.8	638.1	SILTY SAND, brown, moist, trace gravel, clay layers, (FILL)								
SS - 2	3	2 2 2	4	5										
					635.0									
SS - 3	3	2 3 4	7			large gravel piece in SS-3								
				8.4	633.5	GRAVEL WITH SAND, brown, moist, trace silt, (FILL)								
SS - 4	7	2 11 10	21	10										
					630.0									
				12	629.9	SANDY SILT, gray, moist, dense, trace gravel	ML							Driller noted rig chatter at 12 feet.
SS - 5	13	8 18 22	40	15										
					625.0									
				17.5	624.4	SANDY SILT, gray, moist, medium dense, trace gravel, clay laminations	ML							
SS - 6	18	4 6 7	13	20										
					620.0									
				22.7	619.2	SANDY SILT, gray, wet, loose	ML							
SS - 7	15	2 3 4	7	25										
				26	615.9	End of Boring at 26.0 ft.								
					615.0									

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 24 ft.	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼ WATER LEVEL AT COMPLETION: 19.5 ft.	CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼ WATER LEVEL AFTER 0 HOURS: NMR		

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SOIL BORING LOG

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PROJECT NAME: Wauwatosa Utility Planning		DATE DRILLING STARTED: 1/3/2024	BORING NUMBER: SB-09
PROJECT LOCATION: Wauwatosa, Wisconsin		DATE DRILLING ENDED: 1/3/2024	PROJECT NUMBER: 23414-10
			DRILLING RIG: CME 75 (International)
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: A. Woerpel	FIELD LOG: C. Dietz	NORTHING: 301536	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 585085	SURFACE ELEVATION: 633.5 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						ASPHALT (5.5-inches) — 0.5 (633)								
						CONCRETE (4-inches) — 0.8 (632.7)								
						BASE COURSE (7-inches) — 1.4 (632.1)								
SS - 1	15	2 7 12	19		630.0	SANDY SILT WITH GRAVEL, brown, moist, medium dense — 3.9 (629.6)	ML							
SS - 2	15	6 10 19	29	5		SILTY SAND, gray, moist, medium dense, trace gravel — 6.4 (627.1)	SM							
SS - 3	14	5 9 15	24	▽	625.0	SILTY SAND, brown and gray, wet, medium dense, trace gravel — 8.8 (624.7)	SM							
SS - 4	18	4 16 19	35	10		SANDY SILT, gray, moist to wet, dense, trace gravel	ML							
					620.0									
SS - 5	17	5 15 18	33	15 ▼		— 17.7 (615.8)								Gravel = 15.3% Sand = 37.8% P200 = 46.9%
					615.0	SAND WITH GRAVEL, gray, wet, dense	SP							
SS - 6	10	6 16 22	38	20		— 22.4 (611.1)								No sample retained.
					610.0	LEAN CLAY, brown, moist, hard, silt lenses	CL							
SS - 7	14	6 10 11	21	25		— 26 (607.5)				4.5+			27	
						End of Boring at 26.0 ft.								
					605.0									

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 7.5 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AT COMPLETION: 15 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼ WATER LEVEL AFTER 0 HOURS: NMR	

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SOIL BORING LOG

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PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/10/2024	BORING NUMBER: **SB-10**	PROJECT NUMBER: 23414-10
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/10/2024	DRILLING RIG: CME 75 (International)	
BORING DRILLED BY: FIRM: GESTRA, CREW CHIEF: D. Harris	FIELD LOG: T. Engel	NORTHING: 305768	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 583777	SURFACE ELEVATION: 696.9 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 1	11	1 3 3 3	6		695.0	TOPSOIL (6-inches) 0.5 (696.4); SANDY LEAN CLAY, dark brown, moist, trace gravel, trace root hairs, (FILL)							13.1	
SS - 2	6	1 2 1	3										17.8	
				5		5 (691.9)								
SS - 3	10	1 2 4	6			LEAN CLAY, brown to dark brown, moist, trace sand and gravel, (FILL)							19.8	
					690.0	6.2 (690.7); LEAN CLAY WITH SAND, gray, moist, stiff, trace gravel								Driller noted mild rig chatter at 6 feet.
SS - 4	18	3 2 4	6							1.00			11.7	
SS - 5	18	2 2 4	6	10						1.00			11.7	
					685.0		CL							
SS - 6	18	1 2 4	6	15						1.00 **(2.3)**			13.1	γ_d = 128.1 pcf γ_T = 144.9 pcf
					680.0	17.8 (679.1); SILT, gray, moist, medium dense								
SS - 7	18	3 9 11	20	20			ML							
					675.0	22.7 (674.2); LEAN CLAY, gray, wet, very stiff, silty sand lenses								
				∇			CL							
SS - 8	18	6 9 12	21	25		26 (670.9)				3.50			16.2	
					670.0	End of Boring at 26.0 ft.								

WATER & CAVE-IN OBSERVATION DATA

∇	WATER ENCOUNTERED DURING DRILLING: 24.5 ft.		CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
▼	WATER LEVEL AT COMPLETION: NE		CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA

GESTRA Engineering Inc.
191 W Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/10/2024	BORING NUMBER: SB-11	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/10/2024	PROJECT NUMBER: 23414-10	DRILLING RIG: CME 75 (International)
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: D. Harris	FIELD LOG: T. Engel	NORTHING: 305460	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 583862	SURFACE ELEVATION: 691.4 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						TOPSOIL (3-inches) — 0.2 (691.2)								
SS - 1	14	1 2 2 3	4		690.0	SANDY LEAN CLAY, dark brown, moist, trace gravel, trace root hairs, (FILL) — 1.6 (689.8)							19.2	
SS - 2	11	2 2 3	5			CLAYEY SAND, brown to dark brown, moist, trace gravel, trace root hairs, (FILL)								
SS - 3	2	3 7 7	14	5		5.8 (685.6)								Driller noted mild rig chatter at 4 feet. Poor recovery.
					685.0	SANDY LEAN CLAY, brown, moist, medium stiff	CL							
SS - 4	6	3 4 5	9			8.5 (682.9)							13.2	Sample disturbed. No Qp taken.
						LEAN CLAY, brown, moist, very stiff, trace gravel	CL							
SS - 5	18	3 4 6	10	10	680.0					2.50			12.2	
						12.7 (678.7)								
						LEAN CLAY, gray, moist, very stiff to hard, trace gravel	CL							
SS - 6	18	2 5 8	13	15	675.0	sand lens in sample in SS-6				2.00			11.4	
SS - 7	18	2 6 10	16	20	670.0	no gravel, silt lenses				4.00 **(6.7)**	28	15	15	γ_d = 121.1 pcf; γ_T = 139.4 pcf
SS - 8	18	4 6 10	16	25	665.0	26 (665.4)				3.00			15.4	
						End of Boring at 26.0 ft.								

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: NE ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: NE	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA Engineering Inc.
191 W Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PROJECT NAME: Wauwatosa Utility Planning	DATE DRILLING STARTED: 1/23/2024	BORING NUMBER: **SB-12**	
PROJECT LOCATION: Wauwatosa, Wisconsin	DATE DRILLING ENDED: 1/23/2024	PROJECT NUMBER: 23414-10	DRILLING RIG: Diedrich D50 ATV
BORING DRILLED BY: FIRM: GESTRA; CREW CHIEF: C. Ray	FIELD LOG: C. Noll	NORTHING: 303431	DRILLING METHOD: 3¼" HSA
	LAB LOG / QC: C. Senechalle	EASTING: 584533	SURFACE ELEVATION: 659.3 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						TOPSOIL (3.5-inches) 0.3 (659)						
SS - 1	16	2 4 3 3	7			CLAYEY SAND WITH GRAVEL, brown, moist, (FILL)						
SS - 2	11	1 1 2	3			silt lens in SS-2						
					655.0							
SS - 3	9	1 2 2	4	5		crushed brick and asphalt pieces in SS-3						
SS - 4	14	2 5 10	15			large gravel pieces in SS-4						
					650.0	10.5 (648.8)						
SS - 5	12	8 10 6	16	10		LEAN CLAY, grayish brown, moist, very stiff, trace sand and gravel	CL	3.50			14.1	Driller noted rig chatter at 12 feet.
					645.0							
SS - 6	9	23 28 8	36	15		17.4 (641.9)		2.00			13.8	
						SANDY SILT, gray, moist, very dense, trace gravel	ML					
					640.0							
SS - 7	17	6 17 50/5"	R	20		21 (638.3)						
						GRAVEL WITH SAND, light gray, wet, very dense	GP					Driller noted rig chatter from 20 to 24 feet.
					635.0							
SS - 8	6	16 50/2"	R	25		25.2 (634.1)						
						End of Boring at 25.2 ft.						
					630.0							

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: 23 ft.	CAVE DEPTH AT COMPLETION: NMR (WET ☐ DRY ☐)
WATER LEVEL AT COMPLETION: 21 ft.	CAVE DEPTH AFTER 0 HOURS: NMR (WET ☐ DRY ☐)
WATER LEVEL AFTER 0 HOURS: NMR	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GESTRA

GESTRA Engineering Inc.
191 W Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

SOIL BORING LOG

PROJECT NAME	Wauwatosa Utility Planning
PROJECT LOCATION	Wauwatosa, Wisconsin
DATE DRILLING STARTED	1/3/2024
DATE DRILLING ENDED	1/3/2024
BORING NUMBER	SB-13
PROJECT NUMBER	23414-10
DRILLING RIG	CME 75 (International)
BORING DRILLED BY	FIRM: GESTRA CREW CHIEF: A. Woerpel
FIELD LOG	C. Dietz
LAB LOG / QC	C. Senechalle
NORTHING	302659
EASTING	585043
DRILLING METHOD	3¼" HSA
SURFACE ELEVATION	642.8 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						ASPHALT (5.5-inches) 0.5 (642.3)						
SS - 1	9	6 5 6	11			BASE COURSE (5-inches) 0.9 (641.9)						
SS - 2	9	3 6 5	11		640.0	CLAYEY SAND, brown, moist, trace gravel, (FILL) sand and gravel layer in SS-2 3.6 (639.2)						
SS - 3	14	2 3 3	6	5		SILT, brown, moist to very moist, loose 6.3 (636.5)	ML					
SS - 4	15	2 6 5	11		635.0	SILTY SAND, brown, moist to very moist, medium dense 8.9 (633.9)	SM					
SS - 5	15	4 5 4	9	10		SANDY SILT, gray, moist, loose, trace gravel 12.6 (630.2)	ML					
					630.0	LEAN CLAY, gray, moist, stiff, trace sand, silt lenses	CL					
SS - 6	18	1 4 4	8	15				1.50			17	
					625.0							
SS - 7	18	1 3 4	7	20		decrease in silt lenses in SS-7 22.7 (620.1)		1.50 **(1.6)**	27	13	14.6	γ_d = 112.2 pcf γ_T = 128.7 pcf
					620.0	SAND, gray, wet, loose	SP					
SS - 8	18	4 1 4	5	25 ▽		26 (616.8)						
						End of Boring at 26.0 ft.						
					615.0							

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 25 ft.		CAVE DEPTH AT COMPLETION: NMR — WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR		CAVE DEPTH AFTER 0 HOURS: NMR — WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GENERAL NOTES

DRILLING AND SAMPLING SYMBOLS

SYMBOL	DEFINITION
HSA	Hollow Stem Auger
HSA w/ RW	Hollow Stem Auger converted to Rotary Wash Boring (initiated with Mudding Fluid)
SS	2” O.D. Split Spoon Sample – (ASTM D 1586)
SH	3” Thin-Walled Tube Sample (Shelby Tube) – (ASTM D 1587)
AU	Solid Stem Auger Sample
CA	Modified California Sample – (ASTM D 3550)
RC	Rock Core Sample – (ASTM D 2113)
HA	Hand Auger Sample
GB	Grab Bag Sample
R	SPT Refusal (N-value of 50 blows for less than 6 inches of penetration)
NMR	No Measurement Recorded
NE	Not Encountered

TEST SYMBOLS

SYMBOL	DEFINITION
MC	Moisture Content (%) – (ASTM D 2216)
LOI	Organic Content (Loss on Ignition) (%) – (ASTM D 2974)
Qp	Hand Penetrometer Reading (tsf)
Qu	Unconfined Comp. Strength (tsf) – (ASTM D 2166)
γ_d	Dry Density (pcf) – (ASTM D 7263)
γ_T	Total (Moist) Density (pcf)
LL, PL	Liquid and Plastic Limit (%) – (ASTM D 4318)
PI	Plasticity Index (%)
P200	Percent passing the #200 Sieve – (ASTM D 1140)
Ts	Hand Torvane Reading (tsf)
SG	Specific Gravity – (ASTM D854)
pH	Hydrogen Ion Content – (ASTM D4972)
RQD	Rock Quality Designation (%) – (ASTM D6032)

WATER LEVEL

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In some soils, it may not be possible to determine the groundwater level within the normal time required for test borings and an extended period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol may not indicate the true level of the groundwater table. Perched water refers to water above an impervious layer, thus impeded in reaching the water table. The available water level information is given at the bottom of the respective boring log sheet.

DESCRIPTIVE TERMINOLOGY

DENSITY TERM	SPT N-VALUE
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	Over 50

CONSISTENCY TERM	Unconfined Compressive Strength, (tsf)	SPT N-VALUE
Very Soft	<0.25	0 - 2
Soft	0.25 - 0.49	2 - 4
Medium Stiff	0.50 - 0.99	4 - 8
Stiff	1.00 - 1.99	8 - 16
Very Stiff	2.00 - 3.99	16 - 30
Hard	4.0+	Over 30

Standard Penetration Test N-Value: Blows per Foot of a 140 Pound Hammer Falling 30 inches on a 2-inch OD Split Barrel Sampler

Note: If unconfined compressive strength data is not available, then N-value should be used to describe consistency term

Lamination	Up to 1/2” thick horizontal stratum
Layer	1/2” thick or greater horizontal stratum
Lens	1/2” to 6” discontinuous horizontal stratum
Varved	Alternating laminations
Dry	Powdery, dusty
Moist	Damp, below saturation
Wet	Saturated, above liquid limit

RELATIVE SIZES

U.S. Standard Sieve

	12"		3"		#4		#200			
Boulders		Cobbles		Gravel		Sand		Silt		Clay
	300		75		4.75		0.075		0.002	

Grain Size (mm)

Table 1—Classification of Soils and Soil–Aggregate Mixtures

General Classification	Granular Materials (35 Percent or Less Passing 75 µm)			Silt–Clay Materials (More Than 35 Percent Passing 75 µm)			
Group Classification	A-1	A-3[a]	A-2	A-4	A-5	A-6	A-7
Sieve analysis, percent passing:							
2.00 mm (No. 10)	—	—	—	—	—	—	—
0.425 mm (No. 40)	50 max	51 min	—	—	—	—	—
75 µm (No. 200)	25 max	10 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40):							
Liquid limit	—			40 max	41 min	40 max	41 min
Plasticity index	6 max	Nonplastic (NP)	[b]	10 max	10 max	11 min	11 min
General rating as subgrade	Excellent to Good			Fair to Poor			

[a] The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.
[b] See Table 2 for values.

Table 2—Classification of Soils and Soil–Aggregate Mixtures

General Classification	Granular Materials (35 Percent or Less Passing 75 µm)							Silt–Clay Materials (More Than 35 Percent Passing 75 µm)			
	A-1			A-2							A-7
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5, A-7-6
Sieve analysis, percent passing:											
2.00 mm (No. 10)	50 max	—	—	—	—	—	—	—	—	—	—
0.425 mm (No. 40)	30 max	50 max	51 min	—	—	—	—	—	—	—	—
75 µm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40):											
Liquid limit	—		—	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index	6 max		NP	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min[a]
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to Good							Fair to Poor			

[a] Plasticity index of A-7-5 subgroup is equal to or less than $LL - 30$. Plasticity index of A-7-6 subgroup is greater than $LL - 30$. (See Figure 2.)

NOTE: Charts obtained from Standard Speifications for Transportation Materials and Method of Sampling and Testing and AASHTO Provisional Standards, 2022

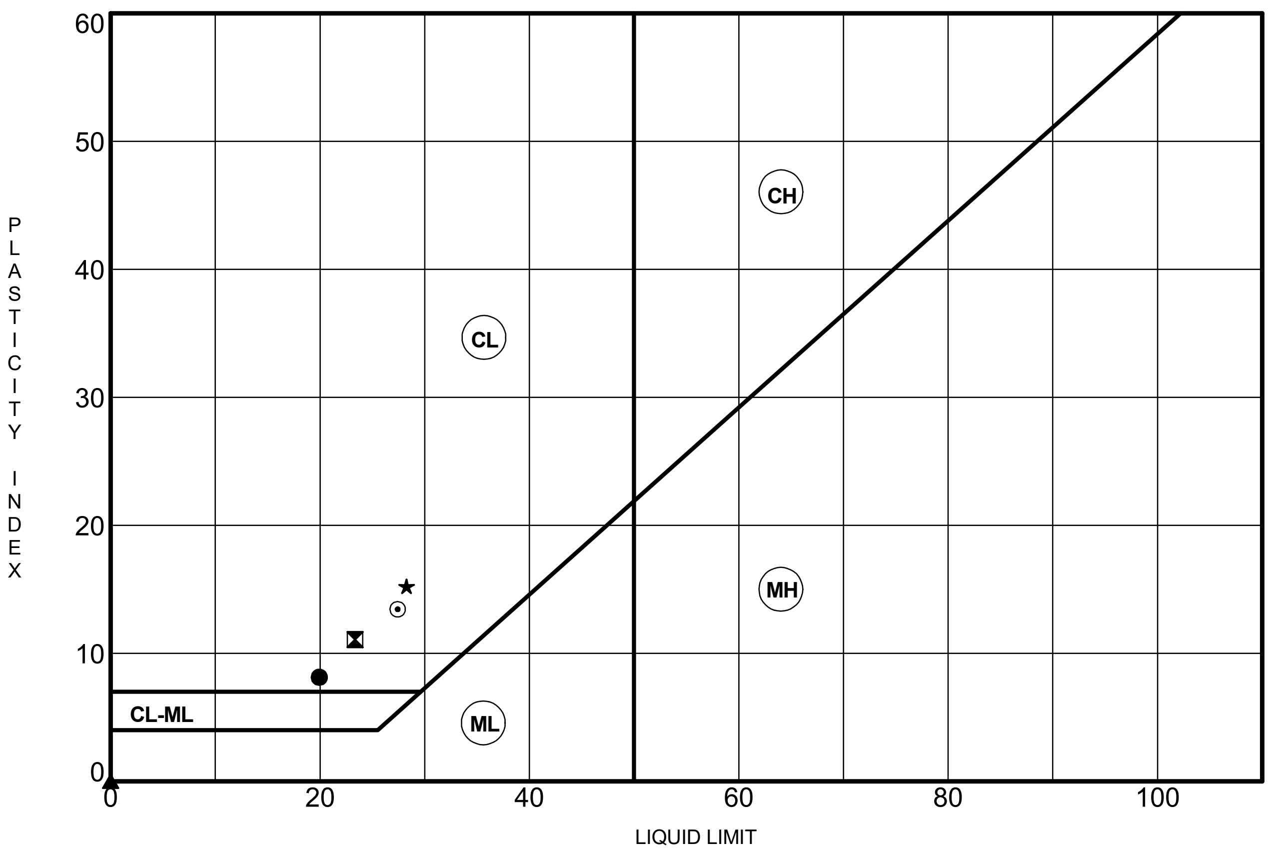
APPENDIX II

LABORATORY TEST RESULTS

GESTRA Engineering, Inc
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: (414) 933-7444, Fax: (414) 933-7844

LABORATORY TEST RESULTS
ATTERBERG LIMITS RESULTS (ASTM D4318)

Project Name: Wauwatosa Utility Planning
Project Number: 23414-10
Project Location: Wauwatosa, Wisconsin



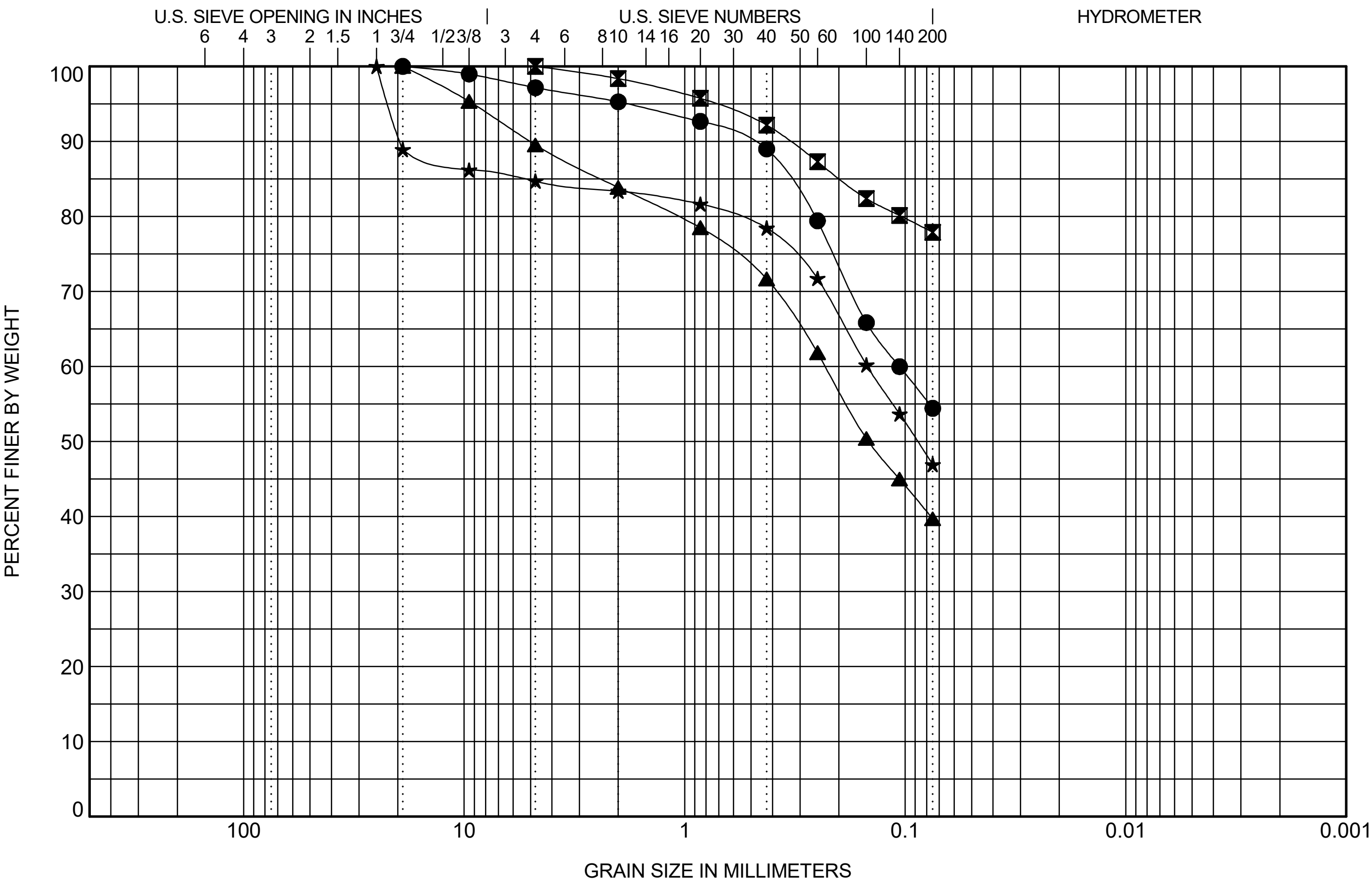
Unless otherwise noted, Atterberg limit sample was air-dried, Liquid limit was performed using mutiple points, and plastic limit test was hand rolled.

	Specimen Identification		LL	PL	PI	Fines	MC	Notes
●	**SB-02, SS-7**	**19.5'-21'**	**20**	**12**	**8**		**13.8**	
⧗	**SB-04, SS-7**	**19.5'-21'**	**23**	**12**	**11**		**15.6**	
▲	**SB-05, SS-7**	**19.5'-21'**	**NP**	**NP**	**NP**			
★	**SB-11, SS-7**	**19.5'-21'**	**28**	**13**	**15**		**15.0**	
⊙	**SB-13, SS-7**	**19.5'-21'**	**27**	**14**	**13**		**14.6**	

GESTRA Engineering, Inc
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: (414) 933-7444, Fax: (414) 933-7844

LABORATORY TEST RESULTS
GRAIN SIZE DISTRIBUTION (ASTM D6913 and D7928)

Project Name: Wauwatosa Utility Planning
Project Number: 23414-10
Project Location: Wauwatosa, Wisconsin



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	SB-03, SS-8	24.5'-26'	SANDY LEAN CLAY (CL)					
⧗	SB-05, SS-5	9.5'-11'						
▲	SB-07, SS-5	9.5'-11'						
★	SB-09, SS-5	14.5'-16'						

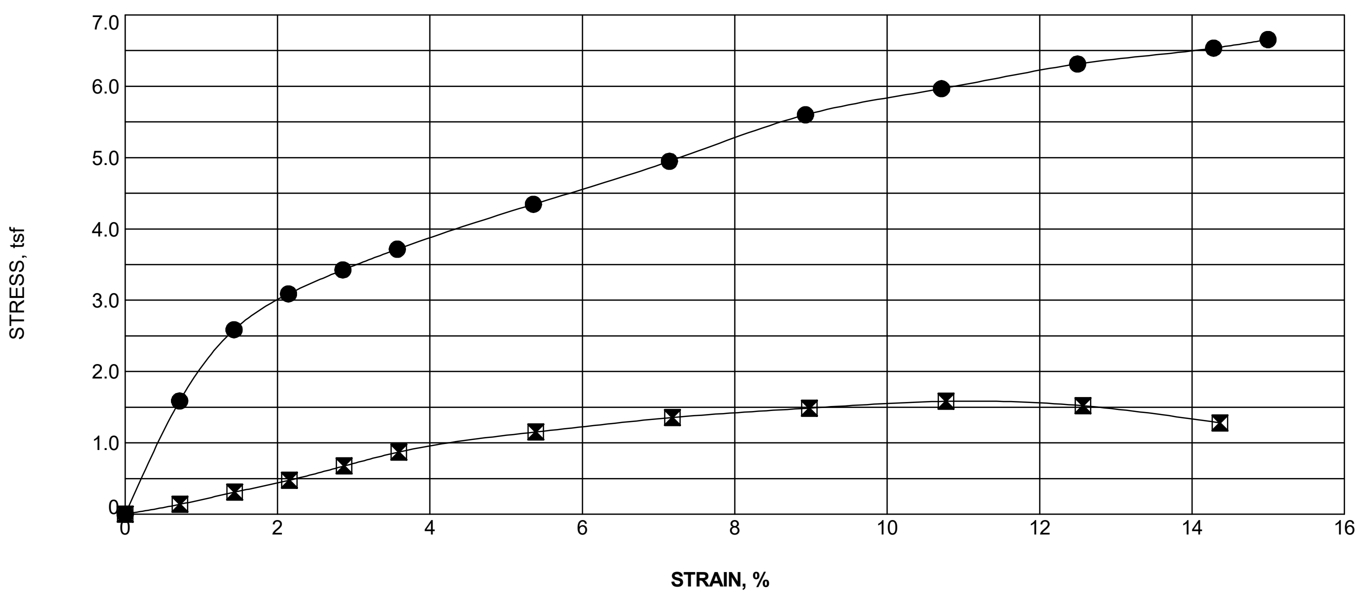
	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SB-03, SS-8	24.5'-26'	19	0.106			2.8	42.7	54.4	
⧗	SB-05, SS-5	9.5'-11'	4.75				0.0	22.1	77.9	
▲	SB-07, SS-5	9.5'-11'	19	0.23			10.5	49.8	39.7	
★	SB-09, SS-5	14.5'-16'	25	0.148			15.3	37.8	46.9	

GRAIN SIZE - GINT STD US LAB.GDT - 03/01/24 13:57 - T:\PROJECTS\2023\MILWAUKEE - 10 (GEOTECH)\23414-10EJ (TOSA UTILITY PLANNING)\LOGS\WAUWATOSA UTILITY PLANNING.GPJ

GESTRA Engineering, Inc
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: (414) 933-7444, Fax: (414) 933-7844

LABORATORY TEST RESULTS
UNCONFINED COMPRESSION TEST (ASTM D2166)

Project Name: Wauwatosa Utility Planning
Project Number: 23414-10
Project Location: Wauwatosa, Wisconsin



Specimen Indentification	● **SB-11, SS-7**	⊠ **SB-13, SS-7**	
Depth (feet)	**19.5'-21'**	**19.5'-21'**	
USCS Classification	**CL**	**CL**	
Sample Height (in)	2.80	2.78	
Sample Diameter (in)	1.38	1.50	
Height:Diameter Ratio	1.86	1.86	
Q_u (tsf)	**6.66**	**1.58**	
MC (%)	**15.0**	**14.6**	
γ_d (pcf)	**121.1**	**112.2**	
γ_T (pcf)	**139.4**	**128.7**	

GESTRA Engineering, Inc
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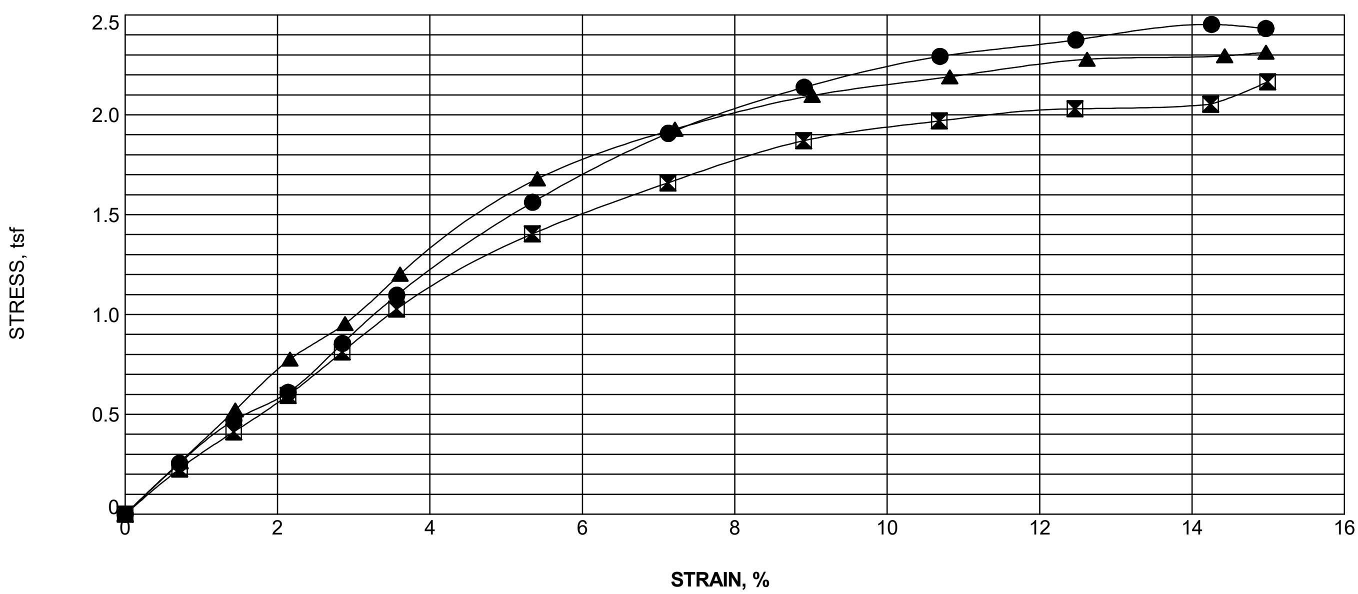
Phone: (414) 933-7444, Fax: (414) 933-7844

LABORATORY TEST RESULTS
UNCONFINED COMPRESSION TEST (ASTM D2166)

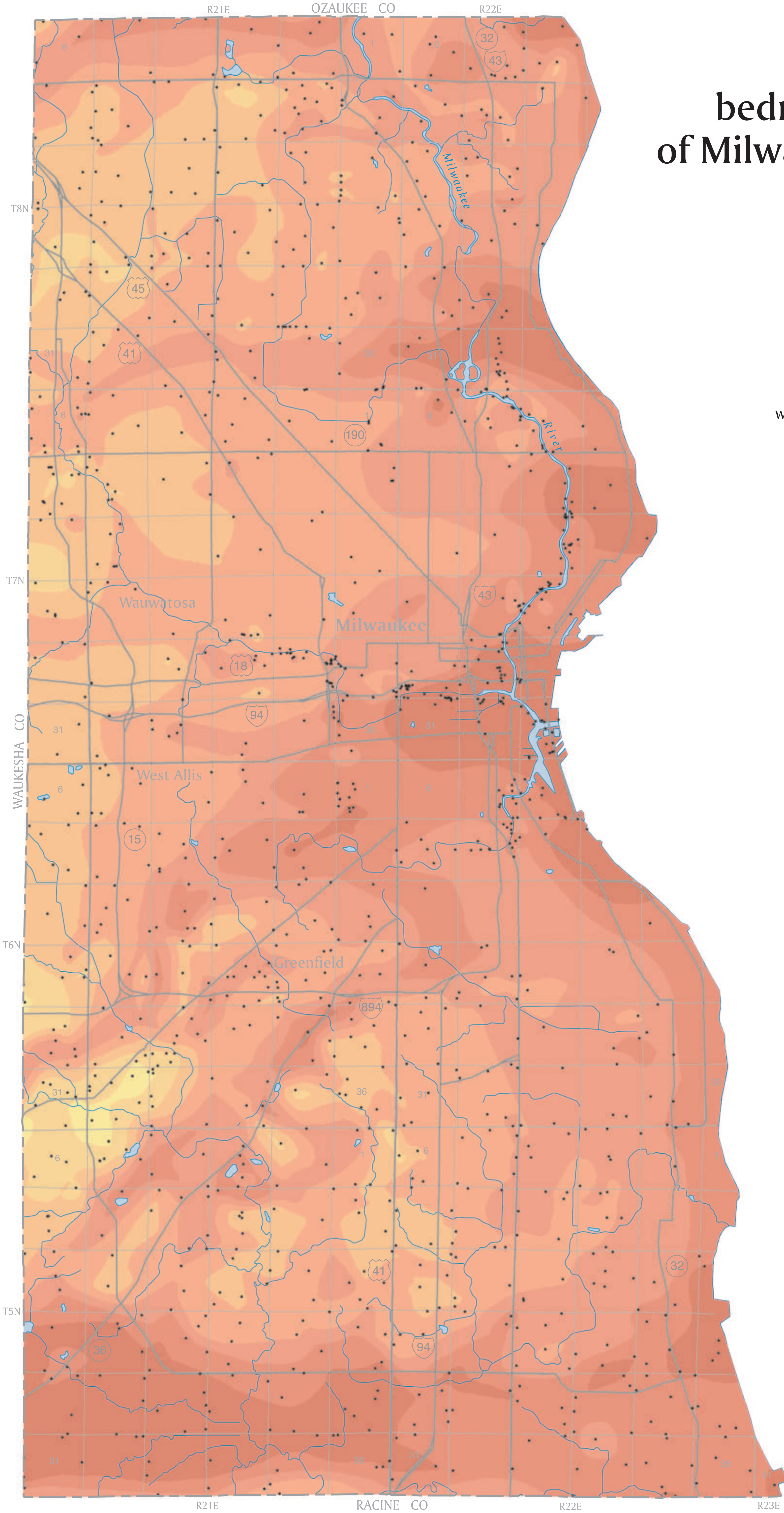
Project Name: Wauwatosa Utility Planning
Project Number: 23414-10
Project Location: Wauwatosa, Wisconsin



Specimen Indentification	● SB-01, SS-10	⊠ SB-02, SS-7	▲ SB-10, SS-6
Depth (feet)	34.5'-36'	19.5'-21'	14.5'-16'
USCS Classification	CL	CL	CL
Sample Height (in)	2.81	2.81	2.77
Sample Diameter (in)	1.46	1.43	1.44
Height:Diameter Ratio	1.93	1.93	1.93
Q_u (tsf)	2.45	2.16	2.31
MC (%)	11.4	13.8	13.1
γ_d (pcf)	128.2	123.9	128.1
γ_T (pcf)	142.8	141.0	144.9

APPENDIX III

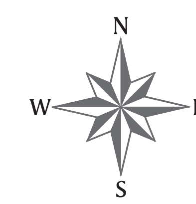
PRELIMINARY BEDROCK TOPOGRAPHY MAP OF MILWAUKEE COUNTY, WISCONSIN BY T.J. EVANS 2004



Preliminary bedrock topography map of Milwaukee County, Wisconsin

T. J. Evans

2004



ESTIMATED ELEVATION IN FEET
(ABOVE MEAN SEA LEVEL)

- > 850
- 800 - 850
- 750 - 800
- 700 - 750
- 650 - 700
- 600 - 650
- 550 - 600
- 500 - 550
- < 500
- • data point

1 0 1 2 3 4 5 6 7 8
KILOMETERS

1 0 1 2 3 4 5
MILES

Wisconsin Transverse Mercator Projection
1991 adjustment to the North American Datum of 1983 (NAD 83/91)

This map represents work performed by the Wisconsin Geological and Natural History Survey and is released to the open files in the interest of making the information readily available. This map has not been edited or reviewed for conformity with Wisconsin Geological and Natural History Survey standards and nomenclature.

This map is part of an ongoing project funded by STATEMAP, the state component of the National Cooperative Geologic Mapping Program of the U.S. Geological Survey.

UW Extension

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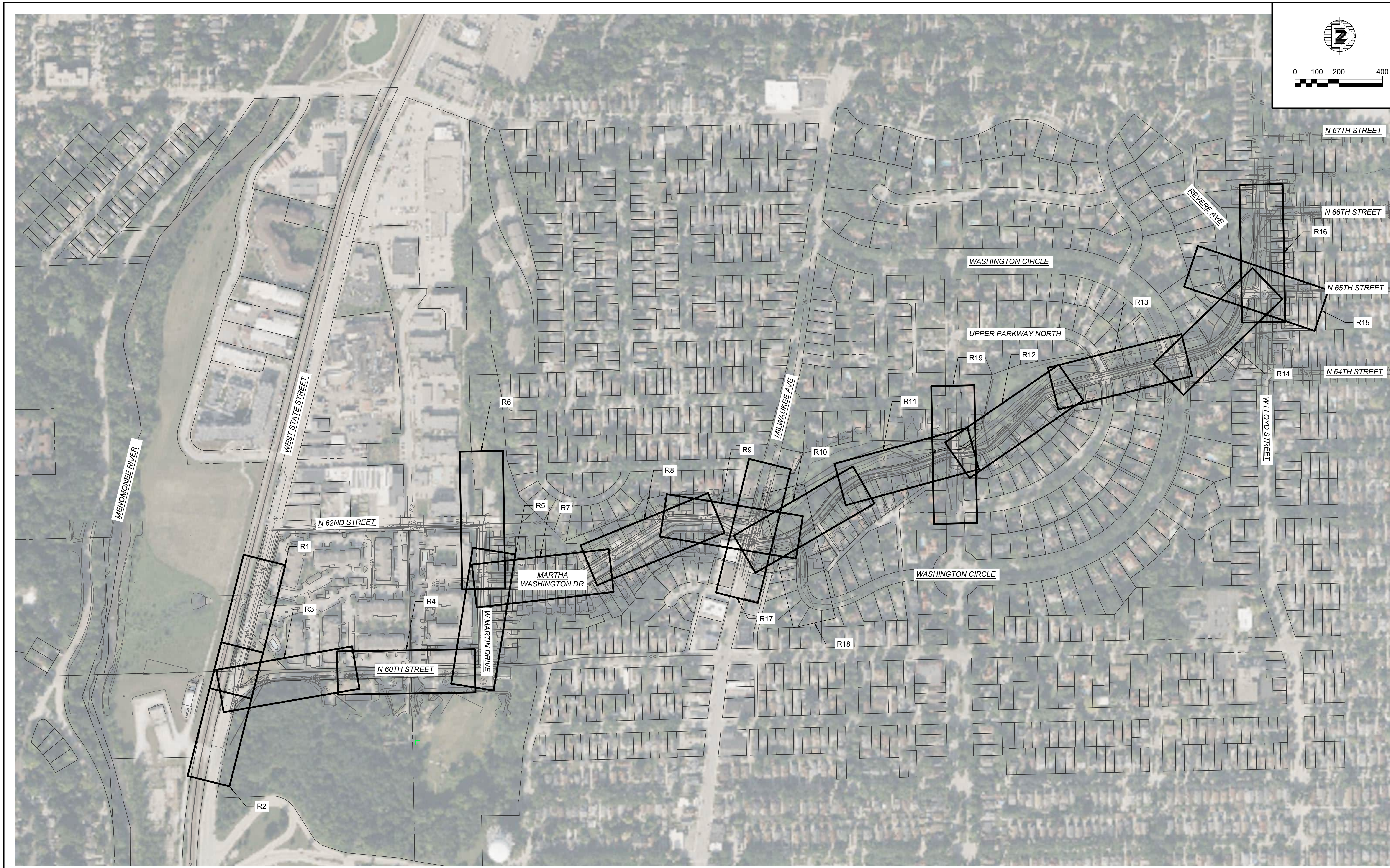
James M. Robertson, *Director and State Geologist*

Data entry and processing by K.K. Zeiler. Cartography by D.L. Patterson.

Wisconsin Geological and Natural History Survey
Open-File Report 2004-14B

Appendix C. 30% Preliminary Plans, Option B



		NO.	DATE	REVISION	BY
PROJECT DATE: .	DRAWN BY: MJW	1	8/12/2024	30% PRELIMINARY PLANS	MJW
	DESIGNED BY: Init	.	.	.	.
	CHECKED BY: Init	.	.	.	.

PRELIMINARY

PLOT DATE: 8/12/2024 10:40 AM, G:\10\10310\10310004\CADD\Construction Documents\10310004 Plan Pages Overview - R Sheets.dwg

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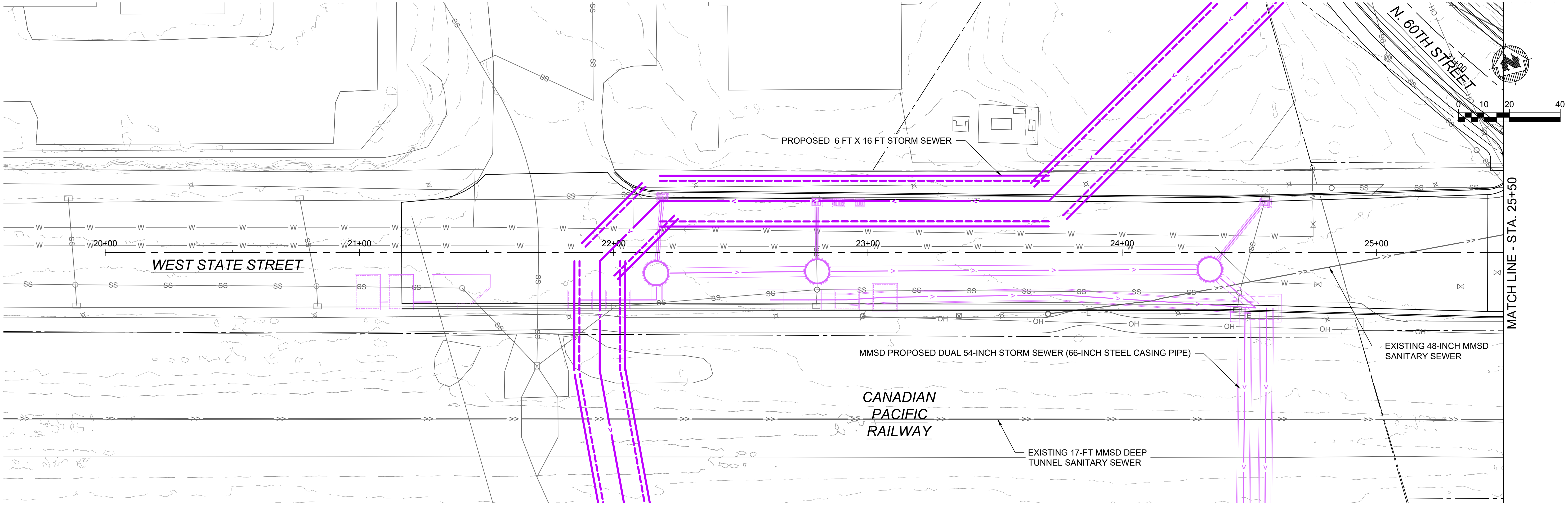
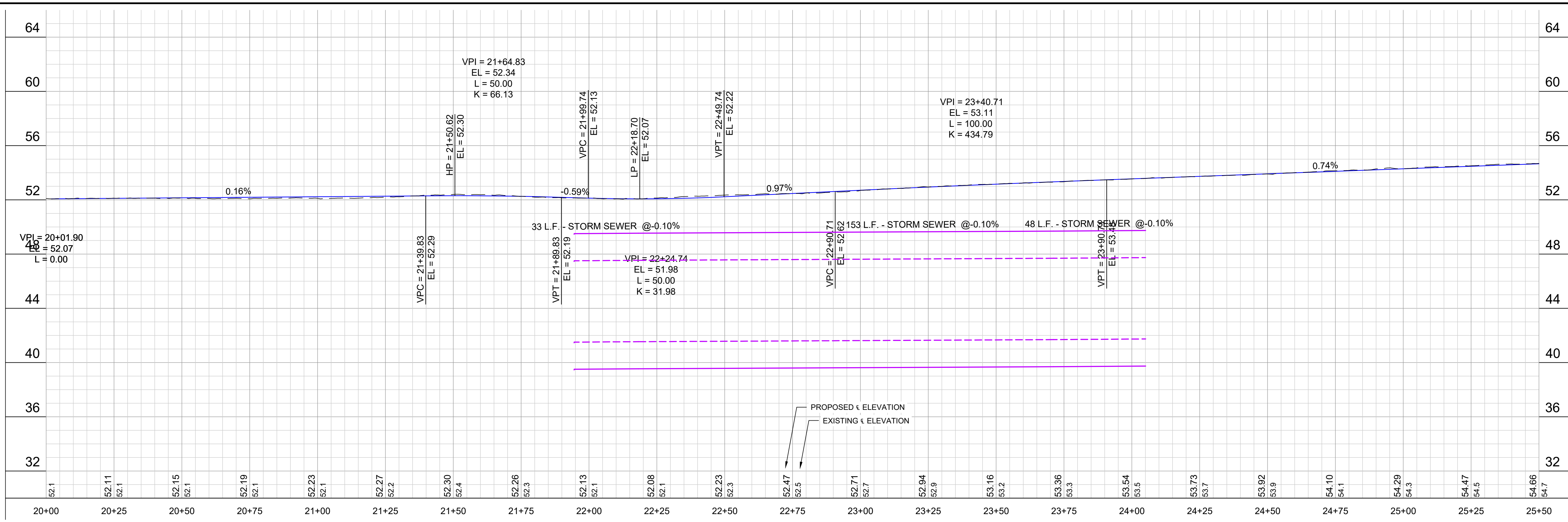
SCHOONMAKER CREEK PRELIMINARY PLANS
CITY OF WAUWATOSA
MILWAUKEE COUNTY, WI

ROADWAY & STORM PLANS - PLAN & PROFILE OVERVIEW

PROJECT NO. 10310004

SHEET R0





PROJECT DATE: .	DRAWN BY:	MJW	NO.	DATE	REVISION	BY
	DESIGNED BY:	Init	1	8/12/2024	30% PRELIMINARY PLANS	MJW
	CHECKED BY:	Init	-	-	-	-

PRELIMINARY

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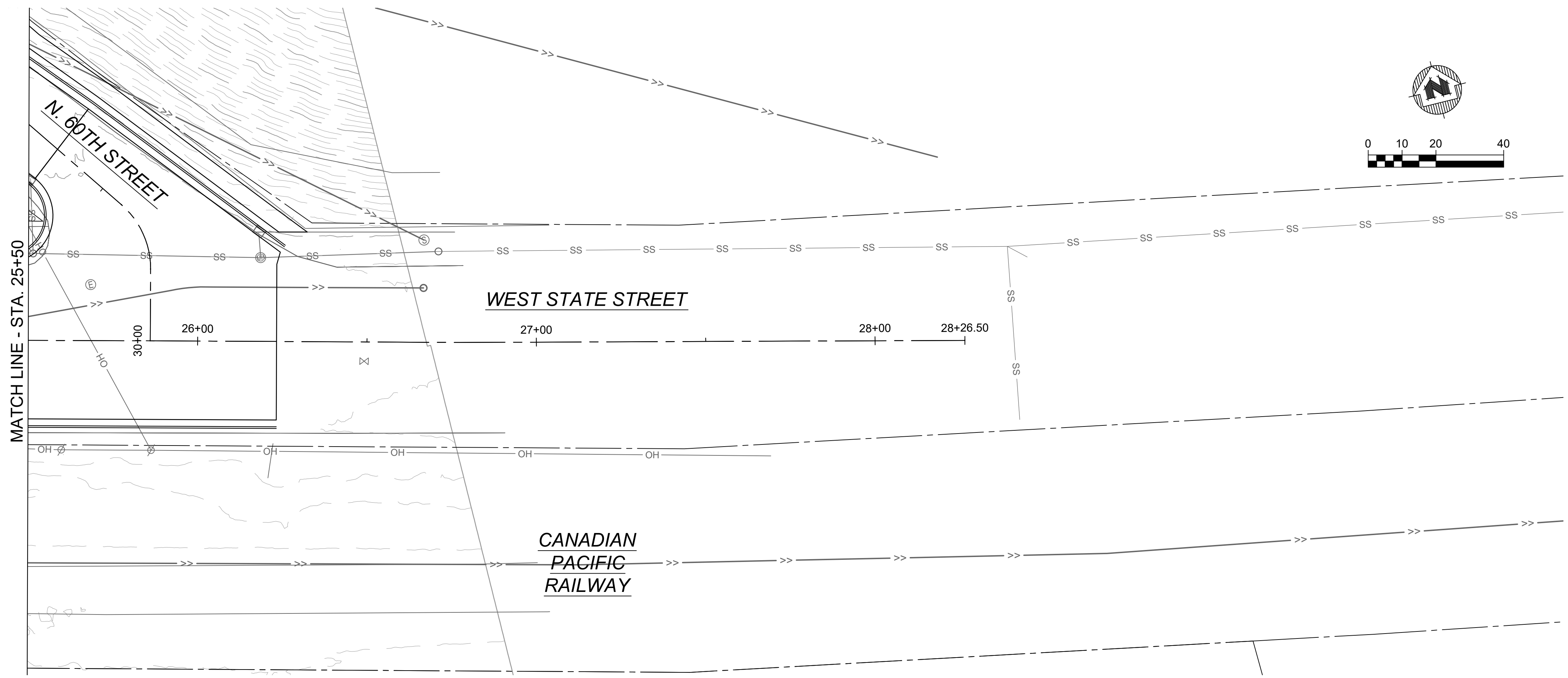
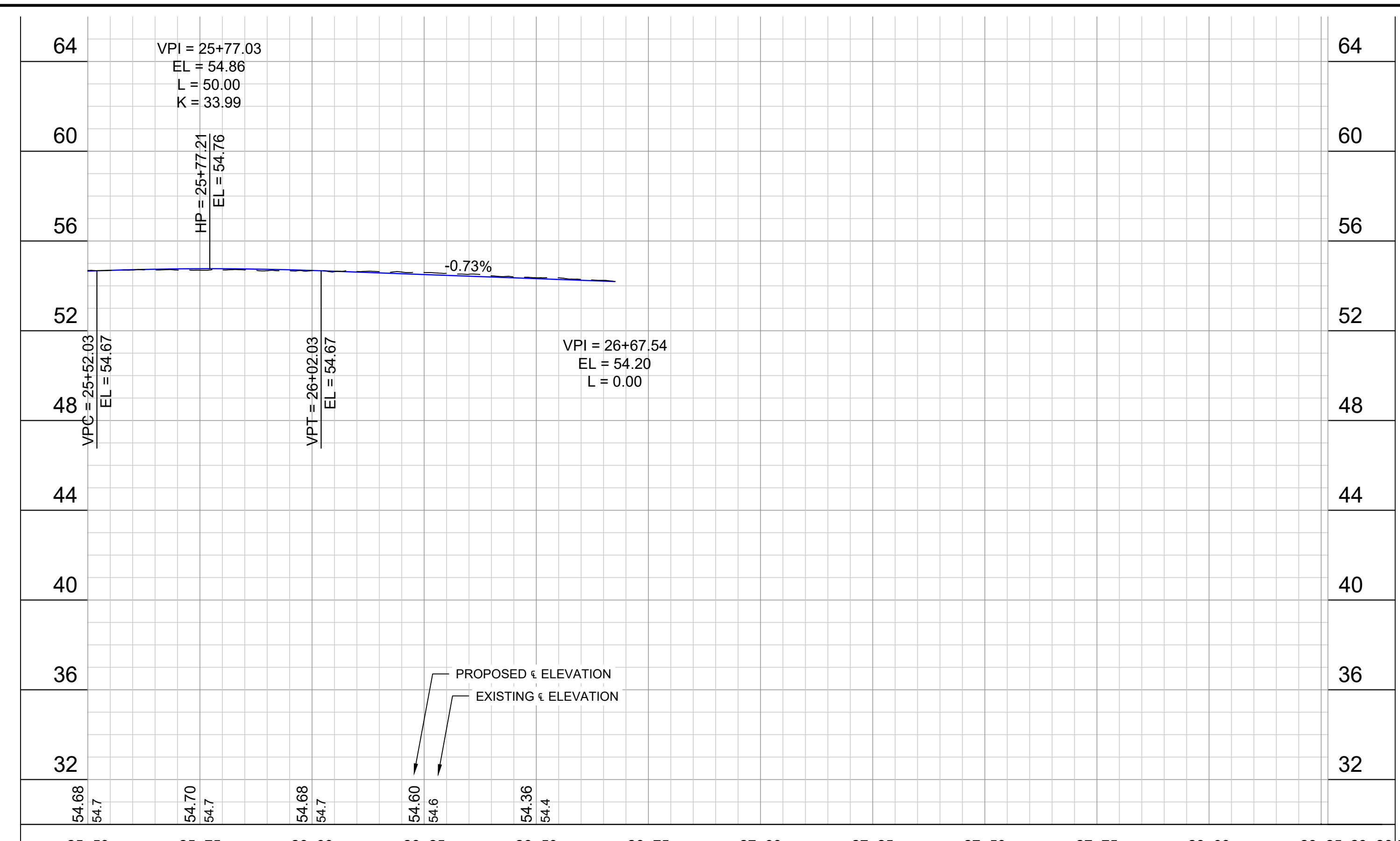
CITY OF WAUWATOSA
MILWAUKEE COUNTY, WI

ROADWAY & STORM PLANS - WEST STATE STREET

PROJECT NO. 10310004

SHEET R1





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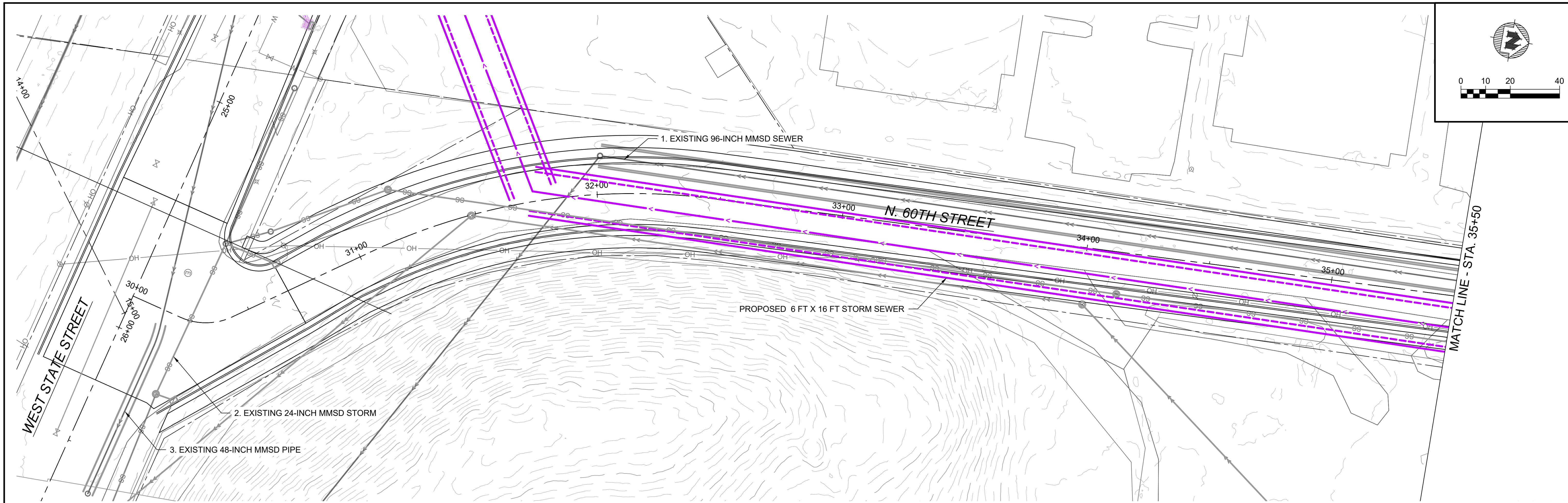
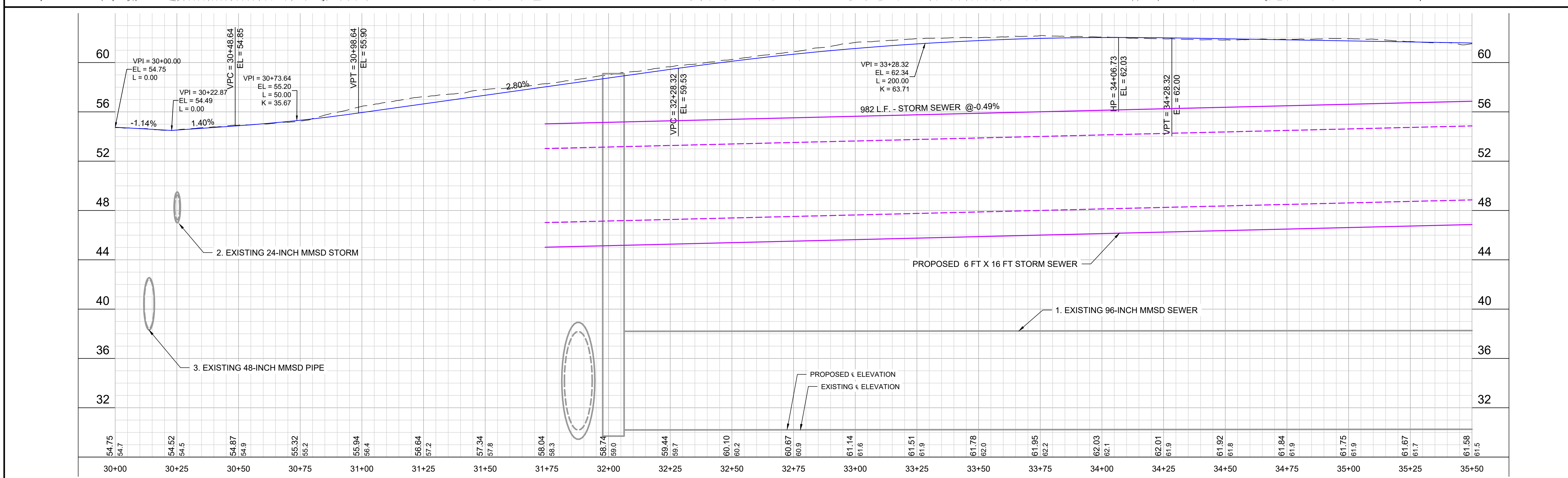
ROADWAY & STORM PLANS - WEST STATE STREET

PROJECT NO. 10310004

SHEET R2





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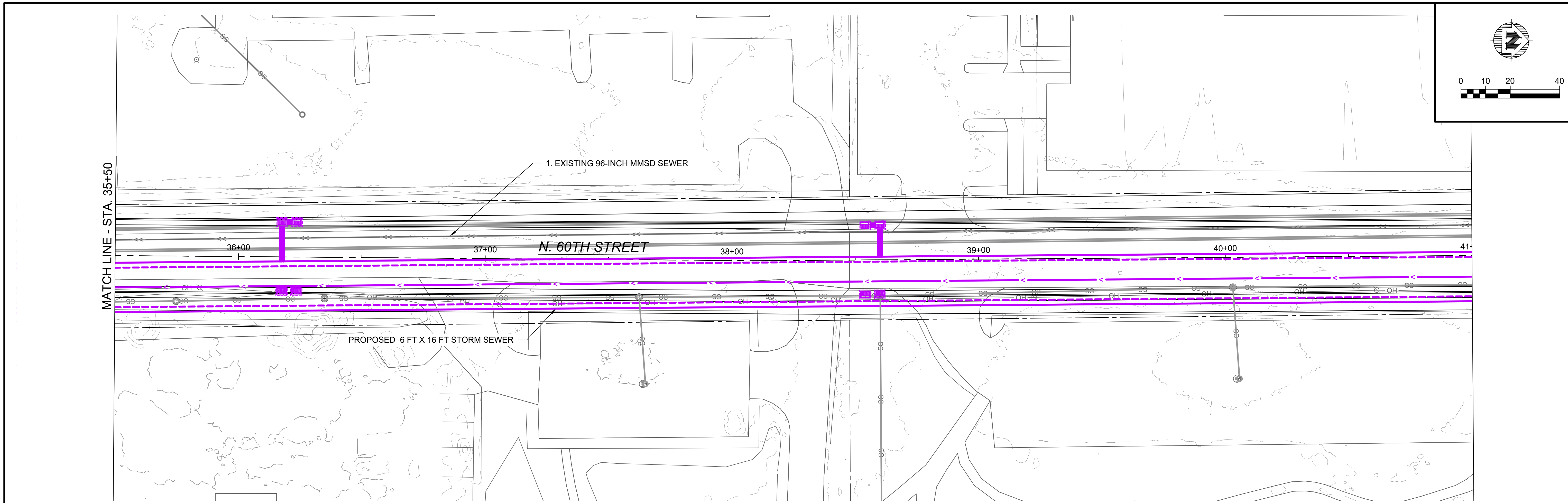
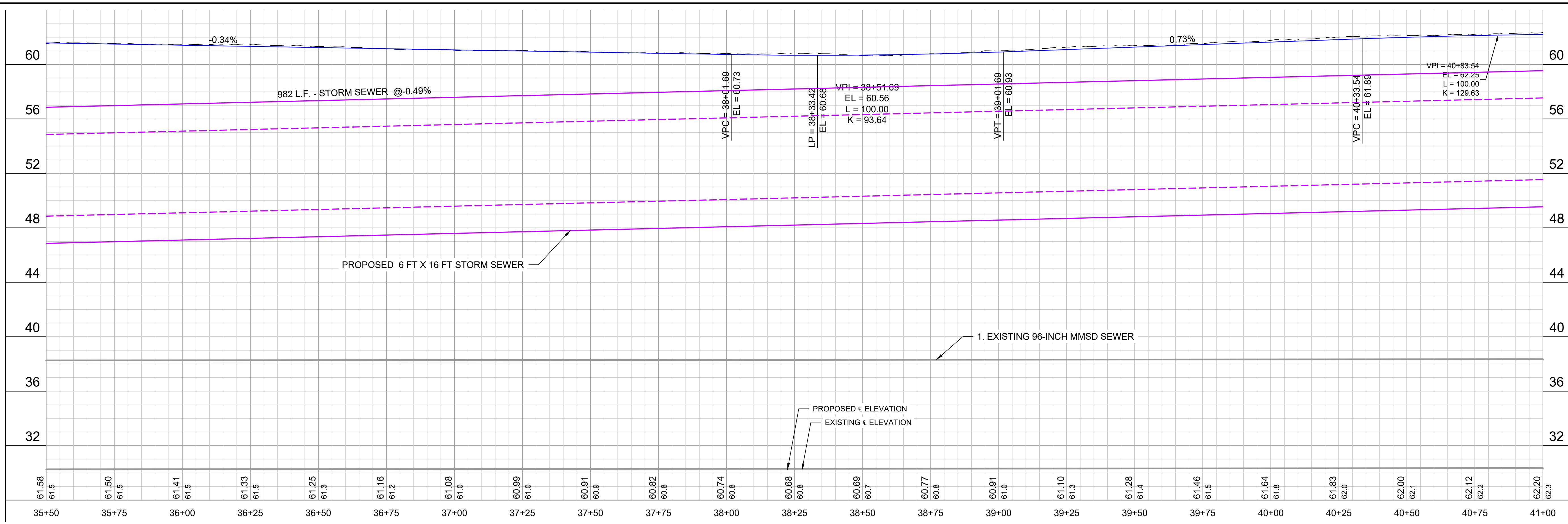
ROADWAY & STORM PLANS - N 60TH STREET

PROJECT NO. 10310004
SHEET R3





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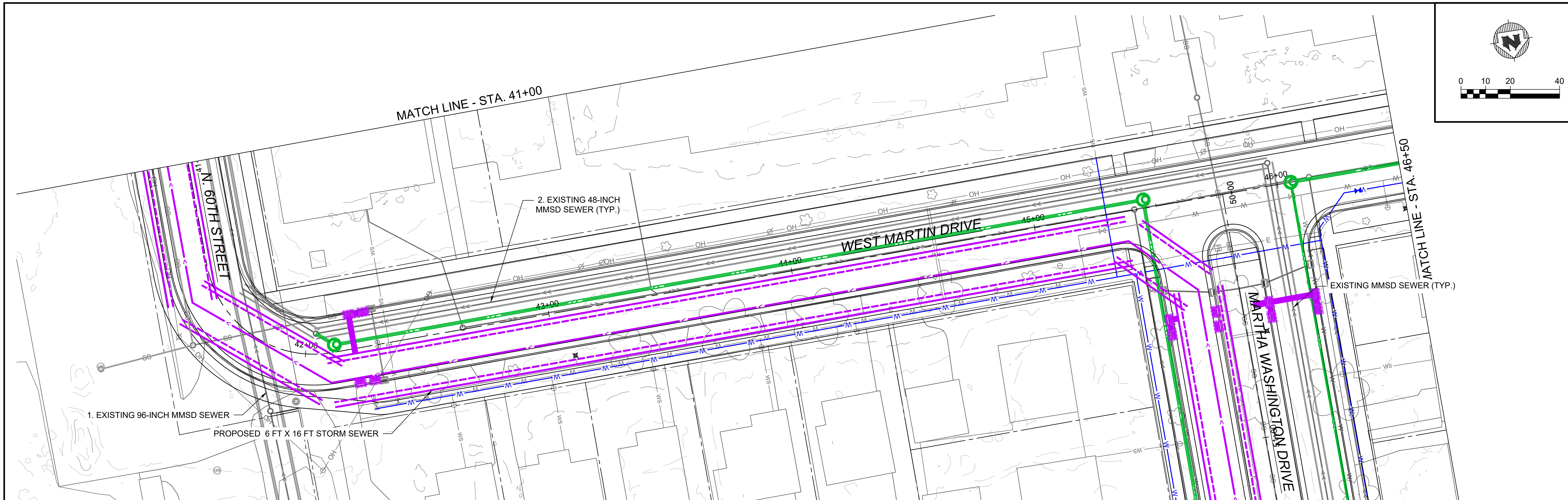
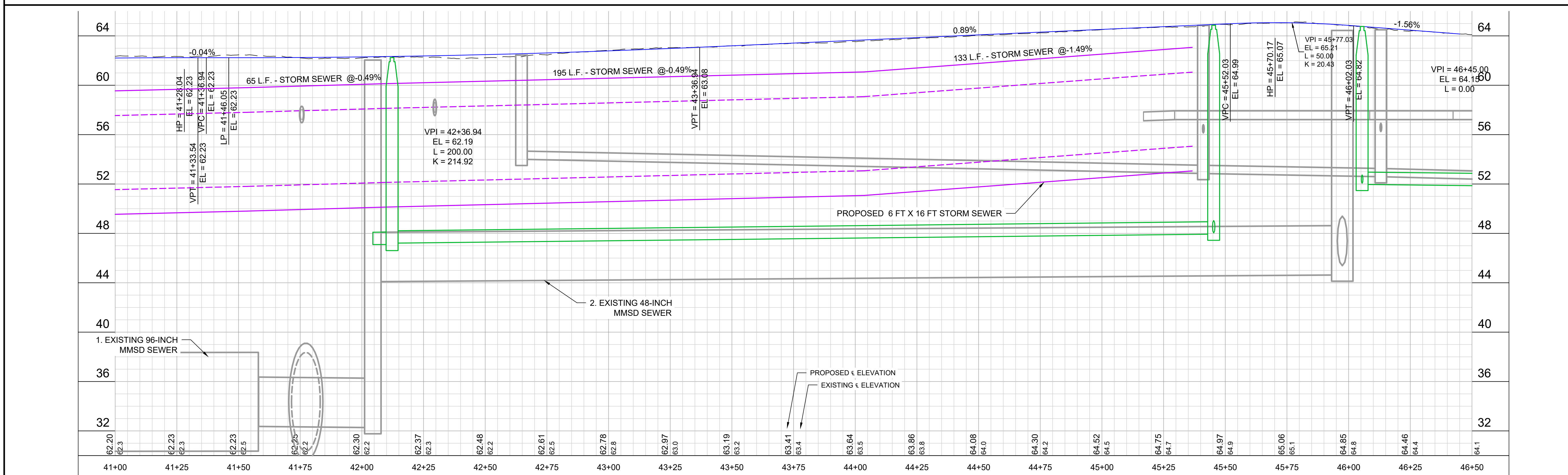
ROADWAY & STORM PLANS - N 60TH STREET

PROJECT NO. 10310004
SHEET R4





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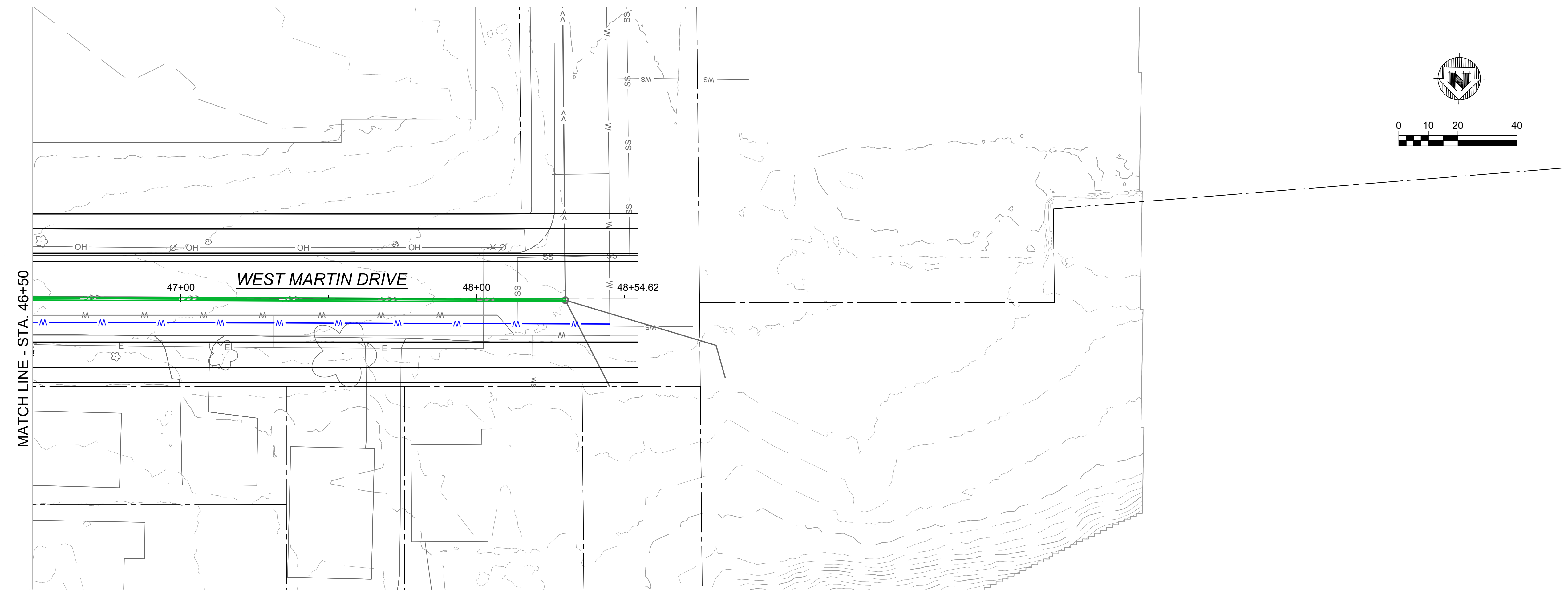
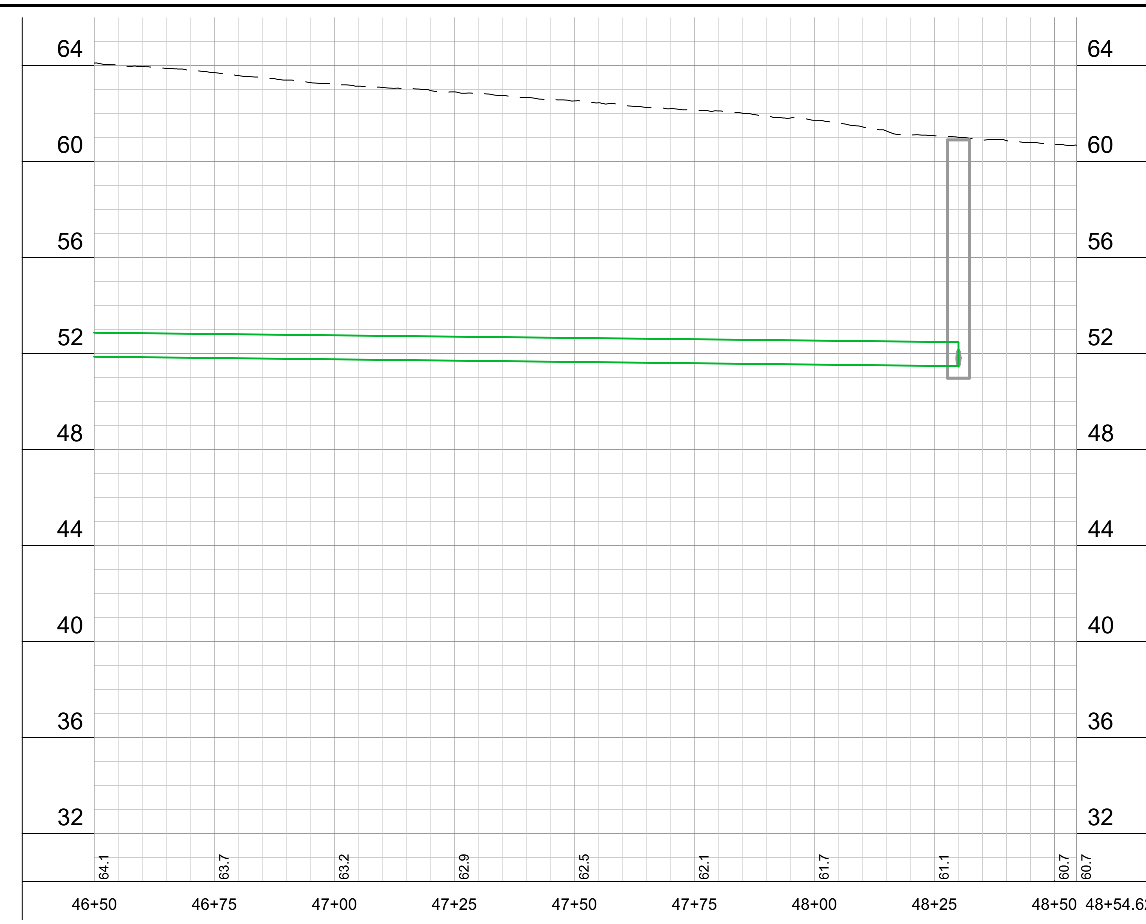
ROADWAY & STORM PLANS - WEST MARTIN DRIVE

PROJECT NO. 10310004

SHEET R5





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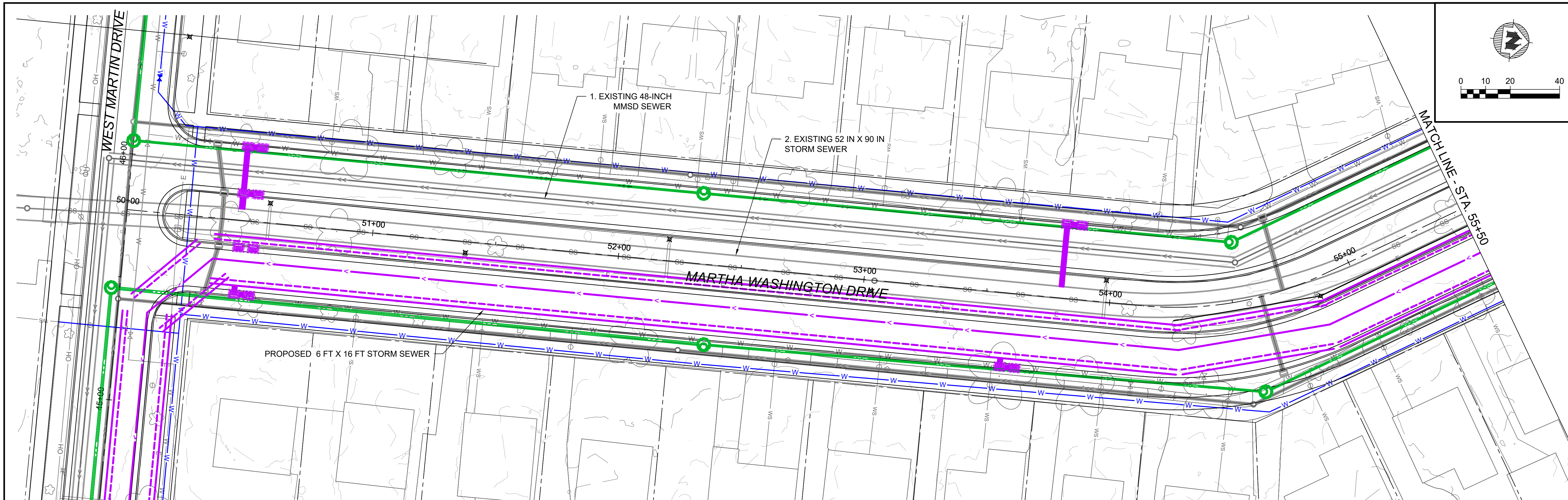
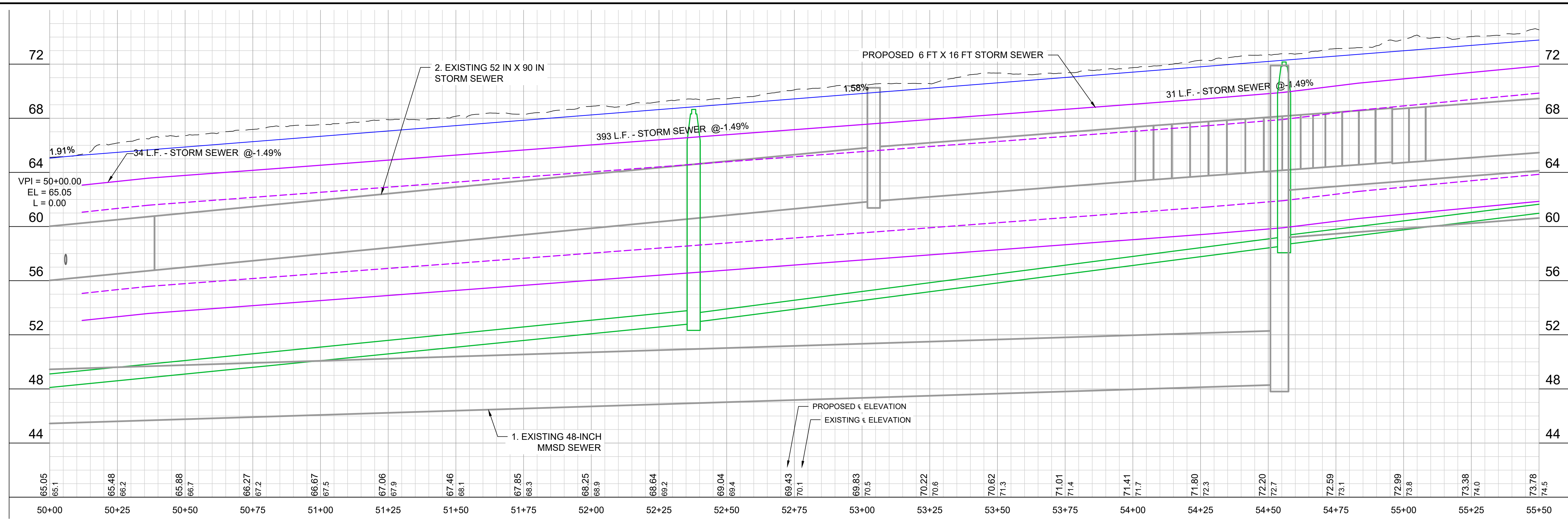
PROJECT NO. 10310004

SHEET R6





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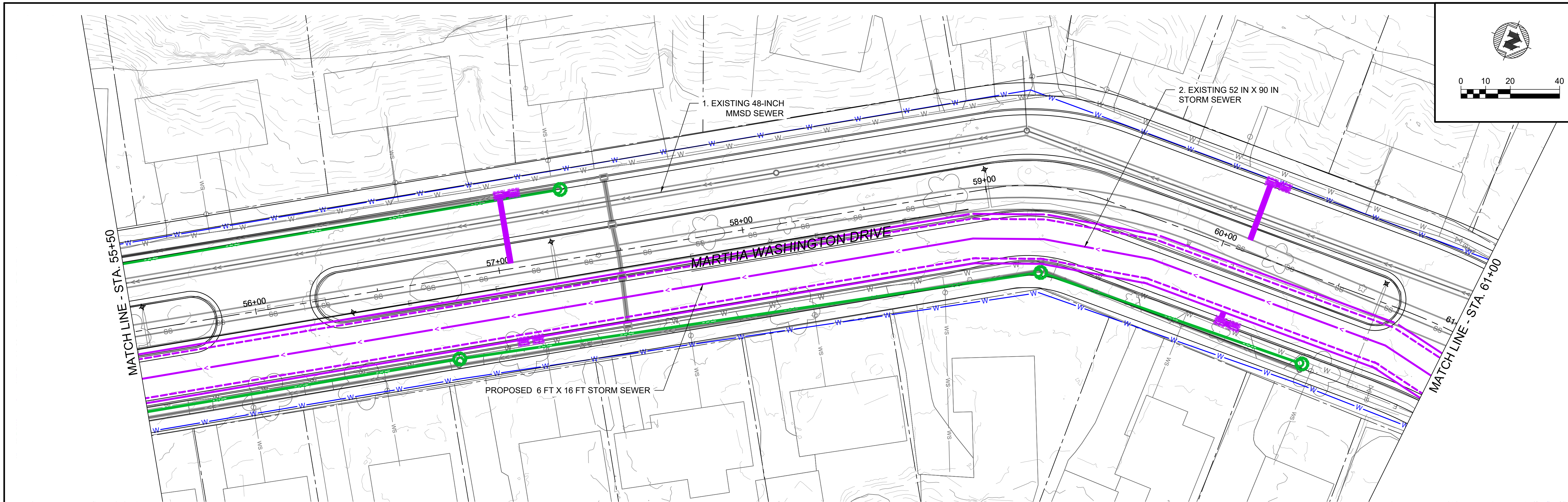
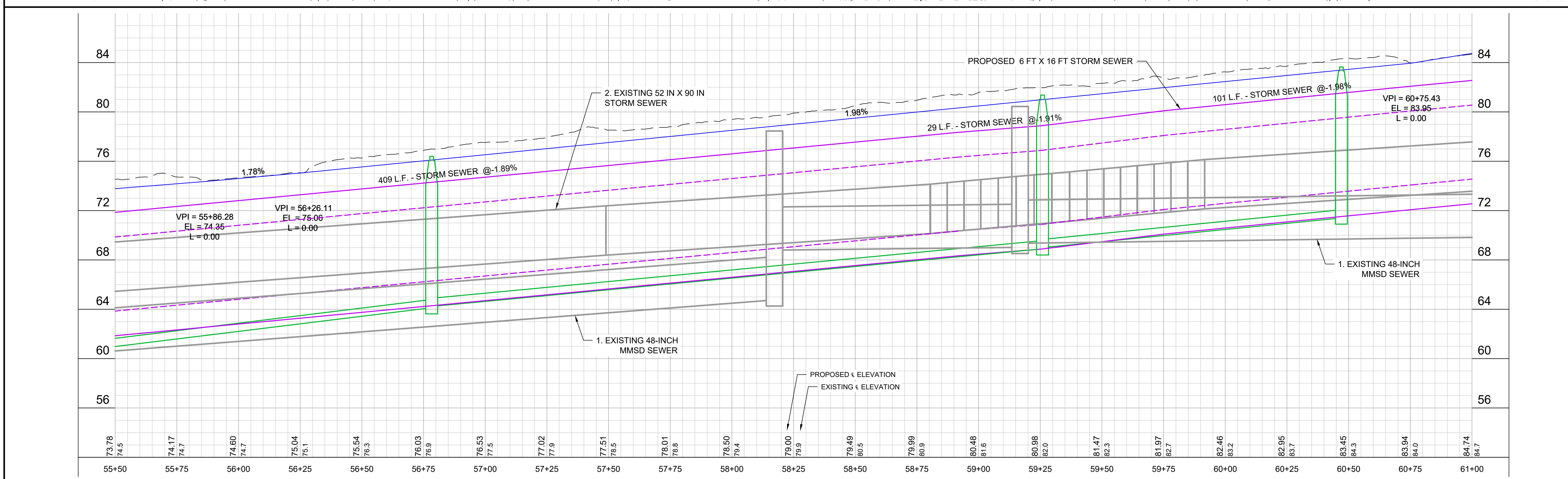
PROJECT NO. 10310004

SHEET R7





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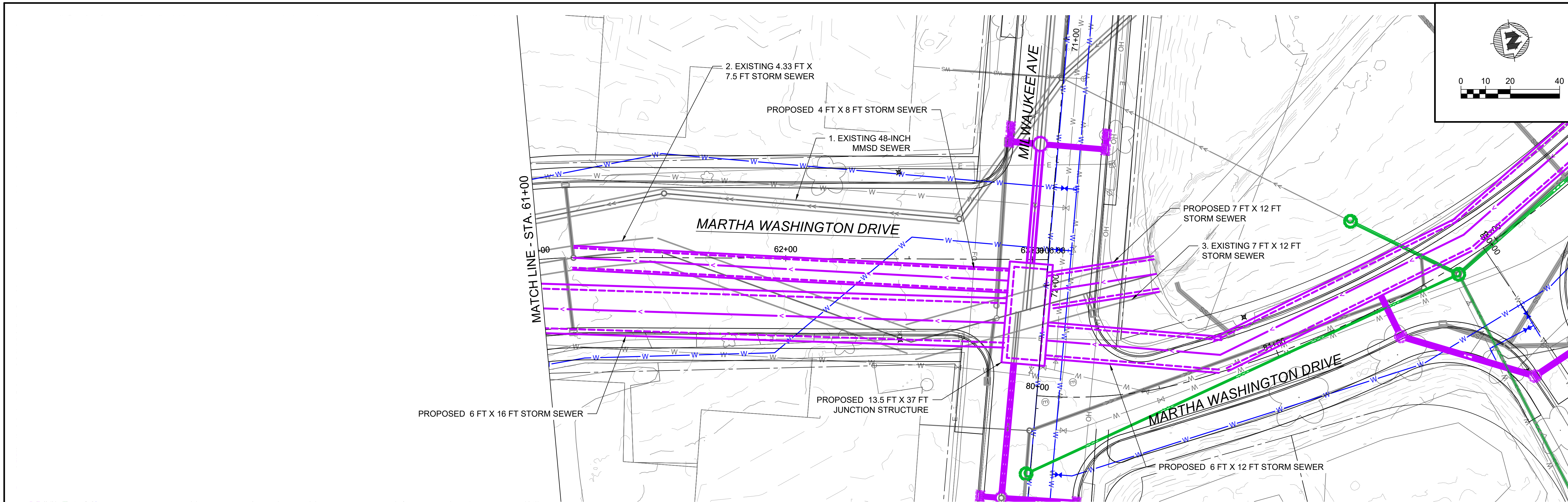
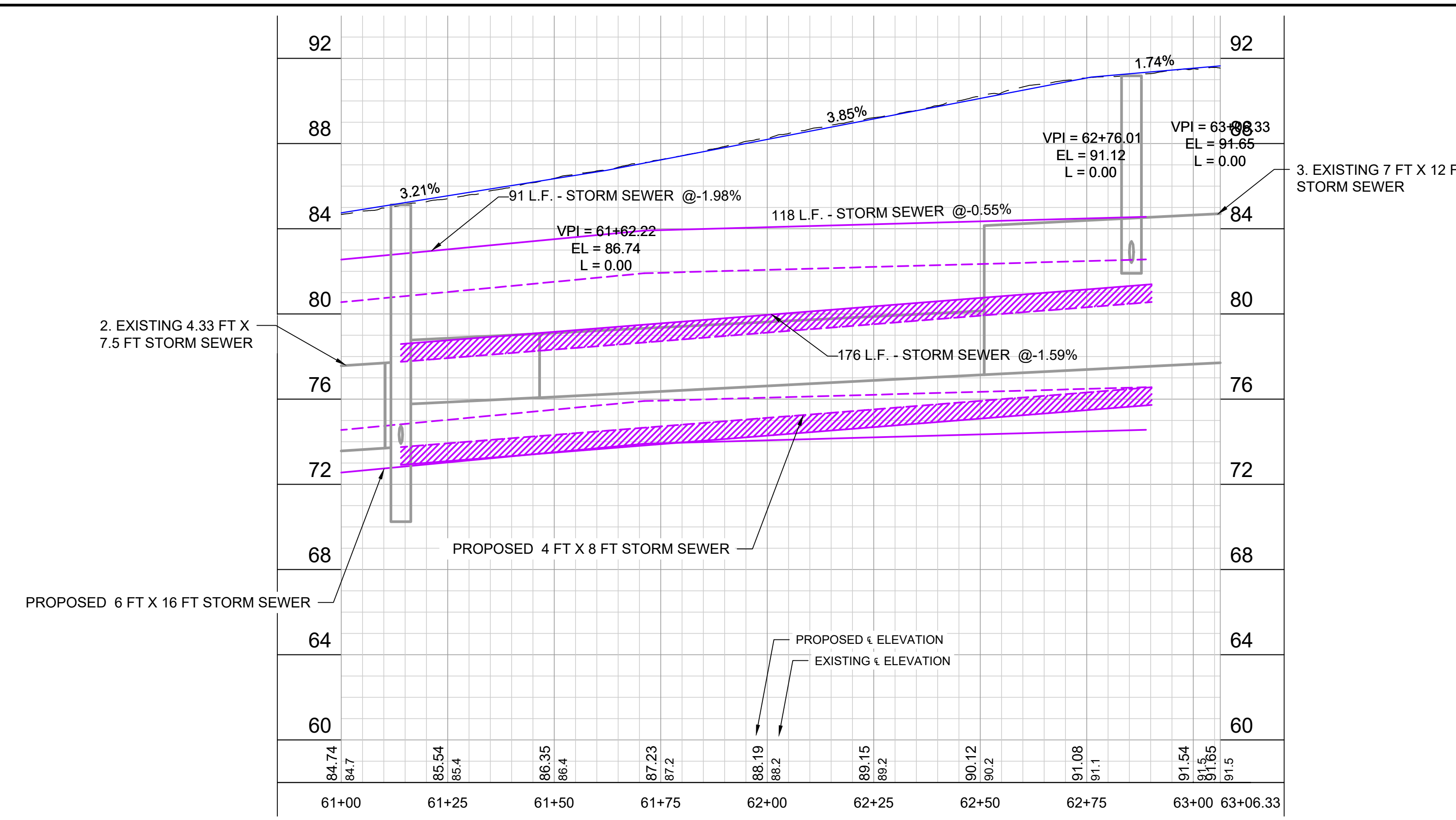
PROJECT NO. 10310004

SHEET R8





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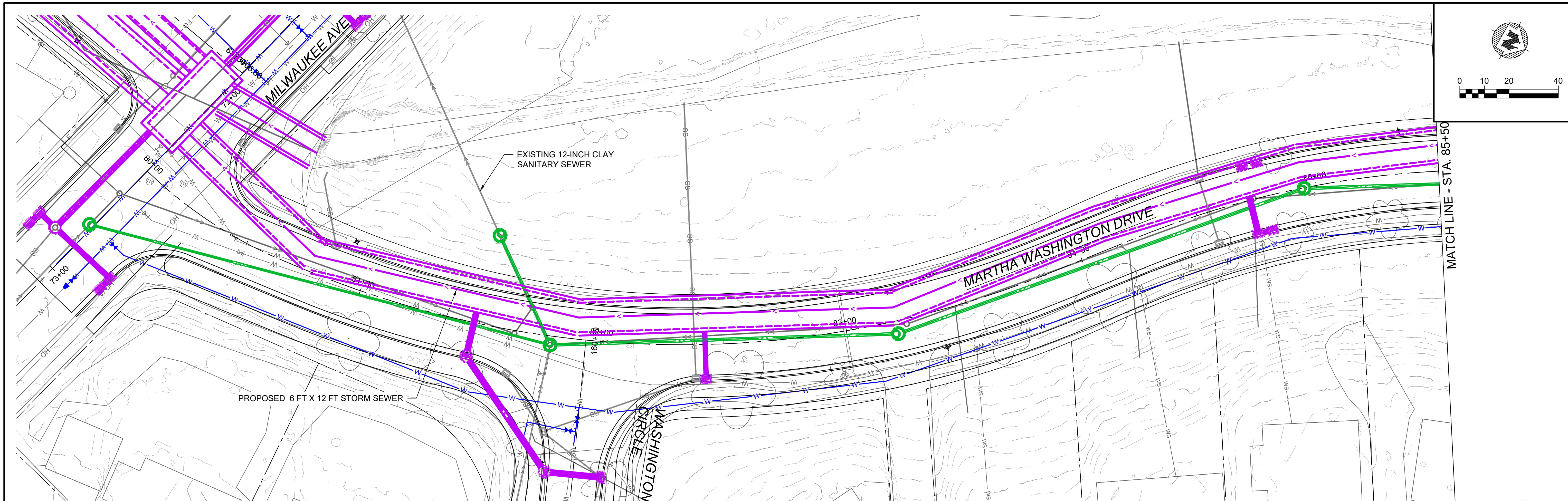
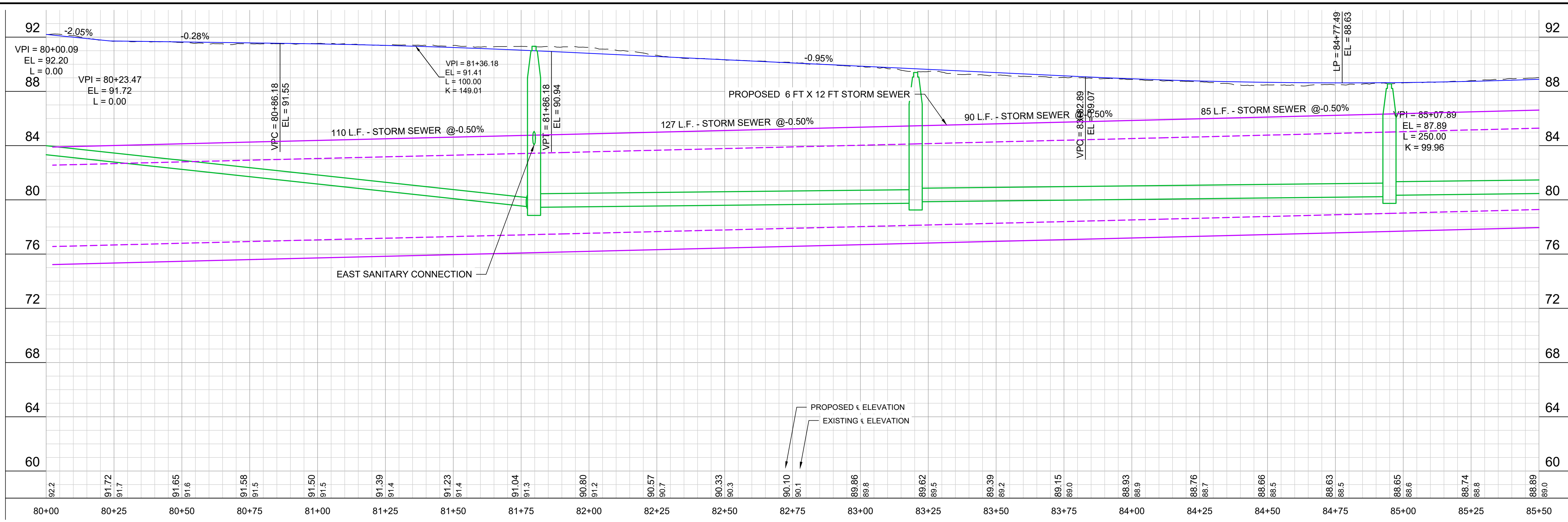
ROADWAY & STORM PLANS - MARTHA WASHINGTON DRIVE

PROJECT NO. 10310004
SHEET R9





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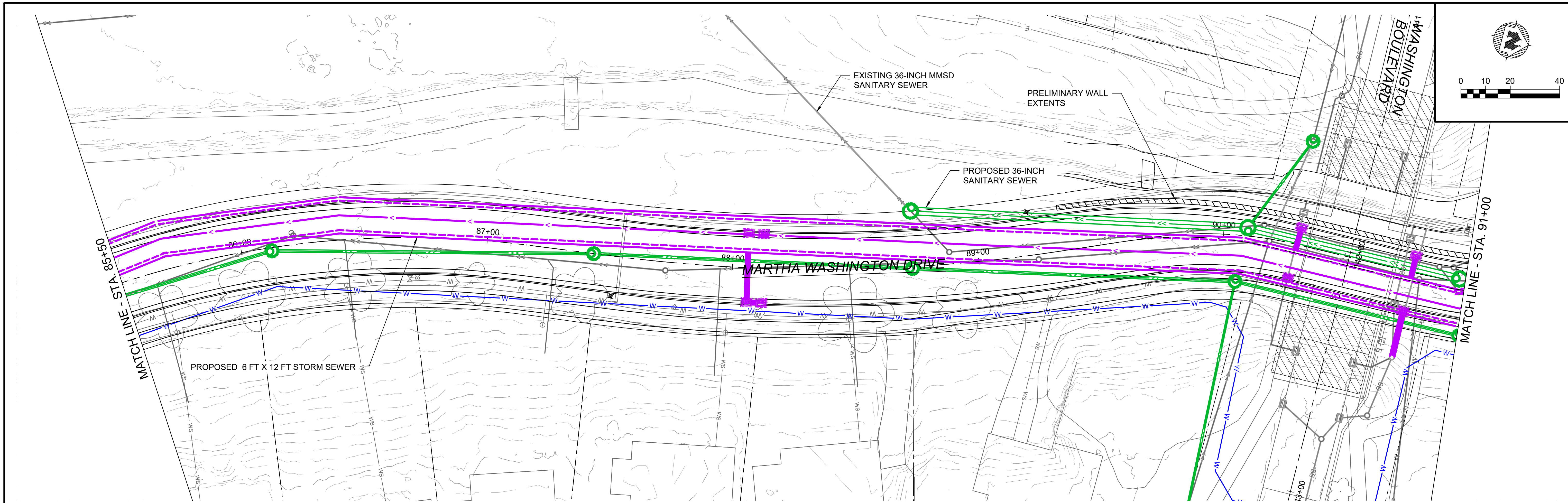
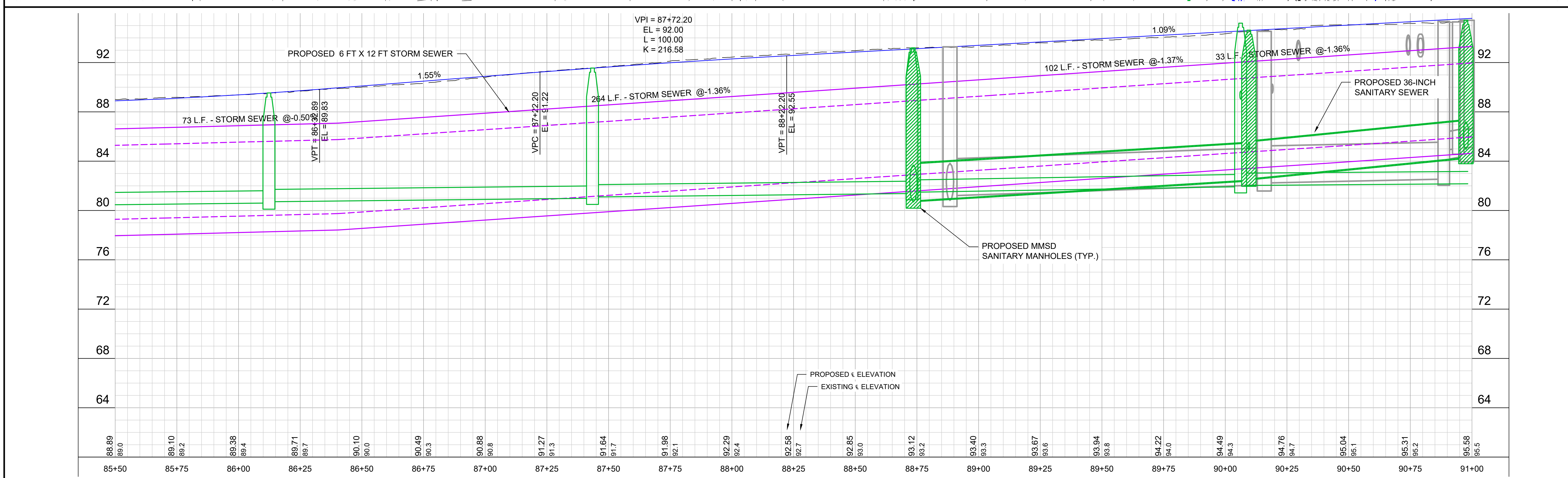
PROJECT NO. 10310004
SHEET R10





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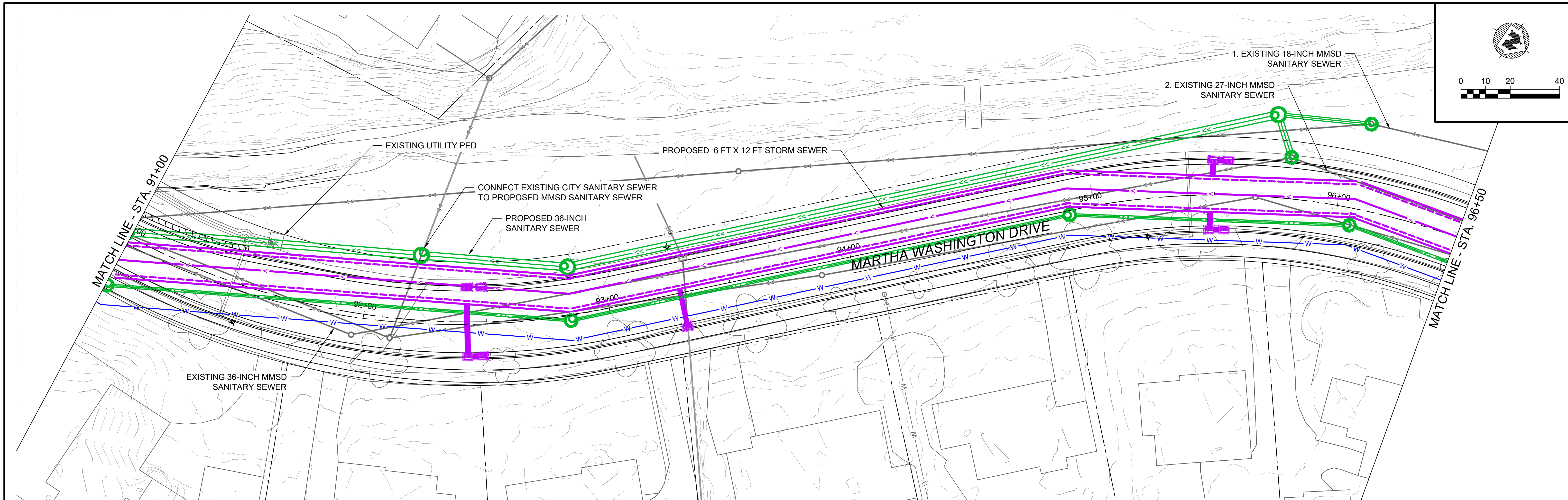
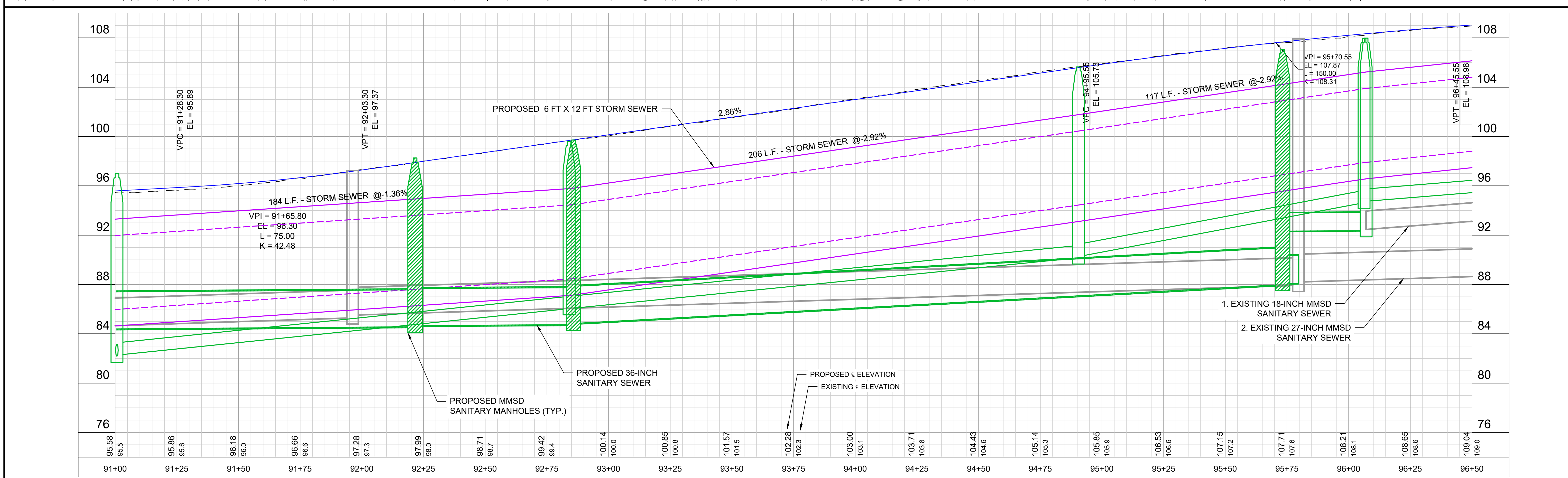
ROADWAY & STORM PLANS - MARTHA WASHINGTON DRIVE

PROJECT NO. 10310004

SHEET R11





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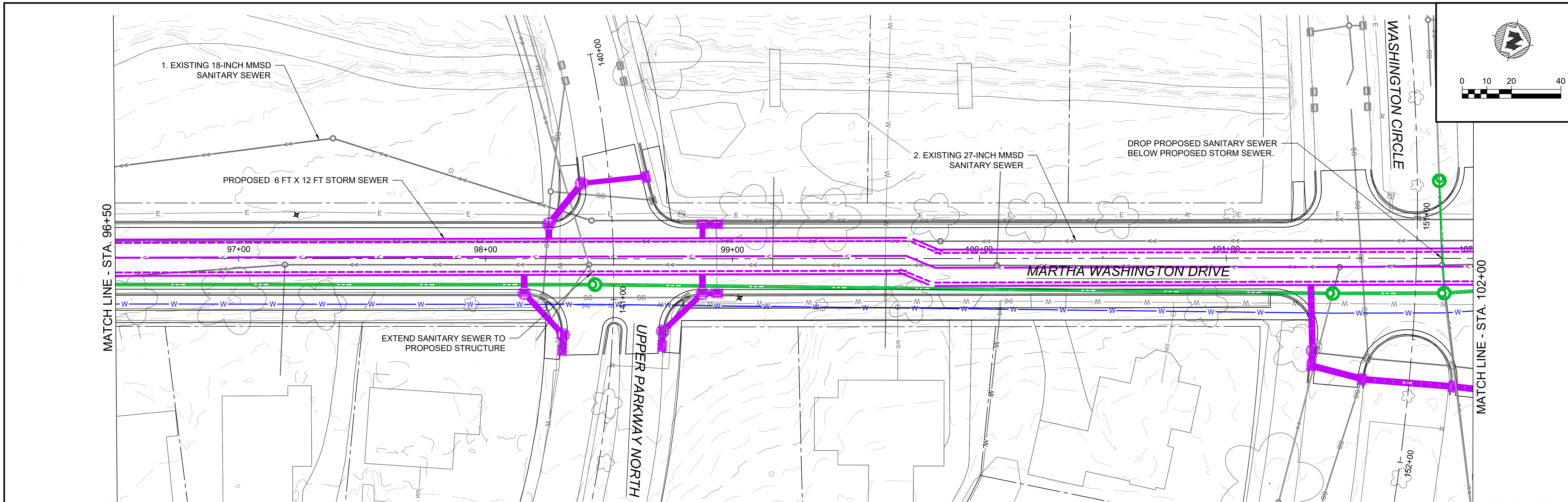
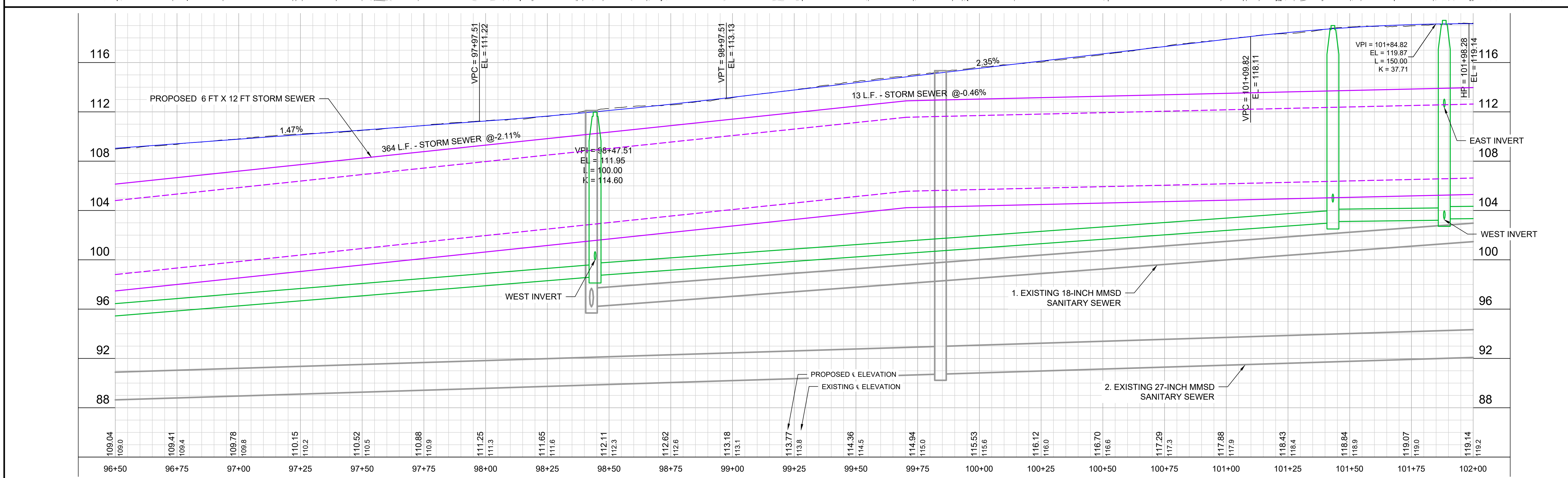
ROADWAY & STORM PLANS - MARTHA WASHINGTON DRIVE

PROJECT NO. 10310004
SHEET R12





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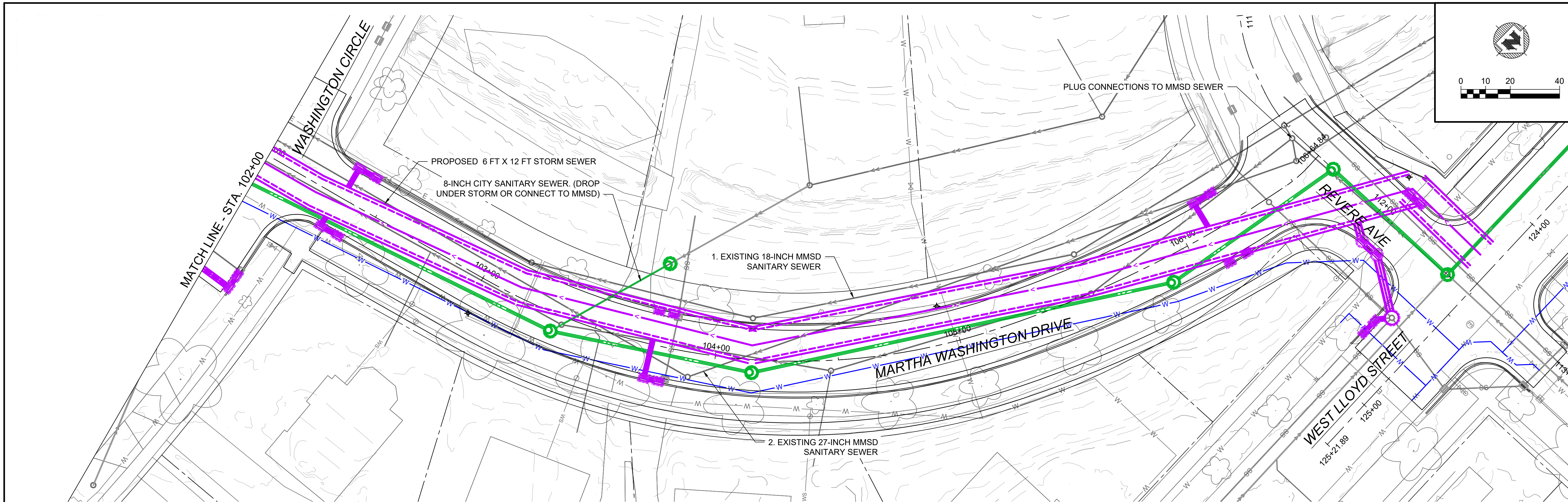
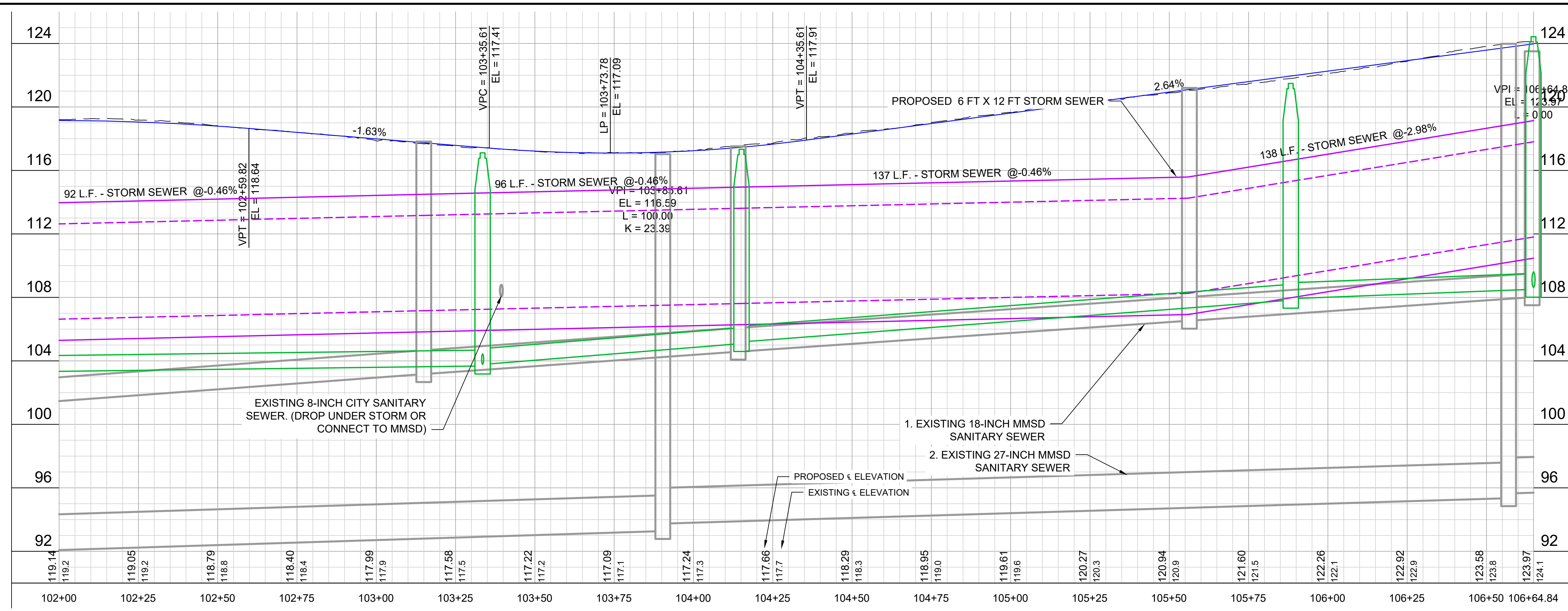
ROADWAY & STORM PLANS - MARTHA WASHINGTON DRIVE

PROJECT NO. 10310004

SHEET R13





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SHEET R14

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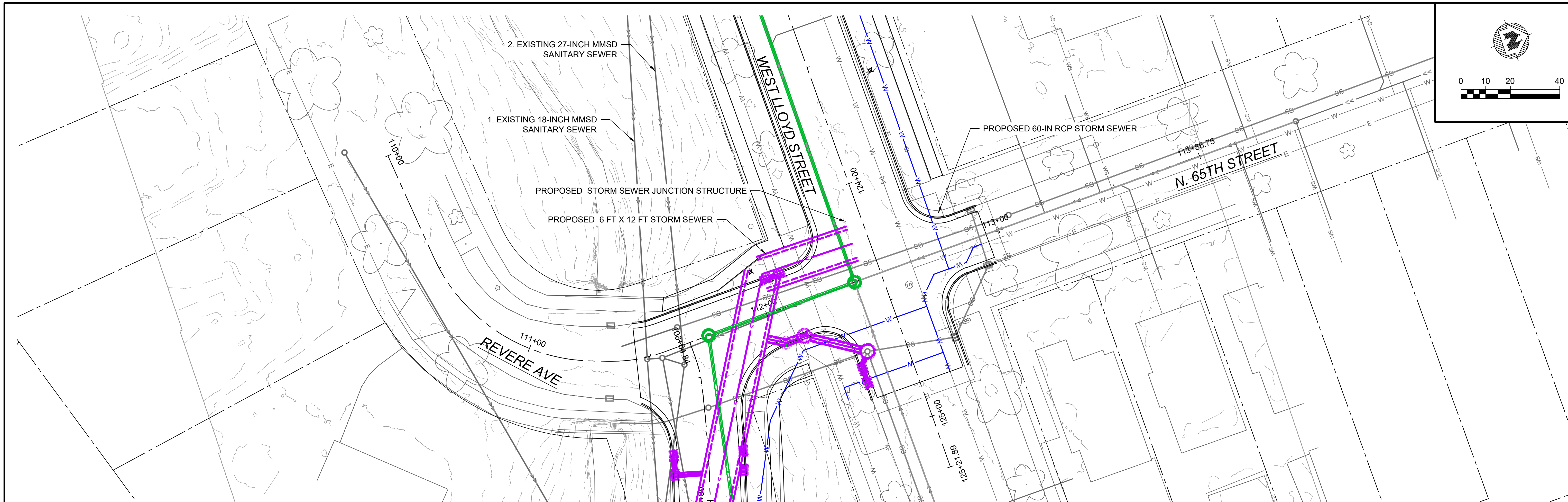

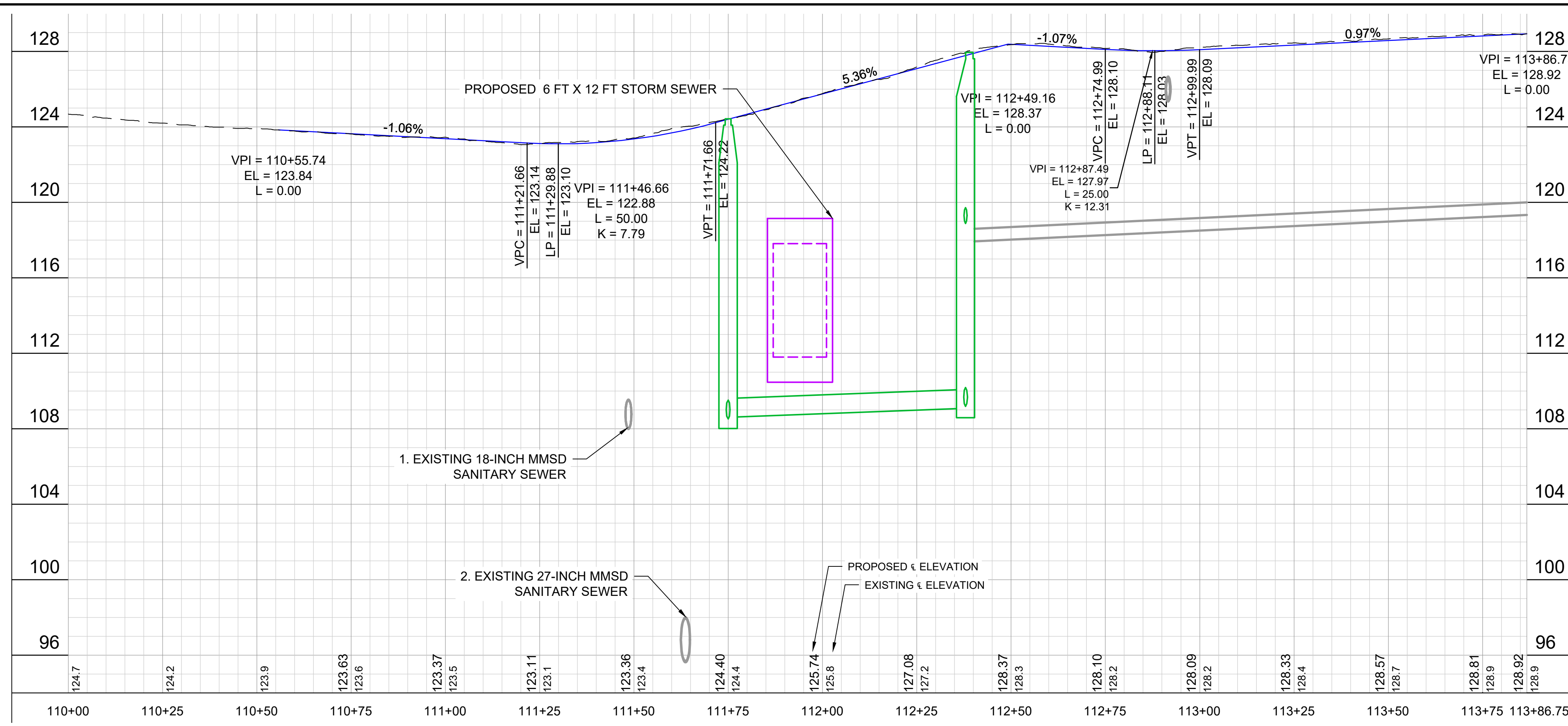

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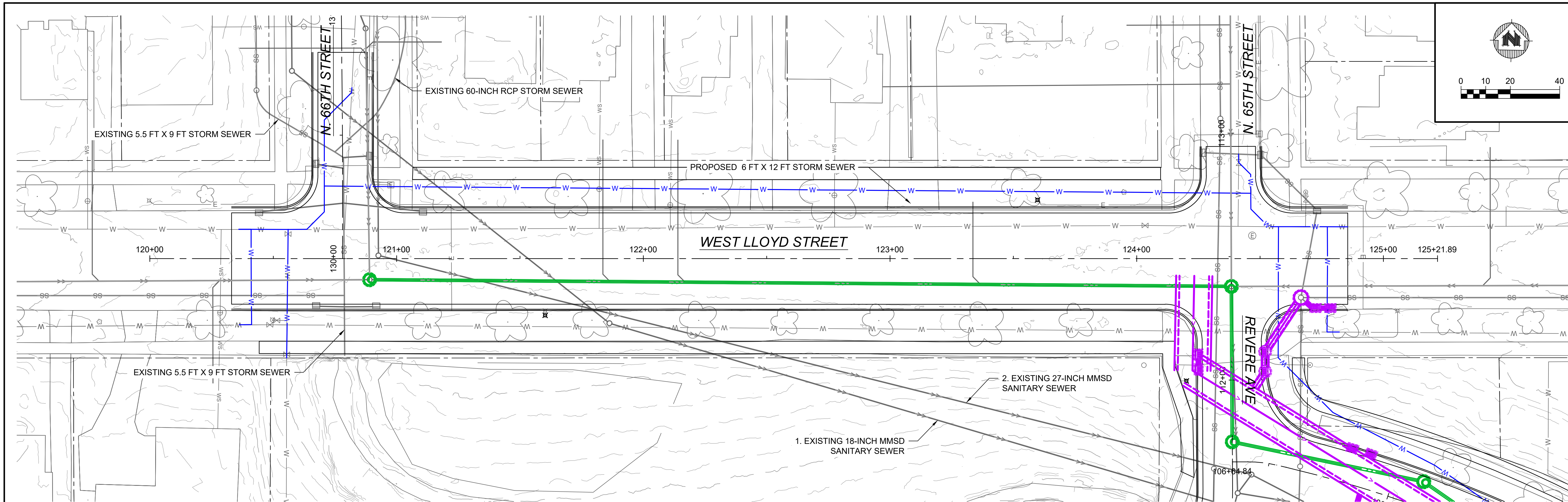
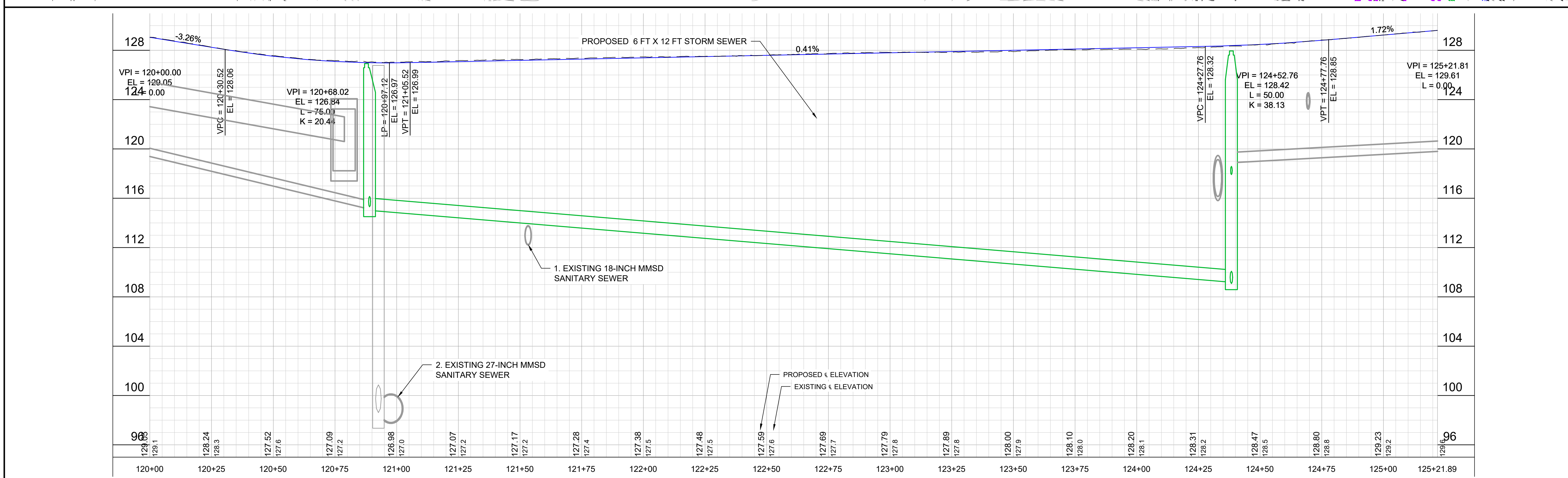
ROADWAY & STORM PLANS - REVERE AVE & N 65TH STREET

PROJECT NO. 10310004

SHEET R15





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ROADWAY & STORM PLANS - WEST LLOYD STREET

PROJECT NO. 10310004
SHEET R16

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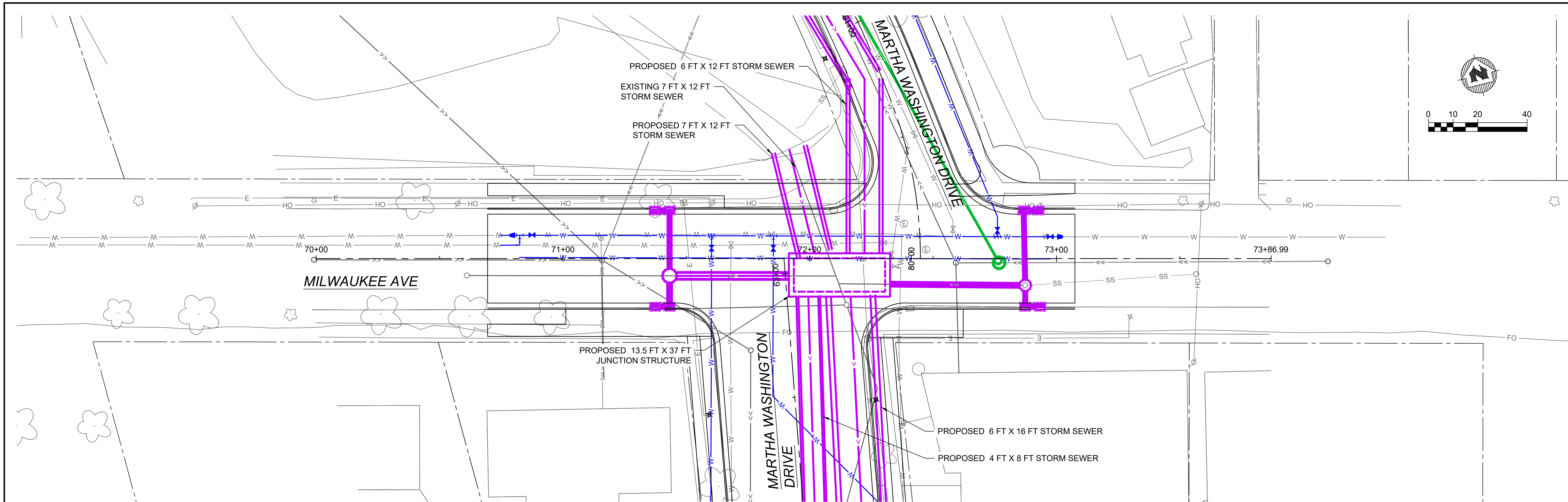

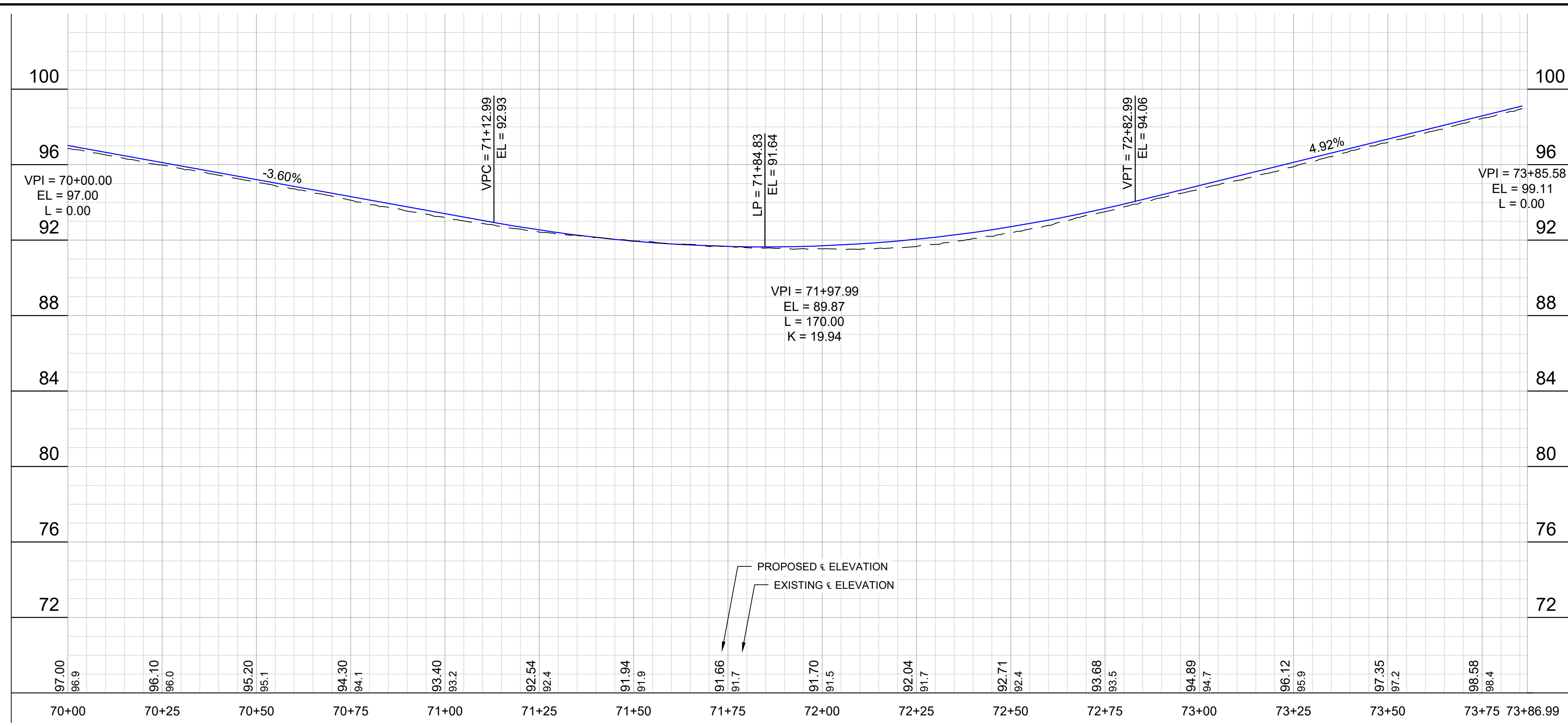

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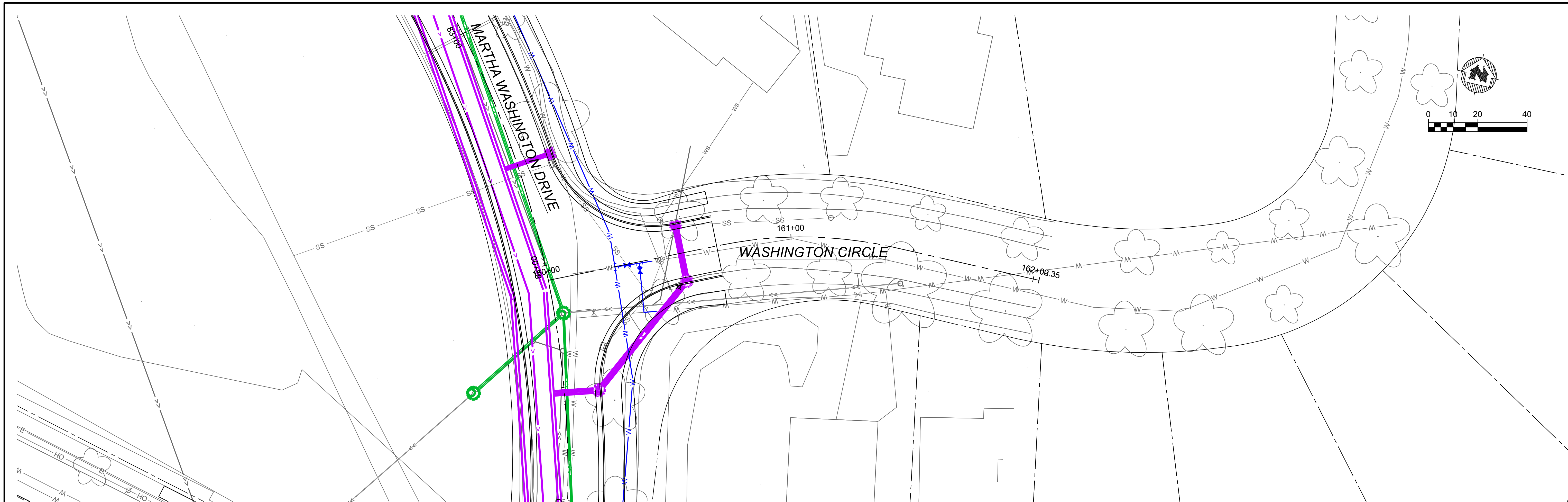
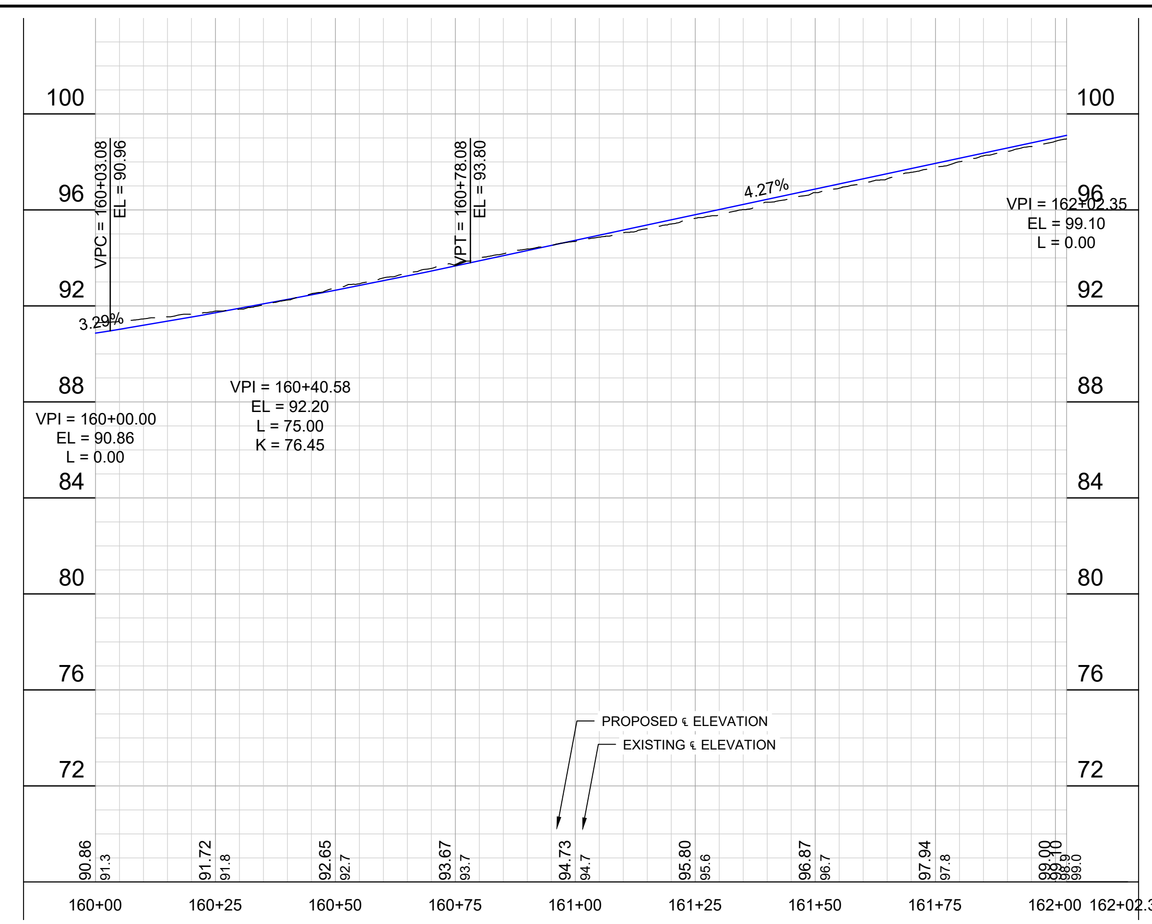
ROADWAY & STORM PLANS - MILWAUKEE AVE

PROJECT NO. 10310004

SHEET R17





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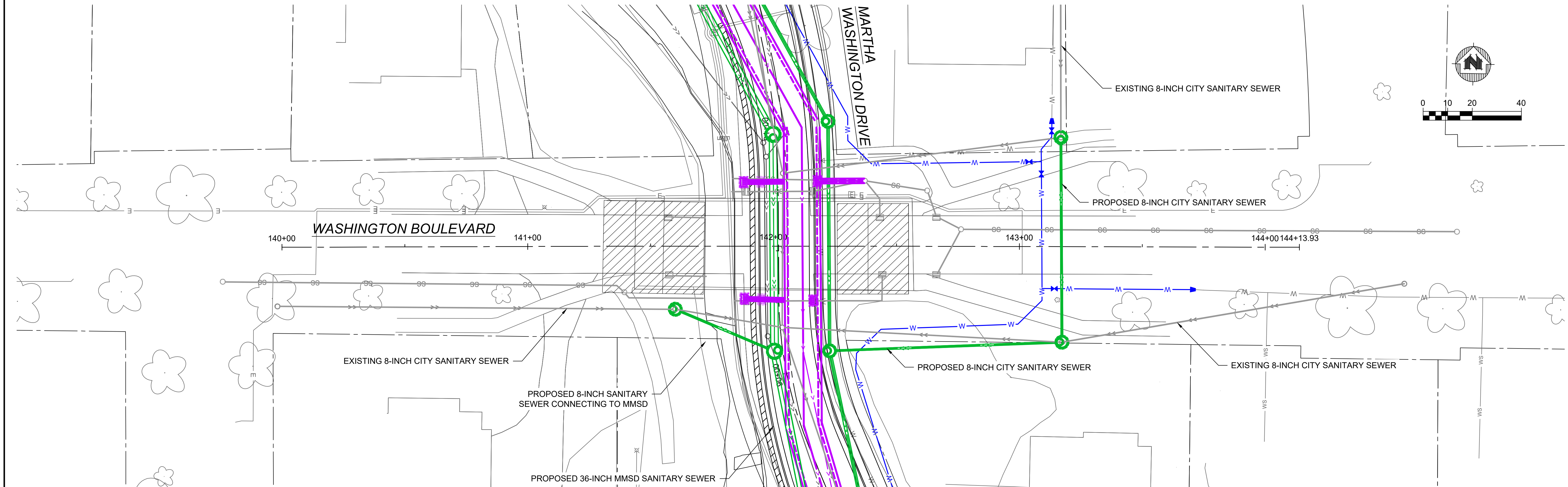
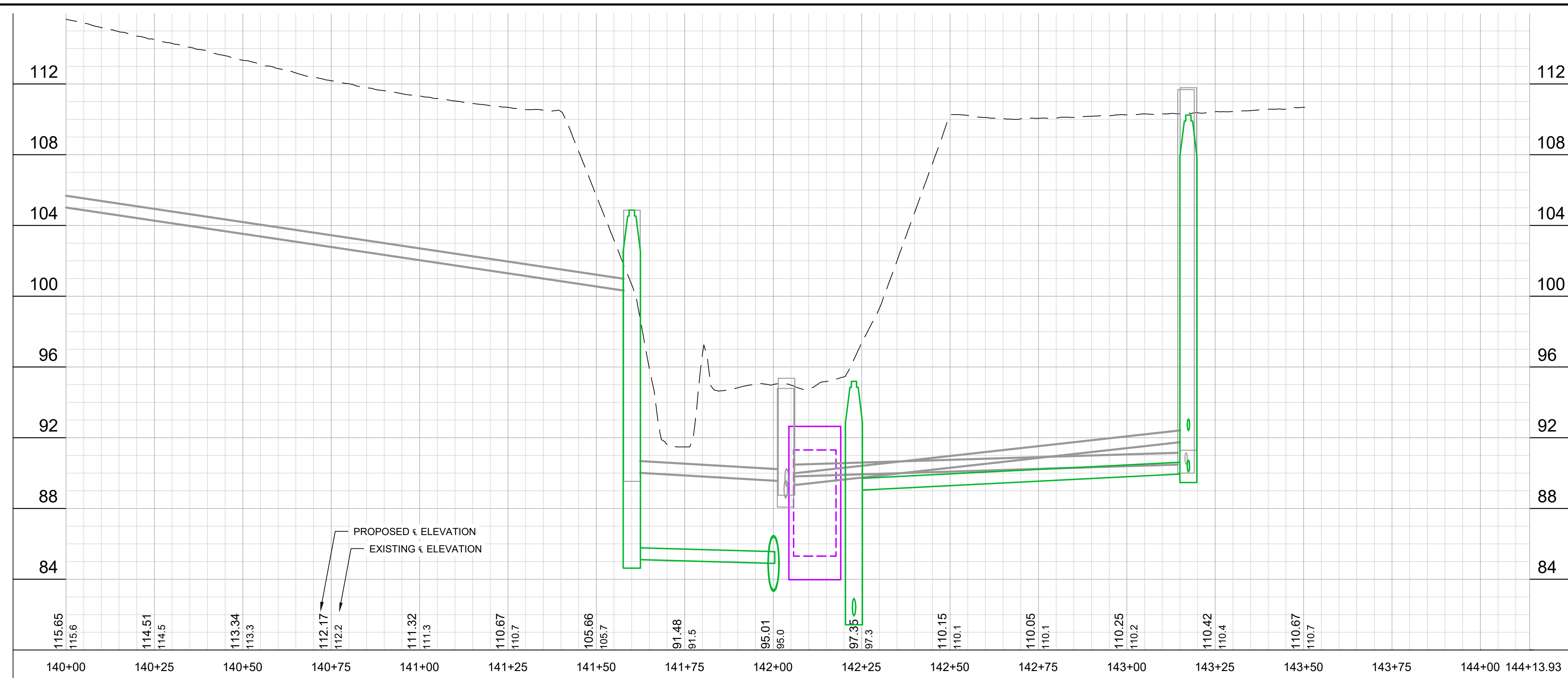
SCHOONMAKER CREEK PRELIMINARY PLANS
CITY OF WAUWATOSA
MILWAUKEE COUNTY, WI

ROADWAY & STORM PLANS - WASHINGTON CIRCLE

PROJECT NO. 10310004

SHEET R18





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SCHOONMAKER CREEK PRELIMINARY PLANS
CITY OF WAUWATOSA
MILWAUKEE COUNTY, WI

ROADWAY & STORM PLANS - WASHINGTON BOULEVARD

PROJECT NO. 10310004

SHEET R19

Appendix D. Desktop Analysis, North of W. Lloyd St, Utility Breakdown

City of Wauwatosa
Desktop Analysis
Date: 07/01/2024, Revised 09/04/2024

Notes and Assumptions:

1. Green cells indicate that water, sanitary or storm sewer within that section of roadway has been identified by the City as needing replacement or upsizing and serves as primary reason for street recontruction.
2. Orange cells indicate that the water, sanitary or storm sewer is being replaced or upsized while street reconstruction is occurring due to other primary utility upgrades within that block.
3. Yellow cells indicate upsized diameter of pipes based on the following:
   - Sanitary Sewer: Based on recommendations from 2011 Brown and Caldwell study
   - Potable Water: Based on preliminary water plan from City of Wauwatosa.
   - Storm Sewer: Pipe replacement of box culverts north of Lloyd Street along trunk line (ranging from 144" x 72" box to 36") based on hydrologic modeling from 2024 study by MSA. All other upsizing was not based on hydrologic modeling but replaced and upsized by a factor of 2.5x existing pipe capacity (slope not accounted for) per the City of Wauwatosa (see table below). Final pipe sizes to be determined during final design and to be based on hydrlogic/hydraulic modeling.
4. White cells are located within blocks that have no primary utility reconstructions scheduled however are branches to adjacent reconstructions and are being replaced or upsized to prevent flow restrictions.
5. Water and sewer cells outlined in red dashed lines are located in corridors where large diameter storm sewer trunk line is being reconstructed and will require water and sanitary mains to be dual pipes to avoid lateral conflicts
6. Street lengths and pavement widths based on WISLR data (pavement widths assume widths of 30" curb and gutter)
7. Curb and gutter lengths are not based on measured lengths and were calculated by doubling the street lengths (c&g on 2 sides of street)
8. Sidewalk areas are not based on measured areas and were calcuated using street lengths and an assumed width of 5' average per sidewalk
9. Existing street light sums based on City of Wauwatosa GIS mapped locations

Street Name	Start of Project	End of Project	Existing/Proposed: Streets					MMSD MIS					City Sanitary Sewer						Potable Water								Storm Sewer					
			Section Length (ft)	Pavement Width (ft)	C&G (LF)	Sidewalk (sf)	Street Lights	Current Diam	Type	Length	MH	Laterals	Current Diam	Planned Upsized Diam	Type	Length	MH	Laterals	Current Diam	Planned Upsized Diam	Type	Length	Hydrants	Valves	Curb Stops	Laterals	Current Diam	Planned Upsized Diam	Main Type	Main Length	MH	Inlets
W Lloyd St	N 61st St	N 62nd St	264	36	528	2640	2						8"	8"	Clay	290.7	3	7	6"	16"	Main	271.1	1	2	5	5	12"	18"	Conc	297.3	2	2
W Lloyd St	N 62nd St	N 63rd St	317	36	634	3170	2						8"	10"	Clay	300.8	2	9	6" 6"	16"	Main DI Main	330.03 303.78	1 0	2 2	5 4	5 4	15"	24"	Conc	301.9	2	2
W Lloyd St	N 63rd St	N 64th St	370	36	740	3700	2						10"	12"	Clay	328.4	2	10	6" 12"	16"	Main DI Main	332.09 332.1	1 0	2 1	6 4	6 4	21"	30"	RCP	346	2	2
W Lloyd St	N 64th St	N 65th St	370	36	740	2960	2						10"	15"	Clay	378.9	1	6	6" 12"	20"	Main DI Main	432.51 429.2	1 0	2 1	6 0	6 0	24"	36"	RCP	344.2	2	2
W Lloyd St	N 65th St	N 66th St	317	36	634	3170	2	18" 27"	Terra Cotta Terra Cotta	80 100	1 1	0 0	10"	15"	Clay	349.2	1	2	6" 12"	16"	Unknown Monocast	361.63 366.67	0 0	1 0	3 0	3 0	N/A	N/A	N/A	N/A	0	2
W Garfield Ave	N 61st St	N 62nd St	264	20	528	2640	2						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12"	18"	Conc	302.8	3	2
W Garfield Ave	N 62nd St	N 63rd St	317	20	634	3170	2						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15"	24"	Conc	298	4	2
W Garfield Ave	N 63rd St	N 64th St	370	20	740	3700	2						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15" 18" 21"	24" 27" 30"	Conc RCP RCP	165.5 5 182	1 1 1	2 0 0
W Garfield Ave	N 64th St	N 65th St	370	20	740	3700	2						8"	8"	PVC	234.7	2	2	6"	8"	Not Listed	379.7	0	2	3	3	24" 24"	36" 36"	Clay Conc	325 26.2	2 1	2 0
W Garfield Ave	N 65th St	N 66th St	370	20	740	3700	2						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24" 24"	 144" x 72"	Conc RCP	116 376.3	2 2	4 0
W Garfield Ave	N 66th St	N 67th St	370	20	740	3700	2	18"	Terra Cotta	300.85	2	0	10" 10"	10" 10"	Clay PVC	231 26.3	4 2	2 0	6"	8"	CI	287.79	0	2	2	2	54" 66"	144" x 72" 	RCP Main Conc Main	390 200	0 0	4 0
W North Ave	N 61st St	N 62nd St	264	40	528	2640	6						8"	12"	Clay	300.4	3	1	16"	16"	MKE cnty Main	300	0	0	1	1 (NC)	21"	30"	RCP Main	296.5	3	2
W North Ave	N 62nd St	N 63rd St	317	40	634	3170	5						8"	12"	Clay	299.4	2	5	12" 16"	16" 	DI MKE cnty Main	326.09 300	0 0	1 0	6 0	6 0	21"	30"	RCP Main	299	4	2
W North Ave	N 63rd St	N 64th St	317	40	634	3170	6						12"	15"	Clay	330.0	2	8	12" 16"	 20"	DI Main MKE cnty Main	328.98 330	0 0	1 1	7 0	 0	24"	36"	RCP Main	323.2	4	1
W North Ave	N 64th St	N 65th St	370	40	740	3700	7						15"	21"	Clay	382.7	2	11	12" 16"	 20"	DI Main MKE cnty Main	384.4 390	0 0	0 0	11 0	11 0	36"	54"	RCP Main	389	5	2
W North Ave	N 65th St	N 66th St	370	40	740	3700	7						18"	21"	Clay	362.0	2	6	12" 16"	 20"	DI Main MKE cnty Main	395.15 360	0 0	1 0	4 0	4 0	36" 26" x 39" Box	54" 	RCP Main RCP Main	377 39.9	3 0	2 0
W North Ave	N 66th St	N 67th St	370	40	740	3700	7	27"	Vitrified Clay	338.12	2	0	18" 18"	21" 21"	Clay Terra Cotta	337.9 13.01	2 1	5 0	12" 16"	 20"	DI Main MKE cnty Main	324.41 360	0 0	1 2	2 2	2 2	36" 42"	54" 60"	RCP Main RCP Main	362.2 19.5	2 3	2 0
W North Ave	N 67th St	N 68th St	317	40	634	3170	6	15" 18" 27"	Terra Cotta Terra Cotta Vitrified Clay	329.56 11.47 319.55	1 N/A 1	0 0 0	10"	18"	Clay	324.1	3	6	12" 16"	 20"	DI Main MKE cnty Main	320.71 330	0 0	0 0	1 3	1 3	48"	144" x 72"	RCP Main	356.2	2	3
W North Ave	N 68th St	N 69th St	317	40	634	3170	7	15" 27"	Terra Cotta Vitrified Clay	318.87 319.28	1 1	0 0	10"	10"	Clay	302.3	2	3	12" 16"	 20"	DI Main MKE cnty Main	348.85 300	1 1	3 3	4 0	4 0	63" x 98"	144" x 72"	RCP Elliptical	360.1	2	2
W North Ave	N 69th St	N 70th St	264	40	528	2640	2						10" 8"	- 15"	Clay Clay	260.55 403.17	3 2	4 6	12" 16"	 20"	DI Main MKE cnty Main	305.76 300	0 0	0 1	6 0	6 0	30" 54"	30" 54"	RCP RCP	79 359.53	1 2	0 1
W Meinecke Ave	N 61st St	N 62nd St	264	20	528	2640	2						N/A	N/A	N/A	N/A	N/A	N/A	6"	8"	Main	306.4	0	4	0	0	15"	24"	RCP Main	300.6	2	1
W Meinecke Ave	N 62nd St	N 63rd St	317	20	634	3170	2						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18" 21"	27" 30"	RCP Main RCP Main	248.7 19.4	1 1	3 0
W Meinecke Ave	N 63rd St	N 64th St	317	20	634	3170	2						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24"	36"	RCP Main	382	3	3
W Meinecke Ave	N 64th St	N 65th St	422	20	844	4220	2						8"	8"	PVC	223.8	2	2	6"	8"	Main	386.84	0	2	2	2	24"	36"	RCP Main	394.9	3	3
W Meinecke Ave	N 65th St	N 66th St	317	20	634	3170	2						8"	8"	Clay	212.7	2	3	6"	8"	Main	361.07	0	2	3	3	24"	36"	RCP Main	412.5	4	2
W Meinecke Ave	N 66th St	N 67th St	370	20	740	3700	2						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A						2
W Meinecke Ave	N 67th St	N 68th St	370	20	740	3700	2						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12" 15"	18" 24"	RCP Main RCP Main	52 321.1	1 3	1 1
W Meinecke Ave	N 68th St	N 69th St	264	20	528	2112	2						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	60" 60"	90" 90"	RCP Main RCP Main	302.3 30	1 1	2 0
W Meinecke Ave	N 69th St	N 70th St	317	20	634	3170	2	24"	Vitrified Clay	268.36	2	0	8"	8"	PVC	28.5	2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	60"	144" x 72"	RCP Main	290	0	0
W Wright St	N 62nd St	N 63rd St	317	26	634	3170	2						N/A	N/A	N/A	N/A	N/A	N/A	8"	8"	Unknown	298.53	0	1	0	0	15" 18"	24" 27"	RCP Main RCP Main	24.5 293.1	2 2	0 2
W Wright St	N 63rd St	N 64th St	317	26	634	3170	2						N/A	N/A	N/A	N/A	N/A	N/A	8"	8"	Unknown	330.16	0	1	0	0	18" 21"	27" 30"	RCP Main RCP Main	278.7 59.4	2 1	2 0
W Wright St	N 64th St	N 65th St	370	26	740	3700	2						8"	8"	PVC	220.1	2	2	12"	12"	CI Main	383.7	0	2	2	2	15" 24"	24" 36"	RCP Main RCP Main	46.4 389.6	0 2	0 3
W Wright St	N 65th St	N 66th St	317	26	634	3170	2						8"	8"	Clay	211.5	2	4	12"	12"	CI Main	360.31	0	1	4	4	27"	42"	Main	337.8	4	3
W Wright St	N 66th St	N 67th St	370	26	740	3700	2						N/A	N/A	N/A	N/A	N/A	N/A	12"	12"	CI Main	356.59	0	1	0	0	12"	18"	Conc Main	20	1	2

Street Name	Start of Project	End of Project	Existing/Proposed																													
			Streets					MMSD MIS					City Sanitary Sewer						Potable Water								Storm Sewer					
			Section Length (ft)	Pavement Width (ft)	C&G (LF)	Sidewalk (sf)	Street Lights	Current Diam	Type	Length	MH	Laterals	Current Diam	Planned Upsized Diam	Type	Length	MH	Laterals	Current Diam	Planned Upsized Diam	Type	Length	Hydrants	Valves	Curb Stops	Laterals	Current Diam	Planned Upsized Diam	Main Type	Main Length	MH	Inlets
W Wright St	N 67th St	N 68th St	370	26	740	3700	2						N/A	N/A	N/A	N/A	N/A	N/A	12"	12"	CI Main	329.21	0	1	0	0	12"	18"	Conc Main	340.9	3	2
																											16"	24"	PVC Main	37.4	0	0
W Wright St	N 68th St	N 69th St	264	26	528	2640	2						N/A	N/A	N/A	N/A	N/A	N/A	12"	12"	CI Main	302.87	0	1	0	0	18"	27"	RCP Main	39	1	2
																											21"	30"	RCP Main	270.9	2	0
W Wright St	N 69th St	N 70th St	317	26	634	3170	2						N/A	N/A	N/A	N/A	N/A	N/A	12"	12"	CI Main	289.64	0	1	0	0	15"	24"	RCP Main	39.1	0	2
																											21"	30"	RCP Main	276.6	2	0
W Wright St	N 70th St	N 71st St	317	26	634	3170	2						N/A	N/A	N/A	N/A	N/A	N/A	12"	12"	CI Main	254.9	0	1	0	0	48"	60" x 120"	RCP Main	268.8	2	2
																			12"	12"	DI Main	24.25	0	1	0	0	54"	60" x 120"	RCP Main	52.5	0	0
W Wright St	N 71st St	N 72nd St	264	26	528	2640	2	24"	Vitrified Clay	296.14	2	0	15"	15"	Clay	298.3	3	0	12"	12"	CI Main	297.97	0	1	0	0	42"	60"	RCP Main	176	1	7
W Wright St	N 72nd St	N Lefeber Ave	317	26	634	3170	2						12"	18"	Clay	287.7	2	0	12"	12"	CI Main	286.59	0	1	0	0	21"	30"	RCP Main	38	0	2
																											36"	54"	RCP Main	286.7	2	0
W Wright St	N Lefeber Ave	N 73rd St	264	26	528	2640	2						12"	15"	Clay	288.6	1	1	12"	12"	CI Main	286.82	0	1	1	1	12"	18"	RCP Main	26	1	2
																											36"	54"	RCP Main	288.2	1	0
W Wright St	N 73rd St	N 74th St	317	26	634	3170	2						12"	15"	Clay	285.8	1	0	12"	12"	CI Main	289.16	0	1	0	0	36"	54"	RCP Main	271.9	3	2
W Wright St	N 74th St	N 75th St	264	26	528	2640	1						8"	10"	Clay	255.2	2	3	12"	12"	CI Main	231.28	1	2	1	1	30"	48"	RCP Main	260.7	1	2
																											36"	54"	RCP Main	47.6	1	2
W Wright St	N 75th St	N 76th St	370	26	740	3700	2						8"	10"	Clay	392.6	3	9	12"	12"	CI Main	395.35	0	2	6	6	30"	48"	RCP Main	60	2	2
W Clarke St	N 62nd St	N 63rd St	317	26	634	3170	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16"	16"	DI Main	293.5	1	2	1	1	18"	27"	RCP Main	233.9	2	1
																			30"	30"	Concrete Main	294	0	0	0	0	15"	24"	RCP Main	28.6	1	0
W Clarke St	N 63rd St	N 64th St	317	26	634	3170	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16"	16"	DI Main	309.36	1	2	1	1	18"	27"	RCP Main	85.8	1	0
																			16"	16"	CI Main	20	0	0	0	0						
																			30"	30"	Concrete Main	330	0	0	0	0	24"	36"	RCP Main	277.3	3	1
W Clarke St	N 64th St	N 65th St	211	26	422	2110	2	N/A	N/A	N/A	N/A	N/A	8"	8"	PVC	38.6	1	1	8"	8"	DI Main	409.32	0	0	0	0	24"	36"	RCP Main	363.8	2	2
													8"	8"	Clay	213.4	2	3	24"	24"	Concrete Main	385	0	3	3	3	16"x30"	36"	Elliptical	25	0	0
W Clarke St	N 65th St	N 66th St	317	26	634	3170	2	N/A	N/A	N/A	N/A	N/A	8"	8"	Clay	316.6	2	7	6"	6"	CI Main	319.39	1	3	5	4	21"	30"	Conc Main	330	3	2
																			8"	8"	DI Main	27.61	0	1	0	0						
																			24"	24"	Concrete Main	360	0	0	2	2						
W Clarke St	N 66th St	N 67th St	370	26	740	3700	2	N/A	N/A	N/A	N/A	N/A	8"	8"	PVC	355.0	1	0	8"	8"	DIP Main	355.12	0	2	0	0	21"	30"	Conc Main	324	3	2
																			24"	24"	Concrete Main	350	0	0	0	0	24"	36"	Conc Main	28.5	0	0
W Clarke St	N 67th St	N 68th St	370	26	740	3700	2	24"	Unknown	338.63	1	0	8"	-	Clay	333.4	1	0	8"	8"	DI Main	328.98	0	2	0	0	24"	36"	Conc Main	303.9	3	2
													24"	27"	Unknown	338.6	1	0	24"	24"	Concrete Main	313.73	0	0	0	0	27"	42"	Conc Main	20	0	0
W Clarke St	N 68th St	N 69th St	317	26	634	3170	2	24"	Unknown	313.73	1	0	24"	24"	Unknown	313.7	1	0	24"	24"	Concrete Main	300	0	0	0	0	27"	42"	Conc Main	259.5	2	2
W Clarke St	N 69th St	N 70th St	264	26	528	2640	2	24"	Unknown	297.2	1	0	N/A	N/A	N/A	N/A	N/A	N/A	24"	24"	Concrete Main	290	0	0	0	0	30"	48"	Conc Main	250.7	2	2
W Clarke St	N 70th St	N 71st St	317	26	634	3170	2	24"	Unknown	256.36	1	0	N/A	N/A	N/A	N/A	N/A	N/A	24"	24"	Concrete Main	280	0	0	0	0	36"	54"	Conc Main	318.5	1	3
W Clarke St	N 71st St	N 72nd St	264	26	528	2640	2	15"	Vitrified Clay	10.11	1	0	N/A	N/A	N/A	N/A	N/A	N/A	24"	24"	Concrete Main	300	0	0	0	0	30"	36"	RCP/Conc Main	299.8	3	3
								24"	Unknown	283.2	2	0																				
W Clarke St	N 72nd St	N Lefeber Ave	317	26	634	3170	2	18"	Vitrified Clay	288	1	0	12"	12"	Clay	287.8	3	0	24"	24"	Concrete Main	290	0	0	0	0	15"	36"	RCP Main	63.7	2	0
																											27"	36"	Conc Main	261.6	1	0
																											30"	36"	Conc Main	32	1	0
W Clarke St	N Lefeber Ave	N 73rd St	264	26	528	2640	2	18"	Vitrified Clay	306.85	2	0	12"	12"	Clay	288.7	2	0	24"	24"	Concrete Main	290	0	1	0	0	24"	36"	Conc Main	262.5	2	2
																											27"	36"	RCP Main	26.5	1	0
W Center St	N 73rd St	N 74th St	264	46	528	2640	2	15"	Vitrified Clay	230.02	2	0	10"	10"	Clay	287.9	2	7	8"	8"	DI Main	286.22	1	3	3	3	54"	78"	Milw. Main	284.7	1	2
W Center St	N 74th St	N 75th St	211	46	422	2110	2	15"	Vitrified Clay	280.46	1	0	10"	10"	Clay	273.5	1	5	8"	8"	PVC	274.07	0	2	3	3	60"	90"	Milw. Main	274.9	1	0
W Center St	N 75th St	N 76th St	317	46	634	3170	2						10"	12"	Clay	350.7	2	4	6"	8"	CI Main	273.44	1	2	1	1	60"	90"	Milw. Main	366.3	1	0
																			8"	8"	CI Main	56.06	0	1	0	0						
N 76th St	W Center St	Eagle St	150	30	150	1500	3						10"	12"	Clay	361.4	4	3	6"	8"	CI Main	138.92	0	1	3	2	21"	30"	Conc Main	359.9	4	1
																			8"	8"	DI Main	214.67	0	2	1	1						
N 73rd St	W Center St	W Clarke St	686	20	1372	6860	3	18"	Vitrified Clay	631.78	2	0	12"	12"	Clay	667.7	5	5	6"	8"	Main	608.26	3	3	23	23	42"	42"	RCP Main	115	2	5
N 71st St	W Clarke St	W Wright St	686	20	1372	6860	3						8"	8"	PVC	663.1	3	1	6"	8"	CI Main	660	3	1	30	30	42"	66"	RCP Main	606.9	3	6
																											48"	66"	RCP Main	20	0	0
N 70th St	W Wright St	W Meinecke Ave	686	20	1372	6860	3						8"	8"	PVC	662.1	3	28	6"	8"	Main	600	3	5	30	30	54"	60" x 120"	RCP Main	613.8	1	4
N 70th St	W Meinecke Ave	W North St	634	20	1268	6340	3						8"	8"	PVC	1066	7	25	6"	8"	Main	705.15	1	2	24	24	54"		RCP Main	554.5	2	6
N 69th St	W Clarke St	W Wright St	634	20	1268	6340	3						8"	12"	Clay	661.7	2	30	6"	8"	CI Main	685.85	1	2	30	30						2
N 69th St	W Wright St	W Meinecke Ave	686	20	1372	6860	3						8"	12"	PVC	331.2	1	16	6"	8"	Main	630	3	5	30	30						2
													8"	-	Clay	332.7	2	14														
N 69th St	W Meinecke Ave	W North Ave	634	20	1268	6340	6	24"	Vitrified Clay	653.36	3	0	10"		PVC	12.1	0	0	6"	8"	Main	670	1	3	23	23	60"	144" x 72"	RCP Main	640	0	2
													15"	18"	Clay	497.8	3	24														
N 68th St	W Clarke St	W Wright St	634	26	1268	6340	3						8"	12"	Clay	663.4	5	30	6"	8"	CI Main	627	1	2	30	30	12"	18"	RCP Main	60.1	2	4
																			8"	8"	DI Main	42.23	0	2	0	0	16"	24"	PVC Main	37.4	2	0
N 68th St	W Wright St	W Meinecke Ave	739	26	1478	7390	3						8"	12"	Clay	663.5	4	30	8"	8"	Main	642	3	5	30	30						2
N 68th St	W Meinecke Ave	W North Ave	634	26	1268	6340	5						8"	12"	Clay	666.3	4	24	8"	8"	Main	711.5	1	2	22	22	12"	18"	RCP Main	106	2	4
N 67th St	W Meineke Ave	W North Ave	634	20	1268	6340	4	24"	Unknown	660	2	0	8"	12"	Clay	666.4	5	23	6"	8"	Main	660	1	2	23	23	12"	18"	RCP Main	116.2	3	3
													12"	12"	Clay	12.5	0	0									15"	24"	RCP Main	29.3	0	1
N 67th St	W North Ave	W Garfield Ave	686	20	1372	6860	4	18"	Terra Cotta	631.91	3`	0	10"	10"	PVC	724.5	3	20	6"	8"	CI Main	534.2	0	1	19	19	54"	144" x 72"	RCP Main	620	1	5
																			6"	8"	DI Main	97.7	0	4	1	1	Unknown	Unknown	Private	40	0	0
N 66th St	W Meineke Ave	W North Ave	634	20	1268	6340	4						8"	12"	Clay	665.8	3	24	6"	8"	Main	310.63	0	0	12	12	30"	48"	RCP Main	231.3	2	4
													12"	12"	Clay	9.3	0	0	6"	8"	CI Main	229.29	1	3	11	11	26" x 39"		RCP Main: BOX	76.8	2	0
N 66th St	W North Ave	W Garfield Ave	686	20	1372	6860	4	27"	Vitrified Clay	277.49	1	0	8"	8"	Clay	416.8	2	17	6"	8"	Main	631.5	3	5	24	24	36"	54"	RCP Main	638.4	4	3
								27"	Terra Cotta	401.65	1	0	8"	8"	PVC	203.9	2	8														
N 65th St	W Wright St	W Meinecke Ave	634	20	1268	6340	3						10"	12"	PVC	663.2	2	30	6"	8"	Main	658.87	2	3	30	30	24"	36"	RCP Main	596	3	4
N 65th St	W Meinecke Ave	W North Ave	686	20	1372	6860	4						10"	12"	PVC	331	1	14	6"	8"	Main	640.44	2	5	24	24	24"	36"	RCP Main	470.6	2	4
													12"	12"	PVC	334.3	1	9									30"	48"	RCP Main	139	1	0
N 65th St	W North Ave	W Garfield Ave	686	20	1372	6860	4						8"	10"	Clay	618.3	4	25	6"	8"	Main	645.58	2	5	24	24	36"	54"	RCP Main	642.1	6	2
N 65th St	W Garfield Ave	W Lloyd Ave	739	20	1478	7390	3						8"	10"	Clay	735.5	4	29	6"	8"	Main	721.34	2	3	28	28	36"	144" x 72"	RCP Main	680	4	2

Street Name	Start of Project	End of Project	Existing/Proposed																													
			Streets					MMSD MIS					City Sanitary Sewer						Potable Water								Storm Sewer					
			Section Length (ft)	Pavement Width (ft)	C&G (LF)	Sidewalk (sf)	Street Lights	Current Diam	Type	Length	MH	Laterals	Current Diam	Planned Upsized Diam	Type	Length	MH	Laterals	Current Diam	Planned Upsized Diam	Type	Length	Hydrants	Valves	Curb Stops	Laterals	Current Diam	Planned Upsized Diam	Main Type	Main Length	MH	Inlets
N 64th St	W Clarke St	W Wright St	792	20	1584	7920	3						8"	8"	PVC	630.1	7	20	6"	24"	CI Main	603.36	0	1	25	25	12"	18"	RCP Main	228.9	2	4
																			8"		DI Main	50	2	3	1	1						
													8"	8"	Clay	159.1	1	6	16"		CI Main	653.01	0	3	1	1						
N 64th St	W Wright St	W Meinecke Ave	528	20	1056	5280	3						8"	10"	Clay	663.3	3	30	6"		CI Main	669.77	2		30	30						3
																			12"	24"	Monocast Main	670	0	1	0	0						
N 64th St	W Meinecke Ave	W North Ave	581	20	1162	5810	4						8"	10"	Clay	665.8	4	22	6"	24"	CI Main	687.75	2	4	20	20						
																			12"		Monocast Main	660	0	1	0	0						4
N 64th St	W North Ave	W Garfield Ave	686	20	1372	6860	4						8"	10"	Clay	623	3	26	6"	20"	Main	647.92	2	4	25	25	15"	24"	RCP Main	219.7	2	5
																			12"		Monocast Main	680	0	2	0	0						
N 64th St	W Garfield Ave	W Lloyd Ave	739	20	1478	7390	3						8"	10"	Clay	734.9	2	30	6"	20"	Main	717.77	2	4	29	29	12"	18"	RCP Main	199.8	2	6
																			12"		Monocast Main	730	0	1	0	0	15"	24"	RCP Main	277.7	1	0
N 63rd St	W Meinecke Ave	W North Ave	686	20	1372	6860	4						8"	12"	Clay	662.2	4	24	6"	8"	Main	603.82	2	2	24	24					1	3
N 63rd St	W North Ave	W Garfield Ave	686	20	1372	6860	4						8"	8"	Clay	561.22	4	30	6"	8"	Main	665.21	2	5	25	25	12"	18"	RCP Main	207.8	1	2
																											15"	24"	RCP Main	33.7	1	2
N 63rd St	W Garfield Ave	W Lloyd St	686	20	1372	6860	4						8"	8"	Clay	733.8	4	28	6"	8"	Main	672.93	2	4	28	28	12"	18"	RCP Main	272.8	2	4
																											15"	24"	RCP Main	58.3	0	0
N 62nd St	W Clarke St	W Wright St	686	20	1372	6860	4						8"	8"	Clay	667.1	3	30	6"		Main	625.4	1	3	27	27	15"	24"	RCP Main	227	2	4
																			16"	16"	DI Main	688.14	0	1	0	0						
N 62nd St	W Wright St	W Meineke Ave	634	20	1268	6340	4						8"	8"	Clay	658.9	4	30	6"		Main	593.62	3	3	28	28	12"	18"	RCP Main	263	2	4
																			16"	16"	DI Main	598.53	0	2	0	0						
N 62nd St	W Meinecke Ave	W North Ave	686	20	1372	6860	4						8"	12"	Clay	663.8	5	23	6"		Main	671.31	1	2	21	21						4
																			16"	16"	DI Main	688.05	0	1	1	1						
N 62nd St	W North St	W Garfield Ave	686	20	1372	6860	4						8"	10"	Clay	616.2	4	28	6"		Main	640	2	5	28	28						2
																			16"	16"	DI Main	700	0	1	0	0						2
N 62nd St	W Garfield Ave	W Lloyd Ave	739	20	1478	7390	3						8"	10"	Clay	735.6	4	29	6"		Main	683.32	2	3	29	29						2
																			16"	16"	DI Main	720	0	1	0	0						
N 61st St	W Meinecke Ave	W North Ave	686	20	1372	6860	4						8"	10"	Clay	665.5	5	27	6"	16"	Main	644.91	1	2	23	23						4
N 61st St	W North Ave	W Garfield Ave	686	20	1372	54880	4						8"	10"	Clay	629.3	5	29	6"	16"	Main	700	2	3	26	26						2
N 61st St	W Garfield Ave	W Lloyd Ave	739	20	1478	7390	3						8"	10"	Clay	376.1	1	18	6"	16"	Main	680	2	3	30	30						2
													8"	10"	PVC	362.8	1	12														

Storm Sewer Upsizing Chart

Diameter (in)	Diameter (ft)	n	K	2.5 x K	Upsized Diameter (in)
8	0.67	0.013	12.1	1.7	12
10	0.83	0.013	21.9	2.1	15
12	1	0.013	35.6	2.5	**18**
15	1.25	0.013	64.6	3.1	**24**
18	1.5	0.013	105.0	3.8	**27**
21	1.75	0.013	158.5	4.4	**30**
24	2	0.013	226.2	5.0	**36**
27	2.25	0.013	309.7	5.6	**42**
30	2.5	0.013	410.2	6.3	**48**
36	3	0.013	667.0	7.5	**54**
42	3.5	0.013	1006.1	8.8	**60**
48	4	0.013	1436.4	10.0	**72**
54	4.5	0.013	1966.5	11.3	**78**
60	5	0.013	2604.4	12.5	**90**
66	5.5	0.013	3358.1	13.8	**96**

Note: Pipe capacity does not account for slope

Appendix E. Option A, Tunnel Alignment, Preliminary Cost Estimate

ESTIMATE OF PROBABLE COST Schoonmaker Creek Alignment 1		ESTIMATE OF PROBABLE COST Schoonmaker Creek Alignment 2		ESTIMATE OF PROBABLE COST Schoonmaker Creek Alignment 3	
ITEM DESCRIPTION	TOTAL COST	ITEM DESCRIPTION	TOTAL COST	ITEM DESCRIPTION	TOTAL COST
Mobe/Demobe		**Mobe/Demobe**		**Mobe/Demobe**	
MOBILIZATION (Mobe equipment site includes MTBM shipping cost, cutters, seal etc.)	$ 410,072.04	MOBILIZATION (Mobe equipment site includes MTBM shipping cost, cutters, seal etc.)	$ 410,072.04	MOBILIZATION (Mobe equipment site includes MTBM shipping cost, cutters, seal etc.)	$ 410,072.04
Receiving Shaft		**Receiving Shaft**		**Receiving Shaft**	
TEMPORARY FENCE, (8 ft. high, chain link)	$ 37,363.04	TEMPORARY FENCE, (8 ft. high, chain link)	$ 37,363.04	TEMPORARY FENCE, (8 ft. high, chain link)	$ 37,363.04
CHAIN LINK VEHICULAR GATE, (8 ft. X 20 ft.)	$ 16,681.52	CHAIN LINK VEHICULAR GATE, (8 ft. X 20 ft.)	$ 16,681.52	CHAIN LINK VEHICULAR GATE, (8 ft. X 20 ft.)	$ 16,681.52
GRAVEL SITE WORK AREA	$ 141,394.40	GRAVEL SITE WORK AREA	$ 141,394.40	GRAVEL SITE WORK AREA	$ 141,394.40
SHORING (assume 30 foot dia 23 foot deep)	$ 401,772.36	SHORING (assume 25 foot dia 54 foot deep)	$ 948,698.76	SHORING (assume 30 foot dia 54 foot deep)	$ 948,698.76
EXCAVATE SHAFT - Soil 30 foot dia 23 foot deep	$ 57,657.84	EXCAVATE SHAFT - Soil 25 foot dia 54 foot deep	$ 144,144.60	EXCAVATE SHAFT - Soil 30 foot dia 54 foot deep	$ 144,144.60
POUR MUDSLAB (assume 3 foot thick)	$ 34,276.87	POUR MUDSLAB (assume 3 foot thick)	$ 34,276.87	POUR MUDSLAB (assume 3 foot thick)	$ 34,276.87
HAUL SPOILS (Shaft) 6-mile cycle	$ 47,467.20	HAUL SPOILS (Shaft) 6-mile cycle	$ 94,934.40	HAUL SPOILS (Shaft) 6-mile cycle	$ 94,934.40
SHAFT STRUCTURE	$ 700,905.00	SHAFT STRUCTURE	$ 1,823,505.30	SHAFT STRUCTURE	$ 1,823,505.30
SHAFT EXCAVATION	$ 672,656.27	SHAFT EXCAVATION	$ 672,656.27	SHAFT EXCAVATION	$ 672,656.27
	$ 2,110,174.50		$ 3,913,655.16		$ 3,913,655.16
Launching shaft		**Launching shaft**		**Launching shaft**	
SHORING (assume 35 foot dia 35 foot deep)	$ 727,984.20	SHORING Secant Piles(assume 35 foot dia 56 foot deep)	$ 1,133,536.56	SHORING (assume 35 foot dia 47. foot deep)	$ 950,804.76
EXCAVATE SHAFT - Soil 35 vf	$ 115,315.68	EXCAVATE SHAFT - Soil 56 vf	$ 201,802.44	EXCAVATE SHAFT - Soil 47 vf	$ 172,973.52
POUR MUDSLAB (assume 3 foot thick)	$ 38,989.42	POUR MUDSLAB (assume 3 foot thick)	$ 38,989.42	POUR MUDSLAB (assume 3 foot thick)	$ 38,989.42
HAUL SPOILS (Shaft) 6-mile cycle	$ 83,067.60	HAUL SPOILS (Shaft) 6-mile cycle	$ 130,534.80	HAUL SPOILS (Shaft) 6-mile cycle	$ 106,801.20
MONITOR SETTLEMENT ARRAY	$ 106,559.41	MONITOR SETTLEMENT ARRAY	$ 166,499.08	MONITOR SETTLEMENT ARRAY	$ 139,859.22
	$ 1,071,916.31		$ 1,671,362.30		$ 1,409,428.12
Outfall		**Outfall**		**Outfall**	
DISCHARGE STRUCTURE	$ 1,568,680.00	DISCHARGE STRUCTURE	$ 1,568,680.00	DISCHARGE STRUCTURE	$ 1,568,680.00
OPEN CUT PIPE	$ 575,000.00	DISCHARGE CHANNEL	$ 156,000.00		
	$ 2,143,680.00		$ 1,724,680.00		$ 1,568,680.00
Tunnel		**Tunnel**		**Tunnel**	
TBM ASSEMBLY/LAUNCH	$ 3,140,148.62	TBM ASSEMBLY/LAUNCH	$ 3,140,148.62	TBM ASSEMBLY/LAUNCH	$ 3,140,148.62
TUNNEL 120 inch	$ 17,094,819.20	TUNNEL 120 inch	$ 18,050,450.47	TUNNEL 120 inch	$ 18,795,552.58
HAUL SPOILS (Tunnel) 6-mile cycle	$ 3,516,639.00	HAUL SPOILS (Tunnel) 6-mile cycle	$ 3,684,098.00	HAUL SPOILS (Tunnel) 6-mile cycle	$ 3,851,557.00
TBM DISASSEMBLY/REMOVAL	$ 1,449,574.31	TBM DISASSEMBLY/REMOVAL	$ 1,449,574.31	TBM DISASSEMBLY/REMOVAL	$ 1,449,574.31
	$ 25,201,181.13		$ 26,324,271.40		$ 27,236,832.51
Subtotal	$ 30,937,023.98		$ 34,044,040.90		$ 34,538,667.83
GC General Conditions	$ 3,093,702.40		$ 3,404,404.09		$ 3,453,866.78
Permits and Bonds	$ 1,242,121.51		$ 1,366,868.24		$ 1,386,727.51
Overhead and Profit	$ 3,527,284.79		$ 3,881,531.32		$ 3,937,926.21
Construction Contingency Class 5	$ 9,700,033.17		$ 10,674,211.14		$ 10,829,297.08
Escalation to 2025	$ -		$ -		$ -
TOTAL	$ 48,500,165.85		$ 53,371,055.69		$ 54,146,485.42

Appendix F. Option B, Storm Improvements, Preliminary Cost Estimate

SCHOONMAKER CREEK PRELIMINARY ESTIMATE OF COSTS
City of Wauwatosa UPDATED 10/08/2024

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	TOTAL PRICE (excl storm)
	West Lloyd St (66th St to 65th St)				$1,855,274.26	$877,411.72
1	Mobilization/Bonds/Insurance (5%)	1	LS	$88,346.39	$88,346.39	$77,844.85
2	Traffic Control (1.5%)	1	LS	$25,857.48	$25,857.48	$25,857.48
3	Erosion Control (lnlet Protection) (1%)	1	LS	$17,238.32	$17,238.32	$17,238.32
4	Unclassified Excation	815	CY	$20.00	$16,300.00	$16,300.00
5	Tree Removal	20	EA	$2,000.00	$40,000.00	$40,000.00
6	Tree Replace in Kind	20	EA	$500.00	$10,000.00	$10,000.00
7	Remove Existing Street Light Pole	2	EA	$550.00	$1,100.00	$1,100.00
8	Street Light Pole Replace in Kind	2	EA	$3,200.00	$6,400.00	$6,400.00
9	Remove Existing Pavement	2153	SY	$37.00	$79,661.00	$79,661.00
10	Remove Existing Curb and Gutter	1010	LF	$40.00	$40,400.00	$40,400.00
11	Remove Existing Sidewalk	3191	SF	$5.00	$15,955.00	$15,955.00
12	Sawcut Asphalt Pavement	130	LF	$2.50	$325.00	$325.00
13	Excavation Below Subgrade (EBS)	179	CY	$55.00	$9,867.91	$9,867.91
14	3-Inch Breaker Run (EBS)	179	CY	$35.00	$6,279.58	$6,279.58
15	Crushed Aggregate Base Course 3/4 Inch	1435	TN	$16.00	$22,965.32	$22,965.32
16	Asphaltic Concrete Pavement Binder, 3.25-Inch Thick	402	TN	$85.00	$34,199.05	$34,199.05
17	Asphaltic Concrete Pavement Surface, 1.75-Inch Thick	217	TN	$85.00	$18,414.87	$18,414.87
18	Concrete Curb and Gutter, 31-Inch Type L W/Base	1010	LF	$40.00	$40,400.00	$40,400.00
19	Concrete Sidewalk, 5-Inch Thick W/4-Inch Base	3191	SF	$10.00	$31,910.00	$31,910.00
20	Concrete Ramp/Driveway Crossing, 7—Inch Thick W/4-Inch Base	186	SF	$12.00	$2,232.00	$2,232.00
21	15" RCP Storm	39	LF	$145.00	$5,655.00	
22	18" RCP Storm	28	LF	$150.00	$4,200.00	
23	144" x 72" Concrete Box Culvert Storm	377	LF	$2,000.00	$754,000.00	
24	12" RCP Storm	24	LF	$145.00	$3,480.00	
25	27" RCP Storm	26	LF	$200.00	$5,200.00	
26	60" RCP Storm	21	LF	$700.00	$14,700.00	
27	Storm Inlet Type 3: 2 ft.x 3 ft. Inlet W/Casting Complete (Double Inlets)	7	EA	$6,000.00	$42,000.00	
28	4' Diameter Cast in Place Storm Manhole with Casting and Grate	3	EA	$4,000.00	$12,000.00	
29	6' Diameter Cast in Place Storm Manhole with Casting and Grate	1	EA	$8,000.00	$8,000.00	
30	8' Diameter Cast in Place Storm Manhole with Casting and Grate	1	EA	$10,000.00	$10,000.00	
31	22' x 27' Cast-In-Place Storm Junction Structure	1	EA	$100,000.00	$100,000.00	
32	Connect to Existing Storm	1	EA	$3,500.00	$3,500.00	
33	Trench Backfill - Storm Sewer	514	TF	$9.00	$4,626.00	
34	Remove Existing Sanitary Sewer Manhole	2	EA	$1,300.00	$2,600.00	$2,600.00
35	48" Sanitary Sewer Manhole W/Casting Complete	2	EA	$12,000.00	$24,000.00	$24,000.00
36	Manhole Chimney Seal	2	EA	$525.00	$1,050.00	$1,050.00
37	Remove Existing Sanitary Sewer	443	LF	$30.00	$13,290.00	$13,290.00
38	12" PVC Sanitary Sewer	413	LF	$200.00	$82,600.00	$82,600.00
39	Connect to Existing Sanitary Sewer	2	EA	$2,000.00	$4,000.00	$4,000.00
40	Trench Backfill - Sanitary Sewer	413	TF	$3.00	$1,239.00	$1,239.00

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	TOTAL PRICE (excl storm)
41	Abandon Existing Watermain	362	LF	$7.00	$2,534.00	$2,534.00
42	Remove Existing Watermain	223	LF	$20.00	$4,460.00	$4,460.00
43	16" PVC Watermain	731	LF	$270.00	$197,370.00	$197,370.00
44	Connect to Existing Watermain	7	EA	$6,000.00	$42,000.00	$42,000.00
45	Terrace Restoration- Topsoil, Seed, Fertilize, & Hydro-Mulch	757	SY	$6.50	$4,918.33	$4,918.33
	Martha Washington Dr (Revere Ave to Washington Circle)				$1,899,724.40	$829,418.96
46	Mobilization/Bonds/Insurance (5%)	1	LS	$90,463.07	$90,463.07	$79,082.63
47	Traffic Control (1.5%)	1	LS	$26,477.00	$26,477.00	$26,477.00
48	Erosion Control (lnlet Protection) (1%)	1	LS	$17,651.33	$17,651.33	$17,651.33
49	Unclassified Excation	684	CY	$20.00	$13,680.00	$13,680.00
50	Tree Removal	18	EA	$2,000.00	$36,000.00	$36,000.00
51	Tree Replace in Kind	18	EA	$500.00	$9,000.00	$9,000.00
52	Remove Existing Street Light Pole	3	EA	$550.00	$1,650.00	$1,650.00
53	Street Light Pole Replace in Kind	3	EA	$3,200.00	$9,600.00	$9,600.00
54	Remove Existing Pavement	1744	SY	$37.00	$64,528.00	$64,528.00
55	Remove Existing Curb and Gutter	1067	LF	$40.00	$42,680.00	$42,680.00
56	Remove Existing Sidewalk	2397	SF	$5.00	$11,985.00	$11,985.00
57	Sawcut Asphalt Pavement	81	LF	$2.50	$202.50	$202.50
58	Excavation Below Subgrade (EBS)	145	CY	$55.00	$7,992.31	$7,992.31
59	3-Inch Breaker Run (EBS)	145	CY	$35.00	$5,086.02	$5,086.02
60	Crushed Aggregate Base Course 3/4 Inch	1163	TN	$16.00	$18,600.29	$18,600.29
61	Asphaltic Concrete Pavement Binder, 3.25-Inch Thick	326	TN	$85.00	$27,698.81	$27,698.81
62	Asphaltic Concrete Pavement Surface, 1.75-Inch Thick	175	TN	$85.00	$14,914.75	$14,914.75
63	Concrete Curb and Gutter, 31-Inch Type L W/Base	1067	LF	$40.00	$42,680.00	$42,680.00
64	Concrete Sidewalk, 5-Inch Thick W/4-Inch Base	2397	SF	$10.00	$23,970.00	$23,970.00
65	Concrete Ramp/Driveway Crossing, 7—Inch Thick W/4-Inch Base	122	SF	$12.00	$1,464.00	$1,464.00
66	15" RCP Storm	81	LF	$145.00	$11,745.00	
67	18" RCP Storm	24	LF	$150.00	$3,600.00	
68	144" x 72" Concrete Box Culvert Storm	464	LF	$2,000.00	$928,000.00	
69	12" RCP Storm	6	LF	$145.00	$870.00	
70	27" RCP Storm	17	LF	$200.00	$3,400.00	
71	Storm Inlet Type 3: 2 ft.x 3 ft. Inlet W/Casting Complete (Double Inlets)	17	EA	$6,000.00	$102,000.00	
72	4' Diameter Cast in Place Storm Manhole with Casting and Grate	1	EA	$4,000.00	$4,000.00	
73	Trench Backfill - Storm Sewer	590	TF	$9.00	$5,310.00	
74	5' x 17' Grade Change Structure (Storm)	1	EA	$2,000.00	$2,000.00	$2,000.00
75	Remove Existing Sanitary Sewer Manhole	5	EA	$1,300.00	$6,500.00	$6,500.00
76	48" Sanitary Sewer Manhole W/Casting Complete	7	EA	$12,000.00	$84,000.00	$84,000.00
77	Manhole Chimney Seal	7	EA	$525.00	$3,675.00	$3,675.00
78	Remove Existing Sanitary Sewer	571	LF	$30.00	$17,130.00	$17,130.00
79	12" PVC Sanitary Sewer	485	LF	$200.00	$97,000.00	$97,000.00
80	8" PVC Sanitary Sewer	102	LF	$60.00	$6,120.00	$6,120.00
81	Connect to Existing Sanitary Sewer	3	EA	$2,000.00	$6,000.00	$6,000.00
82	Trench Backfill - Sanitary Sewer	586	TF	$3.00	$1,758.00	$1,758.00
83	Abandon Existing Watermain	180	LF	$7.00	$1,260.00	$1,260.00

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	TOTAL PRICE (excl storm)
84	Remove Existing Watermain	210	LF	$20.00	$4,200.00	$4,200.00
85	16" PVC Watermain	502	LF	$270.00	$135,540.00	$135,540.00
86	Connect to Existing Watermain	1	EA	$6,000.00	$6,000.00	$6,000.00
87	Terrace Restoration- Topsoil, Seed, Fertilize, & Hydro-Mulch	507	SY	$6.50	$3,293.33	$3,293.33
	Martha Washington Dr (Washington Circle to Upper Parkway N)				**$1,083,655.69**	**$487,369.69**
88	Mobilization/Bonds/Insurance (5%)	1	LS	$51,602.65	$51,602.65	$44,586.65
89	Traffic Control (1.5%)	1	LS	$15,103.22	$15,103.22	$15,103.22
90	Erosion Control (lnlet Protection) (1%)	1	LS	$10,068.81	$10,068.81	$10,068.81
91	Unclassified Excation	468	CY	$20.00	$9,360.00	$9,360.00
92	Tree Removal	10	EA	$2,000.00	$20,000.00	$20,000.00
93	Tree Replace in Kind	10	EA	$500.00	$5,000.00	$5,000.00
94	Remove Existing Street Light Pole	2	EA	$550.00	$1,100.00	$1,100.00
95	Street Light Pole Replace in Kind	2	EA	$3,200.00	$6,400.00	$6,400.00
96	Remove Existing Pavement	1206	SY	$37.00	$44,622.00	$44,622.00
97	Remove Existing Curb and Gutter	698	LF	$40.00	$27,920.00	$27,920.00
98	Remove Existing Sidewalk	1017	SF	$5.00	$5,085.00	$5,085.00
99	Sawcut Asphalt Pavement	78	LF	$2.50	$195.00	$195.00
100	Excavation Below Subgrade (EBS)	100	CY	$55.00	$5,523.47	$5,523.47
101	3-Inch Breaker Run (EBS)	100	CY	$35.00	$3,514.93	$3,514.93
102	Crushed Aggregate Base Course 3/4 Inch	803	TN	$16.00	$12,854.61	$12,854.61
103	Asphaltic Concrete Pavement Binder, 3.25-Inch Thick	225	TN	$85.00	$19,142.57	$19,142.57
104	Asphaltic Concrete Pavement Surface, 1.75-Inch Thick	121	TN	$85.00	$10,307.54	$10,307.54
105	Concrete Curb and Gutter, 31-Inch Type L W/Base	698	LF	$40.00	$27,920.00	$27,920.00
106	Concrete Sidewalk, 5-Inch Thick W/4-Inch Base	1017	SF	$10.00	$10,170.00	$10,170.00
107	Concrete Ramp/Driveway Crossing, 7—Inch Thick W/4-Inch Base	120	SF	$12.00	$1,440.00	$1,440.00
108	15" RCP Storm	40	LF	$145.00	$5,800.00	
109	18" RCP Storm	100	LF	$150.00	$15,000.00	
110	144" x 72" Concrete Box Culvert Storm	255	LF	$2,000.00	$510,000.00	
111	12" RCP Storm	6	LF	$145.00	$870.00	
112	Storm Inlet Type 3: 2 ft.x 3 ft. Inlet W/Casting Complete (Double Inlets)	7	EA	$6,000.00	$42,000.00	
113	4' Diameter Cast in Place Storm Manhole with Casting and Grate	3	EA	$4,000.00	$12,000.00	
114	Trench Backfill - Storm Sewer	400	TF	$9.00	$3,600.00	
115	5' x 17' Grade Change Structure (Storm)	1	EA	$2,000.00	$2,000.00	$2,000.00
116	Remove Existing Sanitary Sewer Manhole	2	EA	$1,300.00	$2,600.00	$2,600.00
117	48" Sanitary Sewer Manhole W/Casting Complete	1	EA	$12,000.00	$12,000.00	$12,000.00
118	Manhole Chimney Seal	1	EA	$525.00	$525.00	$525.00
119	Remove Existing Sanitary Sewer	357	LF	$30.00	$10,710.00	$10,710.00
120	12" PVC Sanitary Sewer	344	LF	$200.00	$68,800.00	$68,800.00
121	Connect to Existing Sanitary Sewer	1	EA	$2,000.00	$2,000.00	$2,000.00
122	Trench Backfill - Sanitary Sewer	344	TF	$3.00	$1,032.00	$1,032.00
123	Remove Existing Watermain	323	LF	$20.00	$6,460.00	$6,460.00
124	16" PVC Watermain	323	LF	$270.00	$87,210.00	$87,210.00
125	Connect to Existing Watermain	2	EA	$6,000.00	$12,000.00	$12,000.00

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	TOTAL PRICE (excl storm)
126	Terrace Restoration- Topsoil, Seed, Fertilize, & Hydro-Mulch	264	SY	$6.50	$1,718.89	$1,718.89
	Martha Washington Dr (Upper Parkway N to W Washington Blvd)				**$3,501,584.81**	**$1,497,953.33**
127	Mobilization/Bonds/Insurance (5%)	1	LS	$166,742.13	$166,742.13	$153,345.65
128	Traffic Control (1.5%)	1	LS	$48,802.58	$48,802.58	$48,802.58
129	Erosion Control (lnlet Protection) (1%)	1	LS	$32,535.05	$32,535.05	$32,535.05
130	Unclassified Excation	901	CY	$20.00	$18,020.00	$18,020.00
131	Tree Removal	15	EA	$2,000.00	$30,000.00	$30,000.00
132	Tree Replace in Kind	15	EA	$500.00	$7,500.00	$7,500.00
133	Remove Existing Street Light Pole	4	EA	$550.00	$2,200.00	$2,200.00
134	Street Light Pole Replace in Kind	4	EA	$3,200.00	$12,800.00	$12,800.00
135	Remove Existing Pavement	2247	SY	$37.00	$83,139.00	$83,139.00
136	Remove Existing Curb and Gutter	1623	LF	$40.00	$64,920.00	$64,920.00
137	Remove Existing Sidewalk	3430	SF	$5.00	$17,150.00	$17,150.00
138	Sawcut Asphalt Pavement	32	LF	$2.50	$80.00	$80.00
139	Excavation Below Subgrade (EBS)	187	CY	$55.00	$10,295.38	$10,295.38
140	3-Inch Breaker Run (EBS)	187	CY	$35.00	$6,551.61	$6,551.61
141	Crushed Aggregate Base Course 3/4 Inch	1498	TN	$16.00	$23,960.17	$23,960.17
142	Asphaltic Concrete Pavement Binder, 3.25-Inch Thick	420	TN	$85.00	$35,680.52	$35,680.52
143	Asphaltic Concrete Pavement Surface, 1.75-Inch Thick	226	TN	$85.00	$19,212.59	$19,212.59
144	Concrete Curb and Gutter, 31-Inch Type L W/Base	1623	LF	$40.00	$64,920.00	$64,920.00
145	Concrete Sidewalk, 5-Inch Thick W/4-Inch Base	3430	SF	$10.00	$34,300.00	$34,300.00
146	Concrete Ramp/Driveway Crossing, 7—Inch Thick W/4-Inch Base	416	SF	$12.00	$4,992.00	$4,992.00
147	Remove and Replace Retaining Wall	184	SF	$300.00	$55,200.00	$55,200.00
148	15" RCP Storm	88	LF	$75.00	$6,600.00	
149	18" RCP Storm	54	LF	$85.00	$4,590.00	
150	144" x 72" Concrete Box Culvert Storm	930	LF	$2,000.00	$1,860,000.00	
151	12" RCP Storm	139	LF	$145.00	$20,155.00	
152	Storm Inlet Type 3: 2 ft.x 3 ft. Inlet W/Casting Complete (Double Inlets)	12	EA	$6,000.00	$72,000.00	
153	4' Diameter Cast in Place Storm Manhole with Casting and Grate	4	EA	$4,000.00	$16,000.00	
154	Trench Backfill - Storm Sewer	1210	TF	$9.00	$10,890.00	
155	5' x 17' Grade Change Structure (Storm)	2	EA	$2,000.00	$4,000.00	$4,000.00
156	Remove Existing Sanitary Sewer Manhole	8	EA	$1,300.00	$10,400.00	$10,400.00
157	48" Sanitary Sewer Manhole W/Casting Complete	8	EA	$12,000.00	$96,000.00	$96,000.00
158	60" Sanitary Sewer Manhole	4	EA	$12,000.00	$48,000.00	$48,000.00
159	Manhole Chimney Seal	12	EA	$525.00	$6,300.00	$6,300.00
160	Remove Existing Sanitary Sewer	943	LF	$30.00	$28,290.00	$28,290.00
161	12" PVC Sanitary Sewer	839	LF	$200.00	$167,800.00	$167,800.00
162	36" PVC Sanitary Sewer	563	LF	$240.00	$135,120.00	$135,120.00
163	18" PVC Sanitary Sewer	38	LF	$120.00	$4,560.00	$4,560.00
164	27" PVC Sanitary Sewer	19	LF	$180.00	$3,420.00	$3,420.00
165	Connect to Existing Sanitary Sewer	2	EA	$2,000.00	$4,000.00	$4,000.00
166	Trench Backfill - Sanitary Sewer	1459	TF	$3.00	$4,377.00	$4,377.00
167	Abandon Existing Watermain	132	LF	$7.00	$924.00	$924.00

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	TOTAL PRICE (excl storm)
168	Remove Existing Watermain	36	LF	$20.00	$720.00	$720.00
169	16" PVC Watermain	902	LF	$270.00	$243,540.00	$243,540.00
170	Valve - Watermain	3	EA	$3,000.00	$9,000.00	$9,000.00
171	Reducer - Watermain	1	EA	$575.00	$575.00	$575.00
172	Terrace Restoration- Topsoil, Seed, Fertilize, & Hydro-Mulch	819	SY	$6.50	$5,322.78	$5,322.78
	Martha Washington Dr (W Washington Blvd to Washington Cir)				**$3,256,756.11**	**$1,460,393.11**
173	Mobilization/Bonds/Insurance (5%)	1	LS	$155,083.62	$155,083.62	$155,083.62
174	Traffic Control (1.5%)	1	LS	$45,390.33	$45,390.33	$45,390.33
175	Erosion Control (lnlet Protection) (1%)	1	LS	$30,260.22	$30,260.22	$30,260.22
176	Unclassified Excation	978	CY	$20.00	$19,560.00	$19,560.00
177	Tree Removal	18	EA	$2,000.00	$36,000.00	$36,000.00
178	Tree Replace in Kind	18	EA	$500.00	$9,000.00	$9,000.00
179	Remove Existing Street Light Pole	4	EA	$550.00	$2,200.00	$2,200.00
180	Street Light Pole Replace in Kind	4	EA	$3,200.00	$12,800.00	$12,800.00
181	Remove Existing Pavement	2430	SY	$37.00	$89,910.00	$89,910.00
182	Remove Existing Curb and Gutter	1743	LF	$40.00	$69,720.00	$69,720.00
183	Remove Existing Sidewalk	4106	SF	$5.00	$20,530.00	$20,530.00
184	Sawcut Asphalt Pavement	13	LF	$2.50	$32.50	$32.50
185	Excavation Below Subgrade (EBS)	202	CY	$55.00	$11,135.49	$11,135.49
186	3-Inch Breaker Run (EBS)	202	CY	$35.00	$7,086.22	$7,086.22
187	Crushed Aggregate Base Course 3/4 Inch	1620	TN	$16.00	$25,915.32	$25,915.32
188	Asphaltic Concrete Pavement Binder, 3.25-Inch Thick	454	TN	$85.00	$38,592.06	$38,592.06
189	Asphaltic Concrete Pavement Surface, 1.75-Inch Thick	244	TN	$85.00	$20,780.34	$20,780.34
190	Concrete Curb and Gutter, 31-Inch Type L W/Base	1743	LF	$40.00	$69,720.00	$69,720.00
191	Concrete Sidewalk, 5-Inch Thick W/4-Inch Base	4106	SF	$10.00	$41,060.00	$41,060.00
192	Concrete Ramp/Driveway Crossing, 7—Inch Thick W/4-Inch Base	224	SF	$12.00	$2,688.00	$2,688.00
193	Remove and Replace Retaining Wall	247	SF	$300.00	$74,100.00	$74,100.00
194	15" RCP Storm	38	LF	$145.00	$5,510.00	
195	18" RCP Storm	17	LF	$150.00	$2,550.00	
196	144" x 72" Concrete Box Culvert Storm	852	LF	$2,000.00	$1,704,000.00	
197	12" RCP Storm	27	LF	$145.00	$3,915.00	
198	Storm Inlet Type 3: 2 ft.x 3 ft. Inlet W/Casting Complete (Double Inlets)	12	EA	$6,000.00	$72,000.00	
199	Trench Backfill - Storm Sewer	932	TF	$9.00	$8,388.00	
200	5' x 17' Grade Change Structure (Storm)	1	EA	$2,000.00	$2,000.00	$2,000.00
201	Remove Existing Sanitary Sewer Manhole	8	EA	$1,300.00	$10,400.00	$10,400.00
202	48" Sanitary Sewer Manhole W/Casting Complete	8	EA	$12,000.00	$96,000.00	$96,000.00
203	60" Sanitary Sewer Manhole	2	EA	$4,000.00	$8,000.00	$8,000.00
204	Manhole Chimney Seal	10	EA	$525.00	$5,250.00	$5,250.00
205	Remove Existing Sanitary Sewer	1028	LF	$30.00	$30,840.00	$30,840.00
206	12" PVC Sanitary Sewer	824	LF	$200.00	$164,800.00	$164,800.00
207	8" PVC Sanitary Sewer	222	LF	$60.00	$13,320.00	$13,320.00
208	36" PVC Sanitary Sewer	137	LF	$240.00	$32,880.00	$32,880.00
209	Connect to Existing Sanitary Sewer	3	EA	$2,000.00	$6,000.00	$6,000.00

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	TOTAL PRICE (excl storm)
210	Trench Backfill - Sanitary Sewer	1183	TF	$3.00	$3,549.00	$3,549.00
211	Remove Existing Watermain	930	LF	$20.00	$18,600.00	$18,600.00
212	16" PVC Watermain	972	LF	$270.00	$262,440.00	$262,440.00
213	Valve - Watermain	2	EA	$3,000.00	$6,000.00	$6,000.00
214	Reducer - Watermain	1	EA	$575.00	$575.00	$575.00
215	Connect to Existing Watermain	2	EA	$6,000.00	$12,000.00	$12,000.00
216	Terrace Restoration- Topsoil, Seed, Fertilize, & Hydro-Mulch	950	SY	$6.50	$6,175.00	$6,175.00
	Martha Washington Dr (Washington Cir to Milwaukee Ave)				**$1,383,964.75**	**$673,542.75**
217	Mobilization/Bonds/Insurance (5%)	1	LS	$65,903.08	$65,903.08	$65,903.08
218	Traffic Control (1.5%)	1	LS	$19,288.71	$19,288.71	$19,288.71
219	Erosion Control (lnlet Protection) (1%)	1	LS	$12,859.14	$12,859.14	$12,859.14
220	Unclassified Excation	606	CY	$20.00	$12,120.00	$12,120.00
221	Tree Removal	4	EA	$2,000.00	$8,000.00	$8,000.00
222	Tree Replace in Kind	4	EA	$500.00	$2,000.00	$2,000.00
223	Remove Existing Street Light Pole	2	EA	$550.00	$1,100.00	$1,100.00
224	Street Light Pole Replace in Kind	2	EA	$3,200.00	$6,400.00	$6,400.00
225	Remove Existing Pavement	1568	SY	$37.00	$58,016.00	$58,016.00
226	Remove Existing Curb and Gutter	710	LF	$40.00	$28,400.00	$28,400.00
227	Remove Existing Sidewalk	1121	SF	$5.00	$5,605.00	$5,605.00
228	Sawcut Asphalt Pavement	95	LF	$2.50	$237.50	$237.50
229	Excavation Below Subgrade (EBS)	131	CY	$55.00	$7,186.41	$7,186.41
230	3-Inch Breaker Run (EBS)	131	CY	$35.00	$4,573.17	$4,573.17
231	Crushed Aggregate Base Course 3/4 Inch	1045	TN	$16.00	$16,724.75	$16,724.75
232	Asphaltic Concrete Pavement Binder, 3.25-Inch Thick	293	TN	$85.00	$24,905.83	$24,905.83
233	Asphaltic Concrete Pavement Surface, 1.75-Inch Thick	158	TN	$85.00	$13,410.83	$13,410.83
234	Concrete Curb and Gutter, 31-Inch Type L W/Base	710	LF	$40.00	$28,400.00	$28,400.00
235	Concrete Sidewalk, 5-Inch Thick W/4-Inch Base	1121	SF	$10.00	$11,210.00	$11,210.00
236	15" RCP Storm	232	LF	$145.00	$33,640.00	
237	18" RCP Storm	169	LF	$150.00	$25,350.00	
238	144" x 72" Concrete Box Culvert Storm	181	LF	$2,000.00	$362,000.00	
239	144" x 84" Concrete Box Culvert Storm	44	LF	$2,250.00	$99,000.00	
240	30" RCP Storm	49	LF	$375.00	$18,375.00	
241	Storm Inlet Type 3: 2 ft.x 3 ft. Inlet W/Casting Complete (Double Inlets)	8	EA	$6,000.00	$48,000.00	
242	4' Diameter Cast in Place Storm Manhole with Casting and Grate	3	EA	$4,000.00	$12,000.00	
243	6' Diameter Cast in Place Storm Manhole with Casting and Grate	1	EA	$6,000.00	$6,000.00	
244	14' x 37' Cast-In-Place Storm Junction Structure	1	EA	$100,000.00	$100,000.00	
245	Trench Backfill - Storm Sewer	673	TF	$9.00	$6,057.00	
246	Remove Existing Sanitary Sewer Manhole	7	EA	$1,300.00	$9,100.00	$9,100.00
247	48" Sanitary Sewer Manhole W/Casting Complete	3	EA	$12,000.00	$36,000.00	$36,000.00
248	Manhole Chimney Seal	3	EA	$525.00	$1,575.00	$1,575.00
249	Remove Existing Sanitary Sewer	624	LF	$30.00	$18,720.00	$18,720.00
250	12" PVC Sanitary Sewer	49	LF	$200.00	$9,800.00	$9,800.00
251	8" PVC Sanitary Sewer	194	LF	$60.00	$11,640.00	$11,640.00

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	TOTAL PRICE (excl storm)
252	Connect to Existing Sanitary Sewer	3	EA	$2,000.00	$6,000.00	$6,000.00
253	Trench Backfill - Sanitary Sewer	243	TF	$3.00	$729.00	$729.00
254	Abandon Existing Watermain	345	LF	$7.00	$2,415.00	$2,415.00
255	Remove Exisiting Watermain	451	LF	$20.00	$9,020.00	$9,020.00
256	16" PVC Watermain	754	LF	$270.00	$203,580.00	$203,580.00
257	Valve - Watermain	6	EA	$3,000.00	$18,000.00	$18,000.00
258	Reducer - Watermain	2	EA	$575.00	$1,150.00	$1,150.00
259	Connect to Existing Watermain	3	EA	$6,000.00	$18,000.00	$18,000.00
260	Terrace Restoration- Topsoil, Seed, Fertilize, & Hydro-Mulch	227	SY	$6.50	$1,473.33	$1,473.33
	Martha Washington Dr (Milwaukee Ave to Martin Dr)				**$7,009,454.46**	**$2,830,382.46**
261	Mobilization/Bonds/Insurance (5%)	1	LS	$333,783.55	$333,783.55	$333,783.55
262	Traffic Control (1.5%)	1	LS	$97,692.75	$97,692.75	$97,692.75
263	Erosion Control (Inlet Protection) (1%)	1	LS	$65,128.50	$65,128.50	$65,128.50
264	Unclassified Excation	2282	CY	$20.00	$45,640.00	$45,640.00
265	Tree Removal	51	EA	$2,000.00	$102,000.00	$102,000.00
266	Tree Replace in Kind	51	EA	$500.00	$25,500.00	$25,500.00
267	Remove Existing Street Light Pole	15	EA	$550.00	$8,250.00	$8,250.00
268	Street Light Pole Replace in Kind	15	EA	$3,200.00	$48,000.00	$48,000.00
269	Remove Existing Pavement	5220	SY	$37.00	$193,140.00	$193,140.00
270	Remove Existing Curb and Gutter	4635	LF	$40.00	$185,400.00	$185,400.00
271	Remove Existing Sidewalk	8053	SF	$5.00	$40,265.00	$40,265.00
272	Excavation Below Subgrade (EBS)	435	CY	$55.00	$23,922.52	$23,922.52
273	3-Inch Breaker Run (EBS)	435	CY	$35.00	$15,223.42	$15,223.42
274	Crushed Aggregate Base Course 3/4 Inch	3480	TN	$16.00	$55,674.24	$55,674.24
275	Asphaltic Concrete Pavement Binder, 3.25-Inch Thick	975	TN	$85.00	$82,907.85	$82,907.85
276	Asphaltic Concrete Pavement Surface, 1.75-Inch Thick	525	TN	$85.00	$44,642.69	$44,642.69
277	Concrete Curb and Gutter, 31-Inch Type L W/Base	4635	LF	$40.00	$185,400.00	$185,400.00
278	Concrete Sidewalk, 5-Inch Thick W/4-Inch Base	10197	SF	$10.00	$101,970.00	$101,970.00
279	Concrete Ramp/Driveway Crossing, 7—Inch Thick W/4-Inch Base	2974	SF	$12.00	$35,688.00	$35,688.00
280	Detectable Warning Field	100	SF	$46.00	$4,600.00	$4,600.00
281	15" RCP Storm	213	LF	$145.00	$30,885.00	
282	18" RCP Storm	6	LF	$150.00	$900.00	
283	192" x 72" Concrete Box Culvert Storm	1249	LF	$3,000.00	$3,747,000.00	
284	96" x 48" Concrete Box Culvert Storm	177	LF	$1,500.00	$265,500.00	
285	Storm Inlet Type 3: 2 ft.x 3 ft. Inlet W/Casting Complete (Double Inlets)	20	EA	$6,000.00	$120,000.00	
286	Trench Backfill - Storm Sewer	1643	TF	$9.00	$14,787.00	
287	5' x 22' Grade Change Structure (Storm)	4	EA	$2,000.00	$8,000.00	$8,000.00
288	Remove Existing Sanitary Sewer Manhole	8	EA	$1,300.00	$10,400.00	$10,400.00
289	48" Sanitary Sewer Manhole W/Casting Complete	10	EA	$12,000.00	$120,000.00	$120,000.00
290	Manhole Chimney Seal	10	EA	$525.00	$5,250.00	$5,250.00
291	Remove Existing Sanitary Sewer	2002	LF	$30.00	$60,060.00	$60,060.00
292	12" PVC Sanitary Sewer	242	LF	$200.00	$48,400.00	$48,400.00
293	8" PVC Sanitary Sewer	1893	LF	$60.00	$113,580.00	$113,580.00

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	TOTAL PRICE (excl storm)
294	Trench Backfill - Sanitary Sewer	2135	TF	$3.00	$6,405.00	$6,405.00
295	Abandon Existing Watermain	103	LF	$7.00	$721.00	$721.00
296	Remove Existing Watermain	2510	LF	$20.00	$50,200.00	$50,200.00
297	16" PVC Watermain	2548	LF	$270.00	$687,960.00	$687,960.00
298	Terrace Restoration- Topsoil, Seed, Fertilize, & Hydro-Mulch	3781	SY	$6.50	$24,577.94	$24,577.94
	Martin Ave (62nd St to 60th St)				**$2,090,927.46**	**$972,042.46**
299	Mobilization/Bonds/Insurance (5%)	1	LS	$99,567.97	$99,567.97	$99,567.97
300	Traffic Control (1.5%)	1	LS	$29,141.85	$29,141.85	$29,141.85
301	Erosion Control (lnlet Protection) (1%)	1	LS	$19,427.90	$19,427.90	$19,427.90
302	Unclassified Excation	785	CY	$20.00	$15,700.00	$15,700.00
303	Tree Removal	19	EA	$2,000.00	$38,000.00	$38,000.00
304	Tree Replace in Kind	19	EA	$500.00	$9,500.00	$9,500.00
305	Remove Existing Street Light Pole	4	EA	$550.00	$2,200.00	$2,200.00
306	Street Light Pole Replace in Kind	4	EA	$3,200.00	$12,800.00	$12,800.00
307	Remove Existing Pavement	1943	SY	$37.00	$71,891.00	$71,891.00
308	Remove Existing Curb and Gutter	1301	LF	$40.00	$52,040.00	$52,040.00
309	Remove Existing Sidewalk	5014	SF	$5.00	$25,070.00	$25,070.00
310	Sawcut Asphalt Pavement	30	LF	$2.50	$75.00	$75.00
311	Excavation Below Subgrade (EBS)	162	CY	$55.00	$8,902.97	$8,902.97
312	3-Inch Breaker Run (EBS)	162	CY	$35.00	$5,665.53	$5,665.53
313	Crushed Aggregate Base Course 3/4 Inch	1295	TN	$16.00	$20,719.64	$20,719.64
314	Asphaltic Concrete Pavement Binder, 3.25-Inch Thick	363	TN	$85.00	$30,854.86	$30,854.86
315	Asphaltic Concrete Pavement Surface, 1.75-Inch Thick	195	TN	$85.00	$16,614.16	$16,614.16
316	Concrete Curb and Gutter, 31-Inch Type L W/Base	1301	LF	$40.00	$52,040.00	$52,040.00
317	Concrete Sidewalk, 5-Inch Thick W/4-Inch Base	5764	SF	$10.00	$57,640.00	$57,640.00
318	Concrete Ramp/Driveway Crossing, 7—Inch Thick W/4-Inch Base	650	SF	$12.00	$7,800.00	$7,800.00
319	15" RCP Storm	17	LF	$145.00	$2,465.00	
320	192" x 72" Concrete Box Culvert Storm	363	LF	$3,000.00	$1,089,000.00	
321	Storm Inlet Type 3: 2 ft.x 3 ft. Inlet W/Casting Complete (Double Inlets)	4	EA	$6,000.00	$24,000.00	
322	Trench Backfill - Storm Sewer	380	TF	$9.00	$3,420.00	
323	5' x 22' Grade Change Structure (Storm)	1	EA	$2,000.00	$2,000.00	$2,000.00
324	Remove Existing Sanitary Sewer Manhole	3	EA	$1,300.00	$3,900.00	$3,900.00
325	48" Sanitary Sewer Manhole W/Casting Complete	3	EA	$12,000.00	$36,000.00	$36,000.00
326	Manhole Chimney Seal	3	EA	$525.00	$1,575.00	$1,575.00
327	Remove Existing Sanitary Sewer	565	LF	$30.00	$16,950.00	$16,950.00
328	12" PVC Sanitary Sewer	567	LF	$200.00	$113,400.00	$113,400.00
329	Connect to Existing Sanitary Sewer	2	EA	$2,000.00	$4,000.00	$4,000.00
330	Trench Backfill - Sanitary Sewer	567	TF	$3.00	$1,701.00	$1,701.00
331	Abandon Existing Watermain	110	LF	$7.00	$770.00	$770.00
332	Remove Existing Watermain	500	LF	$20.00	$10,000.00	$10,000.00
333	16" PVC Watermain	680	LF	$270.00	$183,600.00	$183,600.00
334	Valve - Watermain	1	EA	$3,000.00	$3,000.00	$3,000.00
335	Connect to Existing Watermain	2	EA	$6,000.00	$12,000.00	$12,000.00

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	TOTAL PRICE (excl storm)
336	Terrace Restoration- Topsoil, Seed, Fertilize, & Hydro-Mulch	1153	SY	$6.50	$7,495.58	$7,495.58
	60th Street (Martin Ave to State Street)				**$4,508,530.77**	**$863,929.77**
337	Mobilization/Bonds/Insurance (5%)	1	LS	$214,691.94	$214,691.94	$214,691.94
338	Traffic Control (1.5%)	1	LS	$62,836.67	$62,836.67	$62,836.67
339	Erosion Control (Inlet Protection) (1%)	1	LS	$41,891.11	$41,891.11	$41,891.11
340	Unclassified Excation	1287	CY	$20.00	$25,740.00	$25,740.00
341	Tree Removal	0	EA	$2,000.00	$0.00	$0.00
342	Tree Replace in Kind	0	EA	$500.00	$0.00	$0.00
343	Remove Existing Street Light Pole	9	EA	$550.00	$4,950.00	$4,950.00
344	Street Light Pole Replace in Kind	9	EA	$3,200.00	$28,800.00	$28,800.00
345	Remove Existing Pavement	3218	SY	$37.00	$119,066.00	$119,066.00
346	Excavation Below Subgrade (EBS)	268	CY	$55.00	$14,744.68	$14,744.68
347	3-Inch Breaker Run (EBS)	268	CY	$35.00	$9,382.98	$9,382.98
348	Crushed Aggregate Base Course 3/4 Inch	2145	TN	$16.00	$34,314.90	$34,314.90
349	Asphaltic Concrete Pavement Binder, 3.25-Inch Thick	576	TN	$85.00	$48,946.83	$48,946.83
350	Asphaltic Concrete Pavement Surface, 1.75-Inch Thick	310	TN	$85.00	$26,355.99	$26,355.99
351	Concrete Pavement	136	SY	$100.00	$13,600.00	$13,600.00
352	Concrete Curb and Gutter, 31-Inch Type L W/Base	2304	LF	$40.00	$92,160.00	$92,160.00
353	Concrete Sidewalk, 5-Inch Thick W/4-Inch Base	10404	SF	$10.00	$104,040.00	$104,040.00
354	Concrete Sidewalk, 7-Inch Thick W/4-Inch Base	1065	SF	$12.00	$12,780.00	$12,780.00
355	15" RCP Storm	31	LF	$145.00	$4,495.00	
356	192" x 72" Concrete Box Culvert Storm	1203	LF	$3,000.00	$3,609,000.00	
357	Storm Inlet Type 3: 2 ft.x 3 ft. Inlet W/Casting Complete	8	EA	$2,500.00	$20,000.00	
358	Trench Backfill - Storm Sewer	1234	TF	$9.00	$11,106.00	
359	Terrace Restoration- Topsoil, Seed, Fertilize, & Hydro-Mulch	1481	SY	$6.50	$9,628.67	$9,628.67
	West State Street				**$3,066,171.35**	**$953,631.35**
360	Mobilization/Bonds/Insurance (5%)	1	LS	$135,293.87	$135,293.87	$135,293.87
361	Traffic Control (1.5%)	1	LS	$39,598.21	$39,598.21	$39,598.21
362	Erosion Control (Inlet Protection) (1%)	1	LS	$26,398.80	$26,398.80	$26,398.80
363	Unclassified Excation	932	CY	$20.00	$18,640.00	$18,640.00
364	Tree Removal	2	EA	$2,000.00	$4,000.00	$4,000.00
365	Tree Replace in Kind	2	EA	$500.00	$1,000.00	$1,000.00
366	Remove Existing Street Light Pole	11	EA	$550.00	$6,050.00	$6,050.00
367	Street Light Pole Replace in Kind	11	EA	$3,200.00	$35,200.00	$35,200.00
368	Remove Existing Pavement	2517	SY	$37.00	$93,129.00	$93,129.00
369	Remove Existing Curb and Gutter	867	LF	$40.00	$34,680.00	$34,680.00
370	Sawcut Concrete Pavement	153	LF	$2.50	$382.50	$382.50
371	Excavation Below Subgrade (EBS)	210	CY	$55.00	$11,532.92	$11,532.92
372	3-Inch Breaker Run (EBS)	210	CY	$35.00	$7,339.13	$7,339.13
373	Crushed Aggregate Base Course 3/4 Inch	1678	TN	$16.00	$26,840.25	$26,840.25
374	Concrete Pavement	2517	SY	$100.00	$251,700.00	$251,700.00
375	Concrete Curb and Gutter, 31-Inch Type L W/Base	867	LF	$40.00	$34,680.00	$34,680.00
376	15" RCP Storm	112	LF	$145.00	$16,240.00	

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	TOTAL PRICE (excl storm)
377	192" x 72" Concrete Box Culvert Storm	373	LF	$3,000.00	$1,119,000.00	
378	48" RCP Storm	232	LF	$550.00	$127,600.00	
379	48" CMP Storm	242	LF	$75.00	$18,150.00	
380	54" RCP Storm	188	LF	$600.00	$112,800.00	
381	72" RCP Storm	406	LF	$800.00	$324,800.00	
382	Storm Inlet Type 3: 2 ft.x 3 ft. Inlet W/Casting Complete (Double Inlets)	5	EA	$6,000.00	$30,000.00	
383	108" Storm Manhole (MMSD)	3	EA	$50,000.00	$150,000.00	
384	MMSD PH2 CU Storm Structures (13) (Downstream Outlet Structure/Siphon)	1	EA	$200,000.00	$200,000.00	
385	Trench Backfill - Storm Sewer	1550	TF	$9.00	$13,950.00	
386	Terrace Restoration- Topsoil, Seed, Fertilize, & Hydro-Mulch	333	SY	$6.50	$2,166.67	$2,166.67
387	Railway Flagging	1	LS	$150,000.00	$150,000.00	$150,000.00
388	Jack and Bore Under Roadway	1	LS	$75,000.00	$75,000.00	$75,000.00
	SUBTOTAL: Items #1-#388				**$29,656,044.06**	
	Contingency (20%)				**$5,931,208.81**	
	Engineering / Inspection (10%)				**$3,558,725.29**	
	TOTAL				**$39,145,978.16**	
	Opportunity Cost for Improvements Needed to Reconstruct Martha Washington from Revere to State Street if Tunnel Option is Chosen					
	RECONSTRUCTION OF LLOYD, MARTHA WASHINGTON, MARTIN, 60TH AND STATE STREET) EXCLUDING ANY STORM IMPROVEMENTS				**$11,446,075.60**	
	Contingency (20%)				**$2,289,215.12**	
	Engineering / Inspection (10%)				**$1,373,529.07**	
	TOTAL				**$15,108,819.79**	

BREAKOUT SUMMARY	SUBTOTALS	CONTINGENCY (20%)	ENGINEERING / INSPECTION (10%)	TOTALS
Water	$2,253,824	$450,765	$270,459	$2,975,048
Storm	$18,187,674	$3,637,535	$2,182,521	$24,007,730
Sanitary	$1,963,120	$392,624	$235,574	$2,591,318
Street	$7,251,426	$1,450,285	$870,171	$9,571,882
Total	$29,656,044	$5,931,209	$3,558,725	$39,145,978

Appendix G. Desktop Analysis, North of W. Lloyd St, Preliminary Cost Estimate

SCHOONMAKER CREEK PRELIMINARY DESKTOP ANALYSIS ESTIMATE OF COSTS
City of Wauwatosa 08/13/2024, Updated 10/08/2024

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNITS	UNIT PRICE	TOTAL PRICE	
	Street Related					
1	Mobilization/Bonds/Insurance (5%)	1	LS	$4,149,946.40	$4,149,946	
2	Traffic Control (1.5%)	1	LS	$1,217,589.19	$1,217,589	
3	Erosion Control (Inlet Protection) (1%)	1	LS	$811,726.13	$811,726	
4	Remove Existing Street Light Pole	279	EA	$550.00	$153,450	
5	Street Light Pole Replace in Kind	279	EA	$3,200.00	$892,800	
6	Remove Existing Pavement	111,805	SY	$37.00	$4,136,773	
7	Remove Existing Curb and Gutter	83,588	LF	$40.00	$3,343,520	
8	Remove Existing Sidewalk	286,016	SF	$5.00	$1,430,080	
9	Excavation Below Subgrade (EBS)	9,300	CY	$55.00	$511,500	
10	3-Inch Breaker Run (EBS)	9,300	CY	$35.00	$325,500	
11	Crushed Aggregate Base Course 3/4 Inch	74,500	TN	$16.00	$1,192,000	
12	Asphaltic Concrete Pavement Binder, 3.25-Inch Thick	20,900	TN	$85.00	$1,776,500	
13	Asphaltic Concrete Pavement Surface, 1.75-Inch Thick	11,250	TN	$85.00	$956,250	
14	Concrete Curb and Gutter, 31-Inch Type L W/Base	83,588	LF	$40.00	$3,343,520	
15	Concrete Sidewalk, 5-Inch Thick W/4-Inch Base	286,016	SF	$10.00	$2,860,160	
	Sanitary Sewer					
16	8" Sanitary Sewer	8,800	LF	$200.00	$1,760,000	
17	10" Sanitary Sewer	10,220	LF	$220.00	$2,248,400	
18	12" Sanitary Sewer	9,880	LF	$250.00	$2,470,000	
19	15" Sanitary Sewer	2,350	LF	$260.00	$611,000	
20	18" Sanitary Sewer	1,110	LF	$280.00	$310,800	
21	21" Sanitary Sewer	1,096	LF	$300.00	$328,800	
22	27" Sanitary Sewer	340	LF	$350.00	$119,000	
23	Remove and Replace 48" Sanitary Sewer Manhole W/Casting Complete	107	EA	$12,000.00	$1,284,000	
24	Trench Backfill - Sanitary Sewer	24,175	TF	$3.00	$72,525	
25	Sanitary Lateral Replacement	24,175	LF	$160.00	$3,868,000	
26	8" Sanitary Sewer (Accounting for sections requiring dual mains)	3,544	LF	$200.00	$708,800	
27	Sanitary Sewer Lateral Reconnection	822	EA	$2,000.00	$1,644,000	
	Storm Sewer					
28	Storm Inlet Double Inlets (Quadruple # of Existing Inlets, will be double inlets)	996	EA	$6,000.00	$5,976,000	
29	18" RCP Concrete Pipe (30' length assumed for every storm inlet)	29,880	LF	$150.00	$4,482,000	
30	144" x 72" Concrete Box Culvert Storm	3,712	LF	$2,000.00	$7,424,000	
31	120" x 60" Concrete Box Culvert Storm	935	LF	$1,500.00	$1,402,500	
32	18" RCP Storm Sewer	2,500	LF	$150.00	$375,000	
33	24" RCP Storm Sewer	2,450	LF	$170.00	$416,500	
34	27" RCP Storm Sewer	1,200	LF	$300.00	$360,000	
35	30" RCP Storm Sewer	2,880	LF	$375.00	$1,080,000	
36	36" RCP Storm Sewer	5,600	LF	$420.00	$2,352,000	
37	42" RCP Storm Sewer	735	LF	$500.00	$367,500	
38	48" RCP Storm Sewer	940	LF	$550.00	$517,000	
39	54" RCP Storm Sewer	4,000	LF	$600.00	$2,400,000	
40	60" RCP Storm Sewer	200	LF	$650.00	$130,000	
41	66" RCP Storm Sewer	630	LF	$750.00	$472,500	
42	78" RCP Storm Sewer	285	LF	$900.00	$256,500	
43	90" RCP Storm Sewer	975	LF	$1,000.00	$975,000	
44	4' Diameter Cast in Place Storm Manhole with Casting and Grate	87	EA	$4,000.00	$348,000	
45	6' Diameter Cast in Place Storm Manhole with Casting and Grate	60	EA	$8,000.00	$480,000	
46	8' Diameter Cast in Place Storm Manhole with Casting and Grate	52	EA	$10,000.00	$520,000	
	Potable Water					
47	8" DI Water Main	18,370	LF	$220.00	$4,041,400	
48	12" DI Water Main	4,100	LF	$240.00	$984,000	
49	16" DI Water Main	7,970	LF	$275.00	$2,191,750	
50	20" DI Water Main	4,170	LF	$300.00	$1,251,000	
51	24" DI Water Main	5,120	LF	$350.00	$1,792,000	
52	30" DI Water Main	625	LF	$400.00	$250,000	
53	Hydrant Assembly	131	EA	$7,500.00	$982,500	
54	Water Laterals	31,826	LF	$70.00	$2,227,785	
55	6" Water Valve and Box	131	EA	$1,300.00	$170,300	
56	8" Water Valve and Box	41	EA	$1,800.00	$73,800	
57	12" Water Valve and Box	14	EA	$3,300.00	$46,200	
58	16" Water Valve and Box	17	EA	$5,000.00	$85,000	
59	20" Water Valve and Box	10	EA	$7,500.00	$75,000	
60	24" Water Valve and Box	13	EA	$9,000.00	$117,000	
61	8" Water Main (Accounting for sections requiring dual mains)	2,900	LF	$70.00	$203,000	
	SUBTOTAL: Items #1-#61				**$87,351,874**	**$87,351,874**
	Contingency (20-40%)				**$17,470,375**	**$34,940,750**
	Engineering / Inspection (10%)				**$10,482,225**	**$12,229,262**
	TOTAL				**$115,304,474**	**$134,521,887**

BREAKOUT SUMMARY	SUBTOTALS	CONTINGENCY (20%)	ENGINEERING (10%)	TOTALS
Water	$14,490,735	$2,898,147	$1,738,888	$19,127,770
Storm	$30,334,500	$6,066,900	$3,640,140	$40,041,540
Sanitary	$15,425,325	$3,085,065	$1,851,039	$20,361,429
Street	$27,101,314	$5,420,263	$3,252,158	$35,773,735
Total	$87,351,874	$17,470,375	$10,482,225	$115,304,474

BREAKOUT SUMMARY	SUBTOTALS	CONTINGENCY (40%)	ENGINEERING (10%)	TOTALS
Water	$14,490,735	$5,796,294	$2,028,703	$22,315,732
Storm	$30,334,500	$12,133,800	$4,246,830	$46,715,130
Sanitary	$15,425,325	$6,170,130	$2,159,546	$23,755,001
Street	$27,101,314	$10,840,526	$3,794,184	$41,736,024
Total	$87,351,874	$34,940,750	$12,229,262	$134,521,887

Appendix H. Overall Preliminary Cost Estimate, Options A and B

SCHOONMAKER CREEK PRELIMINARY ESTIMATE OF COSTS
Overall Cost Comparison Summary
City of Wauwatosa
Date: UPDATED 10/08/2024

Table A
Option B: Storm Sewer
Note that contingency of 20% and engineering fees of 10% are included

ITEM DESCRIPTION	TOTAL PRICE
West Lloyd St (66th St to 65th St)	$2,448,962
Martha Washington Dr (Revere Ave to Washington Circle)	$2,507,636
Martha Washington Dr (Washington Circle to Upper Parkway N)	$1,430,426
Martha Washington Dr (Upper Parkway N to W Washington Blvd)	$4,622,092
Martha Washington Dr (W Washington Blvd to Washington Cir)	$4,298,918
Martha Washington Dr (Washington Cir to Milwaukee Ave)	$1,826,833
Martha Washington Dr (Milwaukee Ave to Martin Dr)	$9,252,480
Martin Ave (62nd St to 60th St)	$2,760,024
60th Street (Martin Ave to State Street)	$5,951,261
West State Street	$3,750,346
TOTAL	**$38,850,000**

Table B
Option A: Tunnel
Note that (1) this cost estimate includes the reconstruciton of the Martha Washington corridor included wthin Option B and (2) contingency of 20% and engineering fees of 10% are included

ITEM DESCRIPTION	TOTAL PRICE (EXCL STORM BYPASS)
Tunnel Alignment 1	$48,500,166
SUBTOTAL	**$48,500,166**
West Lloyd St (66th St to 65th St)	$1,158,183
Martha Washington Dr (Revere Ave to Washington Circle)	$1,094,833
Martha Washington Dr (Washington Circle to Upper Parkway N)	$643,328
Martha Washington Dr (Upper Parkway N to W Washington Blvd)	$1,977,298
Martha Washington Dr (W Washington Blvd to Washington Cir)	$1,927,719
Martha Washington Dr (Washington Cir to Milwaukee Ave)	$889,076
Martha Washington Dr (Milwaukee Ave to Martin Dr)	$3,736,105
Martin Ave (62nd St to 60th St)	$1,283,096
60th Street (Martin Ave to State Street)	$1,140,387
West State Street	$1,258,793
SUBTOTAL	**$15,110,000**
OVERALL TOTAL (TUNNEL & MARTHA WASHINGTON)	**$63,620,000**

Table C
Desktop Analysis North of Lloyd Street

ITEM DESCRIPTION	TOTAL PRICE (EXCL STORM BYPASS)
Water Main	$14,490,735
Storm Sewer	$30,334,500
Sanitary Sewer	$15,425,325
Street & Miscellaneous	$27,101,314
SUBTOTAL	**$87,351,874**
Contingency (20-40%)	**$17,470,375 to $34,490,750**
Engineering (10%)	**$10,482,225 to $12,229,262**
TOTAL	**$115,000,000 TO 135,000,000**

Table D
OVERALL COST COMPARISON

Option A (Sum of Tables B & C): Tunnel, Desktop Analysis & Martha Washington corridor to State St	**$180,000,000 to $200,000,000**
Option B (Sum of Tables A & C): Storm Sewer & Desktop Analysis	**$155,000,000 to $175,000,000**
Option B: Storm Sewer & Desktop Analysis	**$23,000,000 to $26,000,000**
Option B: Storm Sewer & Desktop Analysis	**$65,000,000 to $71,000,000**
Option B: Storm Sewer & Desktop Analysis	**$23,000,000 to $27,000,000**
Option B: Storm Sewer & Desktop Analysis	**$46,000,000 to $53,000,000**

Appendix I. Route Alternatives Matrix, Options A and B

ROUTE ALTERNATIVES MATRIX
SCHOONMAKER CREEK, CITY OF WAUWATOSA, WISCONSIN
Updated 10/08/2024

MSA

LEGEND	
WEIGHT SYSTEM ASSIGED TO FACTORS	
DESCRIPTION	WEIGHT
Minimal Significance	**1**
Moderately Low Significance	**2**
Moderate Signficance	**3**
Moderately High Significance	**4**
High Signficance	**5**
SCORE SYSTEM ASSIGED TO OPTIONS FOR EACH FACTOR	
DESCRIPTION	SCORE
Option provides less benefit or introduces more impediments than other option	**-1**
Option does not provide benefit over other option	**0**
Option provides more benefit or introduces less impediments than the other option	**1**

SCORING UNDERSTANDING

1. **Highest total weighted score indicates recommended option**
2. **A maximum weighted score of 89 indicates one option was more desireable over the other in every category**
3. **A minimum weighted score of -89 indicaates one option was less desireable compared to the other in every category**
4. **A total weighted score of zero indicates that both options are comparatively equal in every category**

SCORING SUMMARY

Option A: Tunnel Total Weighted Score = -1
Option B: Storm Sewer Total Weighted Score = 11
Weighted Total Scoring results in recommended option being Option B Storm Sewer (11 vs -1)

DECISION MAKING MATRIX SUMMARY		WEIGHT (1-5)	OPTION A "TUNNEL"			OPTION B "STORM SEWER"		
FACTORS			COMMENTS / JUSTIFICATION	SCORE (-1, 0, 1)	WEIGHTED SCORE	COMMENTS / JUSTIFICATION	SCORE (-1, 0, 1)	WEIGHTED SCORE
1	**Impacts to residential properties**	**5**	Residential property access not impacted by tunnel alignment. See item 23 for potential for long term liability impacts.	1	5	Project primarily constructed through residenital neighborhood and impacts to residences include access issues during construction as well as staging of equipment and materials.	-1	-5
2	**Political and community support of project**	**5**	MSA cannot comment on political support or opposition to option. Based on PIM completed on 09/12/24, responses were less favorable to tunnel option due to proximity of project in relation to Schoonmaker Creek as well as opportunity to improve Martha Washington Blvd.	-1	-5	MSA cannot comment on political support or opposition to option. Based on PIM completed on 09/12/24, responses were more favorable to open cut option due to proximity of project in relation to Schoonmaker Creek as well as opportunity to improve Martha Washington Blvd.	1	5

DECISION MAKING MATRIX SUMMARY		WEIGHT (1-5)	OPTION A "TUNNEL"			OPTION B "STORM SEWER"		
FACTORS			COMMENTS / JUSTIFICATION	SCORE (-1, 0, 1)	WEIGHTED SCORE	COMMENTS / JUSTIFICATION	SCORE (-1, 0, 1)	WEIGHTED SCORE
3	**Necessity to obtain temporary / permanent easements**	**5**	Based on CDM final report, six easements were identified on private property, Wauwatosa School District property and Milwaukee County related to the tunnel alignment and retrieval/working shafts. Based on preliminary design level, easements may be more difficult to obtain from property owners.	-1	-5	Work is planned primarily within the existing right-of-way however the possiblity exists that temporary or fee title easments will be required however this was not evaluated at the 30% design level. Based on preliminary design level, it is anticipated that easements for this construction process will be easier to obtain with property owners.	1	5
4	**Impacts / coordination with railroad**	**5**	Both options will require coordination and permtting with Canadian Pacific Railroad to allow jack and bore beneath existing railway line. Neither option was expected to provide an option over the other.	0	0	Both options will require coordination and permtting with Canadian Pacific Railroad to allow jack and bore beneath existing railway line. Neither option was expected to provide an option over the other.	0	0
5	**Complexity of permitting**	**5**	Permitting for tunnel is expected to include local permitting with City, WDNR NOI, potential wetland fill at Menomonee River, shoreland zoning, MMSD, archaeological and endangered resources. Additonal permitting may be required.	1	5	Permitting for storm sewer is expected to include local permitting with City, WDNR NOI, potential wetland fill at Menomonee River, shoreland zoning, MMSD, archaeological and endangered resources. This option also requires water and sanitary extensions and potential DNR General / Individual Waterways and Wetland Permitting associated with Schoonmaker Creek near the West Washington Blvd bridge. Additional permitting may be required. Option is considered more complex due to addtional permitting noted.	-1	-5
6	**Preliminary cost determination**	**5**	Preliminary cost determination for tunnel alignment 1a is $48.5M. Additional cost of reconstructing Martha Washington Blvd,Martin Ave, 60th Street and State Street increases cost of project to $63.6M.	-1	-5	Preliminary cost determination for storm sewer is $38.9M.	1	5
7	**Option "solves" the flooding problem for the City**	**5**	Option solves the initial goals of the project to reduce flows within Schoonmaker Creek.	1	5	Option solves the initial goals of the project to reduce flows within Schoonmaker Creek.	1	5
8	**Does option require city to enter into agreement with property owners for long term liability**	**5**	Tunnel option introduces potential for long term liability agreements between City and private property owners due to tunnel being located beneath residential / commercial properties.	-1	-5	Storm sewer option does not require long term liability agreements due to storm sewer being located within exisitng right-of-way.	1	5
9	**Impacts to commercial/business properties**	**4**	Option does not significantly impact commercial/business properties.	0	0	Option does not significantly impact commercial/business properties.	0	0
10	**Complexity of construction**	**4**	Project complexity is high due to type of construction including drop shafts,specialty equipment required, length of project, multi-phase and proximity to developed neighborhoods.	-1	-4	Project complexity is high due to type of construction, length of project, multi-phase and proximity to developed neighborhoods; however construction methods are consistent with projects routinely completed within the City; therefore complexity is less compared with tunnel boring.	1	4

DECISION MAKING MATRIX SUMMARY		WEIGHT (1-5)	OPTION A "TUNNEL"			OPTION B "STORM SEWER"		
FACTORS			COMMENTS / JUSTIFICATION	SCORE (-1, 0, 1)	WEIGHTED SCORE	COMMENTS / JUSTIFICATION	SCORE (-1, 0, 1)	WEIGHTED SCORE
11	**Impacts to City infrastructure**	**4**	CDM report identified potential impacts to City utilities: (1) Sanitary Sewer - An existing 8-inch sanitary sewer is in N68th street with a centerline near the center of the street, (2) Sanitary Sewer - An existing 8-inch sanitary sewer crosses N68th street at Hillcrest Drive, (3) Storm Sewers - An existing 18-inch storm sewer crosses N 69th street at the State Street intersection, (4) Sanitary Sewer - An existing 24-inch sanitary sewer crosses N 69th street at the State Street intersection located at approximate elevation 50.	0	0	Preliminary 30% design presents multiple impacts to existing city infrastructure within Martha Washington Blvd throughout length of project as well as the West Washington Blvd bridge. Impacts are not expected to result in replacement of utilities as storm and sanitary utilities to be upgraded/replaced. Impacts to bridge may be avoided if Martha Washington Blvd is not narrowed at this location.	0	0
12	**Impacts to MIS/MMSD infrastructure**	**4**	CDM report identified potential impacts to MMSD MIS utility: (1) MMSD Sewer - An existing 192-inch MMSD sewer crosses N 69th street at the State Street intersection at approximate elevation -223.54. Tunnel impacts to MMSD infrastructure may be limited or none.	1	4	Preliminary 30% design presents multiple impacts with MMSD MIS and combined lines. At this time it has not been determined if replacement of MMSD MIS will be pursued. Preliminary engineering indicates that impacts to MMSD infrastructure include two lines within Martha Washington Drive and potentially impacts on 66th Street between Lloyd and Garfield.	-1	-4
13	**Additional long term improvements needed from City of Milwaukee to address flooding**	**4**	Improvements to City of Milwaukee storm sewer north of Lloyd may further reduce flooding within Schonmaker Creek watershed. Improvements to City of Milwaukee infrastructure unknown at this time.	0	0	Improvements to City of Milwaukee storm sewer north of Lloyd may further reduce flooding within Schonmaker Creek watershed. Improvements to City of Milwaukee infrastructure unknown at this time.	0	0
14	**Impacts to local traffic during construction**	**3**	Local traffic impacts minor as drop shaft locations located outside of right-of-way.	1	3	Local traffic impacted from start to finish of project due to type of construction.	-1	-3
15	**Number of trees impacted due to construction within "Tree City"**	**3**	Tunnel alignment expected only to impact trees located on drop shaft locations and are not expected to impact street trees.	1	3	Assumed that all street trees to be impacted requiring removal within right-of-way along alignment of project due to type of construction.	-1	-3
16	**Option allows for additional concurrent improvements (ie street, sanitary,water, sidewalk, etc) to be constructed**	**3**	Tunnel option will be constructed beneath existing utilities and will not allow for concurrent upgrades or replacement of water, sanitary, storm sewer or dry utilities due to construciton method.	-1	-3	Storm sewer option will be constructed using open trench methods allowing for concurrent upgrades of water, sanitary and dry utilities while utilities are exposed for storm sewer replacement.	1	3
17	**Level of city effort required to deliver project**	**3**	Project will require final design, bidding, specifications and public bidding. Public bid law requirements to be followed along with requirements of state or federal funding, if obtained. Project delivery from City's effort is less due to the above ground coordination and ongoing coordination with City residents.	1	3	Project will require final design, bidding, specifications and public bidding. Public bid law requirements to be followed along with requirements of state or federal funding, if obtained. Option does requires more effort on behalf of City due to nature and impacts of type of above ground construction.	-1	-3
18	**Duration of project and phasing required**	**3**	Both options will require multiple phases. Actual phasing to be determined in final design based on budget andd City planning.	0	0	Both options will require multiple phases. Actual phasing to be determined in final design based on budget andd City planning.	0	0
19	**Potential for state or federal funding availability**	**3**	Project funding is anticipated to be local funding. State and federal funding options to be evaluated during final design process. At this time, neither option can be considered an advantage or disadvantage over the other.	0	0	Project funding is anticipated to be local funding. State and federal funding options to be evaluated during final design process. At this time, neither option can be considered an advantage or disadvantage over the other.	0	0

DECISION MAKING MATRIX SUMMARY		WEIGHT (1-5)	OPTION A "TUNNEL"			OPTION B "STORM SEWER"		
FACTORS			COMMENTS / JUSTIFICATION	SCORE (-1, 0, 1)	WEIGHTED SCORE	COMMENTS / JUSTIFICATION	SCORE (-1, 0, 1)	WEIGHTED SCORE
20	**Number of intersections impacted**	**2**	Preliminary layout does not impact intersections as drop shafts are planned for property outside of right-of-way.	1	2	Intersections of Revere, Washington Circle, Upper Parkway North, W Washington Blvd, Milwaukee Ave, Martin Ave, 60th Avenue, State Street impacted.	-1	-2
21	**Potential for bedrock to impact construction**	**2**	Due to depth of alignment and type of construction, tunnel option more likely to be impacted by bedrock which will affect complexity and cost.	-1	-2	Due to depth and type of construciton, open cut unlikely to be impacted by bedrock.	1	2
22	**Contribution of cost from MMSD**	**2**	Funds may be available from MMSD to assist with removal of structures from areas included within the 100-yr modeled flood event.	0	0	Funds may be available from MMSD to assist with removal of structures from areas included within the 100-yr modeled flood event.	0	0
23	**Property acquisition required for option**	**2**	Retrieval and working shafts require significant area. The proposed receiving location for the alignment 1A offers approximately 0.6 acres of space for the contractor to stage construction. The site is located on the north side of Washington Elementary School. The school is currently in use but the property may be acquired in the future. If the school property can be used, an additional 0.75 acres consisting of the current paved playground area could be available for the construction.	-1	-2	The storm sewer option does not require acquisiton of full parcels to accommodate the alignment. It is noted that the property located at 5928 W State Street could be acquired to realign the intesection of W State Street and N 60th Street. Contaminated soils may require additional environmental engineering or closure if site is obtained. At this time, this is in not considered a disadvantage to the projects as acquistiion is not required due to the sotrm alignment.	1	2
24	**Potential archaeological impacts**	**1**	Wisconsin Historic Preservation Database search not completed with preliminary phase. Based on proximity of project through fully developed areas, this option does not expect to have more or less impact than storm sewer option. Records search recommended for future phase if alignment is pursued.	0	0	Wisconsin Historic Preservation Database search not completed with preliminary phase. Based on proximity of project through fully developed areas, this option does not expect to have more or less impact than tunnel option. Records search recommended for future phase if alignment is pursued.	0	0
25	**Potential endangered resources impacted**	**1**	WDNR Natural Heritage Inventory Public Portal researched. Both options fall within the same one mile buffer (for terrestrial and wetland species) and a 2-mile buffer (for aquatic species) of the project area. Further actions are required to ensure compliance with Wisconsin's Endangered Species Law (s. 29.604 Wis. Stats.) and the Federal Endangered Species Act (16 USC ss 1531-43). Actions to be further evaluated during final design. Option does not present advantage or disadvantage.	0	0	WDNR Natural Heritage Inventory Public Portal researched. Both options fall within the same one mile buffer (for terrestrial and wetland species) and a 2-mile buffer (for aquatic species) of the project area. Further actions are required to ensure compliance with Wisconsin's Endangered Species Law (s. 29.604 Wis. Stats.) and the Federal Endangered Species Act (16 USC ss 1531-43). Actions to be further evaluated during final design. Option does not present advantage or disadvantage.	0	0
26	**Potential wetland impacts**	**1**	WDNR Surface Water Data Viewer reviewed for alignment. Mapped wetlands and wetland indicators located as expected along Menomonee River. Wetland impacts similar between options.	0	0	WDNR Surface Water Data Viewer reviewed for alignment. Mapped wetlands and wetland indicators located as expected along Menomonee River. Wetland impacts similar between options.	0	0
TOTALS								
WEIGHTED TOTAL SCORE (Range from -89 to 89)		**89**		**Option A: TUNNEL**	**-1**		**Option B: STORM SEWER**	**11**