Pedestrian and Bicycle Underpass

FEASIBILITY STUDY

John Nolen Drive

North Shore Drive to Broom Street
City of Madison
October 18, 2024

City of Madison Engineering

KL Engineering
[A] Better Experience

EXECUTIVE SUMMARY

This feasibility study evaluates the concept of constructing a pedestrian/bicycle underpass of John Nolen Drive between North Shore Drive and Broom Street. The study evaluates the feasibility based on need, existing conditions, potential design alternatives, and risks associated with a proposed pedestrian/bicycle underpass. The study was a cooperative effort between the City of Madison's Engineering and Parks Division.

Study Purpose and Need

The study assesses the feasibility of constructing an underpass for pedestrians and bicycles beneath John Nolen Drive, a major vehicle and pedestrian/bicycle corridor in the City of Madison. The primary objective is to address safety concerns, improve connectivity, and improve operations.

- Safety Concerns: The intersections of North Shore Drive and Broom Street with John Nolen Drive have experienced a significant number of pedestrian and bicycle injury crashes between 2010 and 2022, including 1 fatality and 29 injury crashes (4 pedestrian and 25 bicycle-related). These intersections are busy and complex, making at-grade crossings hazardous.
- Connectivity: The study aligns with the City of Madison's Lake Monona Waterfront Master Plan (recently rebranded as the Madison LakeWay), which seeks to enhance access to the downtown area, recreational spaces, and neighborhoods along the lakefront. An underpass would improve pedestrian and bicycle movement across John Nolen Drive while avoiding conflicts with vehicular traffic.
- Operations: The existing operations at North Shore Drive and Broom Street are extremely poor due to the combination of high traffic and pedestrian/bicycle volumes. The construction of an underpass would reduce the number of pedestrians/bicycles using the at grade crossings, potentially improving operations at the intersections.

Existing Conditions

The study area consists of John Nolen Drive, pedestrian and bicycle facilities, parks, lakeshore, railroads, and a complex set of geotechnical conditions:

- Pedestrian and Bicycle Facilities: The study area is already serviced by multi-use paths, particularly the Capital City Trail, which is heavily used for recreation and commuting. However, the existing crossings at North Shore Drive and Broom Street are inadequate in terms of width and geometry for the volume and diversity of users. Planned intersection improvements with the upcoming John Nolen Drive reconstruction project are expected to improve these geometrical issues.
- Vehicle Traffic: Both intersections (North Shore Drive and Broom Street) experience poor vehicle performance, especially during peak traffic periods, operating at a Level of Service (LOS) F, meaning long delays and queuing. This can contribute to poor decisions by motorists trying to navigate the intersections.
- Land Use: The study area includes parks (Brittingham Park and Law Park), Lake Monona, and two railroad lines owned by Wisconsin Southern Railroad (WSOR).
- Geotechnical Conditions: The site also consists of non-native lake fill material, an underlying compressible clay layer, and shallow groundwater, which poses design and construction challenges. The study notes the potential presence of hazardous materials from a nearby historic closed landfill.

Underpass Alternatives

Two conceptual alternatives for an underpass were evaluated:

Alternative 1A (H-Concept) involves surface connections on the east and west sides of John Nolen Drive at North Shore Drive and Broom Street. The paths descend below the road to an underpass structure located roughly halfway between the two intersections.

Alternative 1A (H-Concept)

- Costs: Total estimated construction costs for this option are $24.7 million, with potential utility relocation costs of $16.4 million. Annual maintenance and operational costs are expected to range from $25,000 to $40,000.
- Advantages: This option does not encroach on the railroad right-of-way or require significant changes to the existing infrastructure, making it more straightforward to construct. It also limits floodwater impacts on Lake Monona.
- Challenges: The design relies on extensive coordination with utility companies and includes a significant amount of excavation, some of which may involve contaminated material. The presence of shallow groundwater requires a robust pumping system and design/construction considerations to mitigate hydrostatic forces.

Alternative 2A (J-Concept) places the underpass in Brittingham Park, with the path passing beneath both the railroad and John Nolen Drive. Surface connections are provided to North Shore Drive and Broom Street, but no direct connection to Broom Street on the west side is provided due to the potential impact on the existing dog park.

Alternative 2A (J-Concept)

- Costs: This alternative is more complex, with an estimated construction cost of $37.5 million and potential utility costs of $17.4 million. Annual maintenance and operational costs are expected to range from $25,000 to $40,000.
- Advantages: Alternative 2A allows for more natural light and a broader path configuration. It has the potential for aesthetic enhancements and could serve as a unique feature for the area.
- Challenges: Along with those mentioned for Alternative 1A, it impacts Brittingham Park, including tennis courts and a basketball court, and has higher costs due to the need for a railroad bridge and deeper excavation. The design also increases the complexity of flood storage management and lake permitting.

Risk Assessment

The study identifies several potential risks and assesses their likelihood and severity, proposing potential mitigation strategies:

- Railroad Impact: Both alternatives are adjacent to the WSOR railroad. Alternative 1A's proximity may require a crash wall, while Alternative 2A relies on approval from the Office of the Commissioner of Railroads (OCR) for a new railroad bridge.
- Differential Settlement: Due to varying soil conditions, there’s a risk of uneven settlement, particularly over the compressible clay near Lake Monona. Detailed geotechnical investigation is recommended to mitigate this risk.
- Hydrostatic Forces: The underpass will be subject to significant hydrostatic pressure due to shallow groundwater levels. Mitigation measures include a robust foundation design and potential use of uplift anchors.
- Hazardous Materials: There’s a risk of encountering contaminants during excavation, especially since the area has a history of landfill use. Coordination with environmental agencies and monitoring of stormwater discharge is recommended.
- Underused Facility: The study notes that the underpass may not be fully utilized if users prefer the at-grade crossings, especially since the underpass involves a longer, uphill and downhill route. Efforts to make the underpass aesthetically pleasing and user-friendly are crucial to encouraging its use.

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1 INTRODUCTION

The City of Madison, renowned for its picturesque landscapes, vibrant neighborhoods, and commitment to sustainability, stands as a testament to the significance of promoting alternative modes of transportation. In this context, the integration of safe bicycle and pedestrian-friendly infrastructure emerges as a pivotal element in enhancing the quality of life for Madison residents. This study focuses on the feasibility of a grade separated bicycle/pedestrian facility via an underpass of John Nolen Drive between North Shore Drive and South Broom Street. A bicycle/pedestrian overpass concept was dismissed from further evaluation based on factors such as the city skyline obstruction, the additional user energy needed to climb to a sufficient grade to pass over the roadway and railroad compared to an underpass concept, and the footprint (size and length) of the necessary ramp approaches needed to elevate over the roadway and railroad. See Figure 1.1 for the study area location.

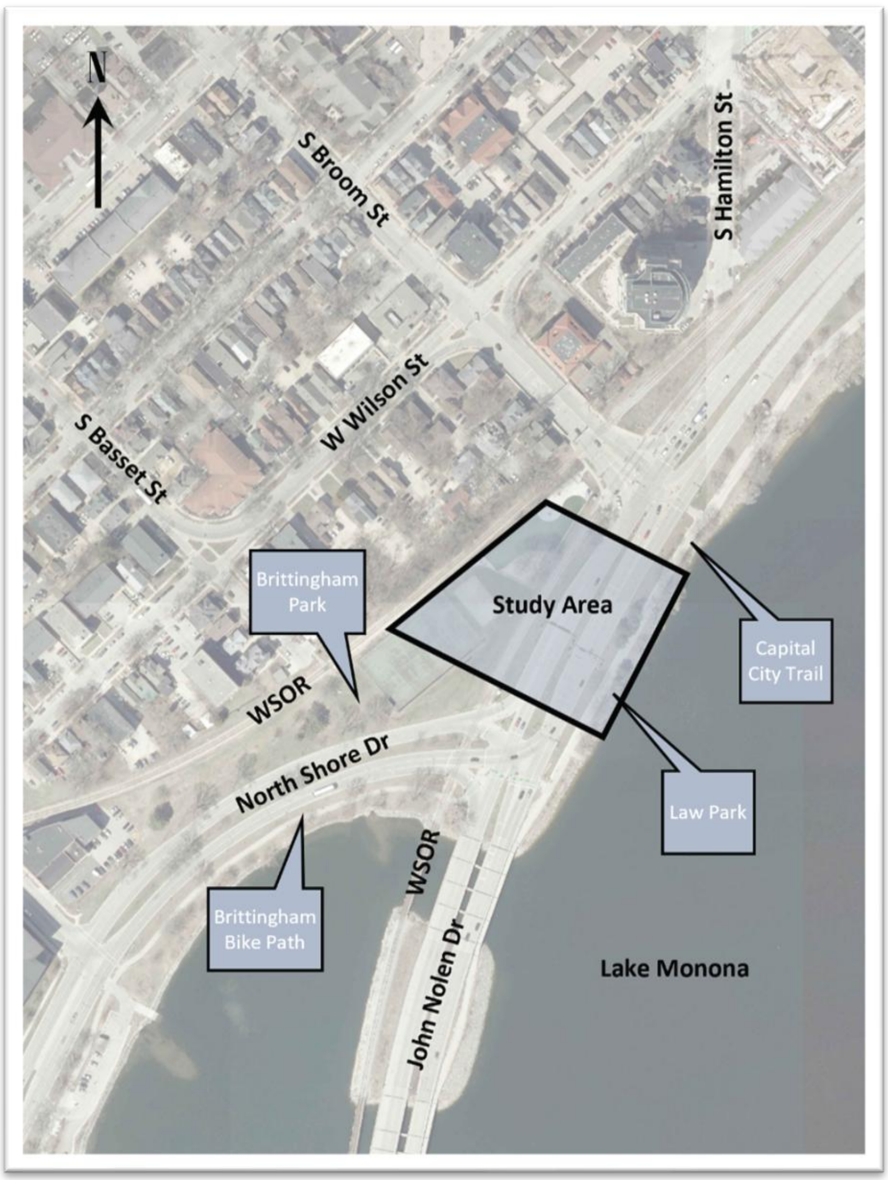


Figure 1.1 Study Location

2 NEED FOR STUDY

Although the Madison urban area ranked as one of the safest among the 100 largest US metropolitan areas in 2021[1], more than 50 pedestrians were killed locally in crashes between 2010 and 2019[1]. More specifically, the intersections of North Shore Drive and Broom Street along John Nolen Drive have had a significant number of pedestrian and bicycle injury crashes. Between 2010 and 2022 the intersections have combined for 29 injury related pedestrian and bicycle crashes including 1 fatality. Table 2.1 shows the distribution of injury type at both intersections and a crash diagram is included in Appendix A.

Table 2.1. Crash Data (2010 – 2022)

Crash Type	Pedestrian	Bicycle
K (Fatality)	0	1
A (Incapacitating Injury)	2	2
B (Non-Incapacitating Injury)	1	12
C (Possible Injury)	7	7
PD (Property Damage)	0	3
Totals	4	25
Total Pedestrian and Bicycle	29	

In addition to the safety needs, the area of study is identified in the City of Madison's Lake Monona Waterfront Master Plan (recently rebranded as the Madison LakeWay) as part of the Lake Lounge segment. As shown in Figure 2.1, this segment is planned to offer exciting lake front opportunities with easier access to downtown Madison and surrounding neighborhoods through a potential pedestrian/bicycle underpass. These amenities will further drive the need for pedestrians and bicycles to cross John Nolen Drive. This knowledge, along with the historical safety issues, drives the need to evaluate the feasibility of a grade separated alternative for bicycles and pedestrians looking to cross John Nolen Drive in the vicinity of North Shore Drive and South Broom Street.

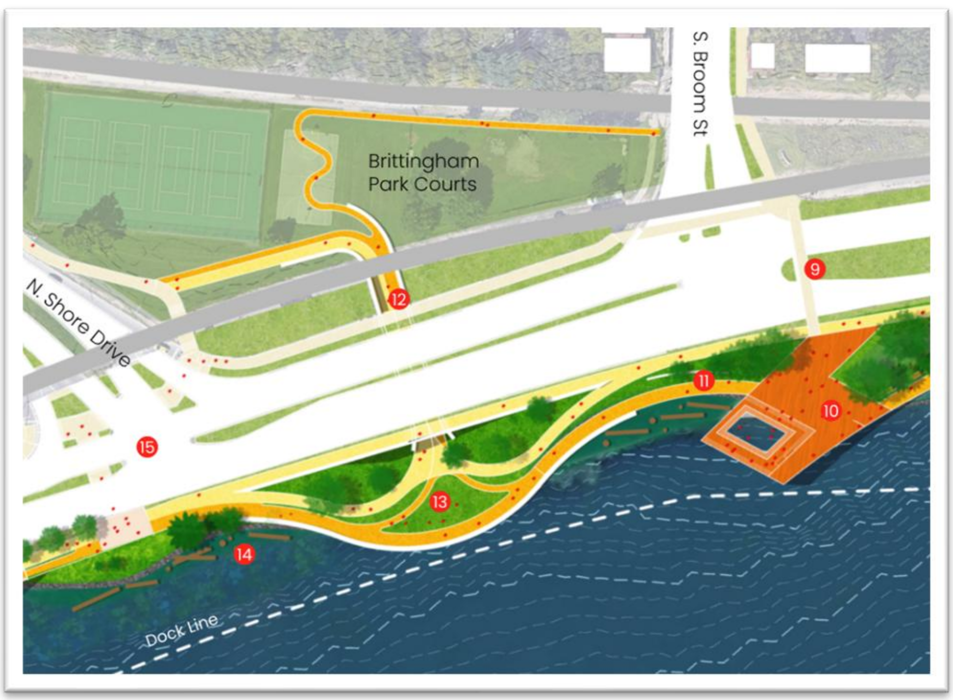


Figure 2.1 Waterfront Master Plan

[1]Greater Madison MPO,Pedestrian/Bicycle Facilities,
Policies, and Street Standards, May 2021

3 Existing Conditions

3.1 Pedestrian and Bicycle Facilities

As shown in Figure 3.1, the study area contains multi-use paths used for recreation and commuting within the City of Madison and surrounding communities. Located between John Nolen Drive and Lake Monona is the Capital City Trail. The Capital City Trail is a shared facility constructed and maintained between Dane County, City of Madison, City of Fitchburg, and the Wisconsin Department of Natural Resources. The trail provides a unique cultural and aesthetic experience traversing wetlands, prairies, creeks, lakes, uplands, and woods. The trail is surfaced with asphalt and is suitable for bicycles, skaters, strollers, walkers, joggers, and wheelchairs. Within the study area, the existing path is 10' wide and does not provide a separated facility to accommodate the amount and variety of users this segment experiences. To the north and just outside the study area, the trail is a separated facility with a buffer separating the bicyclists and pedestrians. The trail is used extensively and is accessed from the west by an at grade crossing of John Nolen Drive at North Shore Drive and Broom Street. To the west, pedestrians and cyclists can access the Southwest Commuter Path and the anticipated Cannonball Path. Together, these two paths offer a connection to Madison's southwest side, Capitol Square area, and the University of Wisconsin campus.

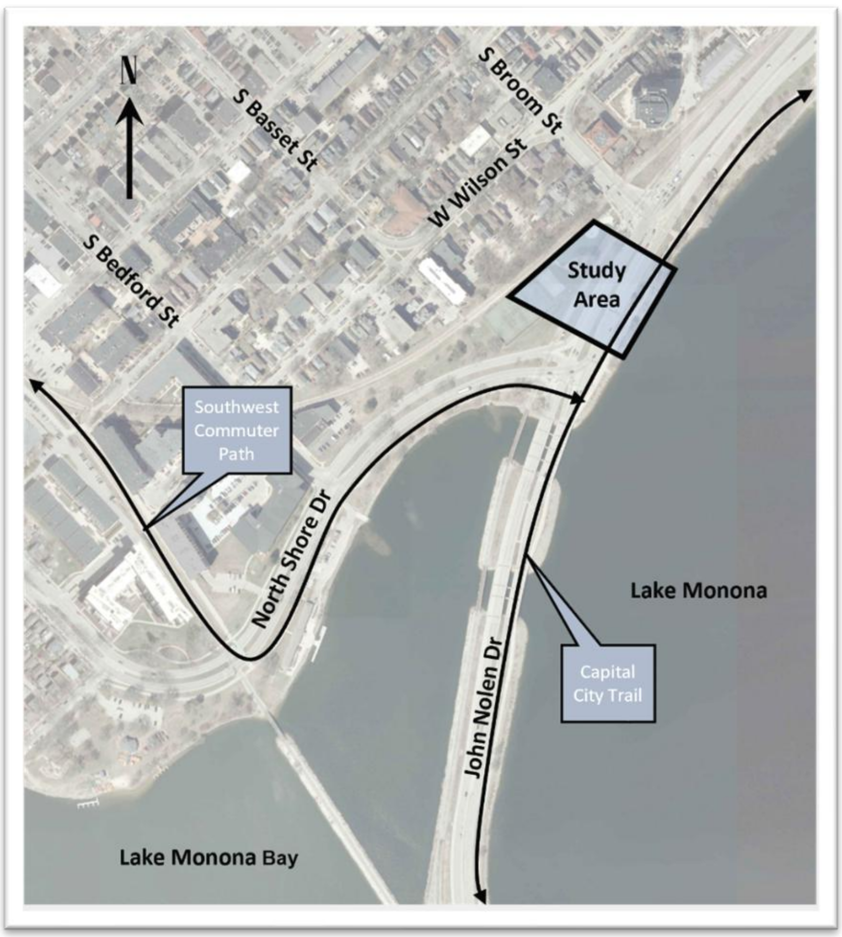


Figure 3.1 Trail & Path Locations

The existing at-grade pedestrian/bicycle crossings that connect these facilities across John Nolen Drive are insufficient regarding width and geometry to safely cross the congested intersections of North Shore Drive and Broom Street. The City of Madison's John Nolen Drive reconstruction project plans to improve these crossings with the reconstruction of John Nolen Drive which is currently anticipated to start in 2025. The new intersections, shown in Figure 3.2, will increase the size of refuge islands, cross walk widths, curb ramps, and include a raised crossing of the eastbound right turn movement at North Shore Drive. The Broom Street intersection is planned to be converted from a continuous green T-intersection (with confusing crosswalk alignments) to a conventional T-intersection. At the same time, the crossing distances of John Nolen Drive will be decreased due to narrower lanes, lane reductions, and removal of unused pavement. In addition to the intersection improvements, a new multi-use path will be constructed along the west side of John Nolen Drive between North Shore Drive and Broom Street and along the north side of North Shore Drive to enhance multi-modal connectivity of the area. Although bicyclists and pedestrians will still be required to maneuver through right turn islands and medians to cross John Nolen Drive, these planned improvements will make crossings safer and more efficient.

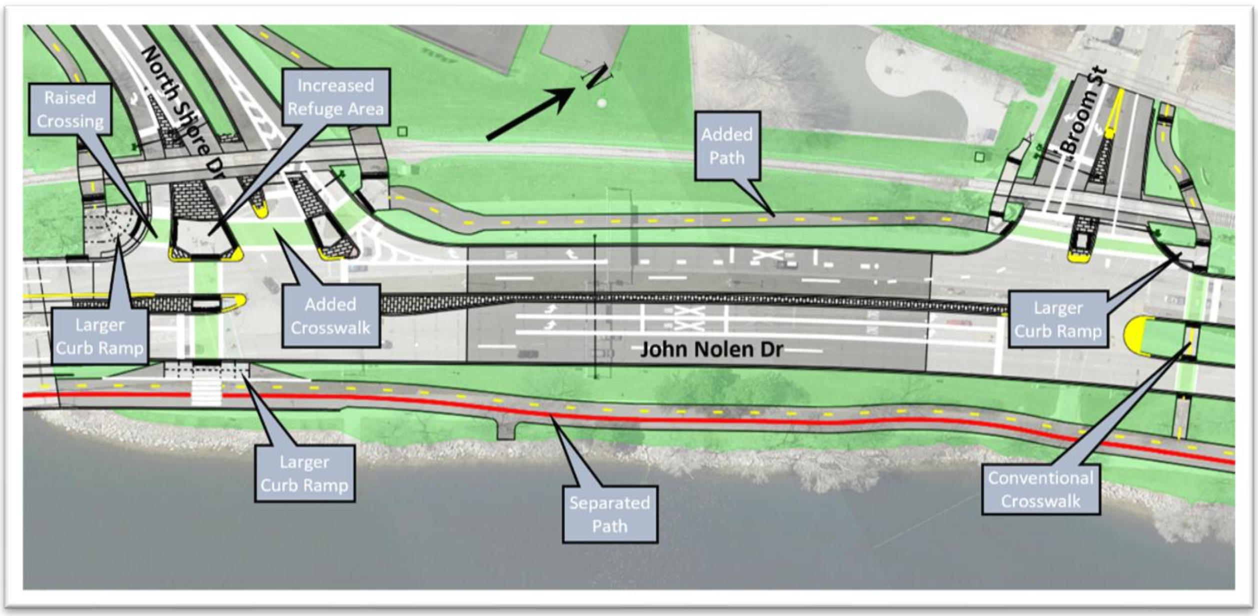


Figure 3.2 Planned Intersection Improvements

3.2 Intersection Vehicle Performance

The existing intersections of North Shore Drive and Broom Street are exhibiting a poor level of service leading to long vehicular delays and queues during the peak hours. The City of Madison's John Nolen Drive reconstruction project plans to reconstruct both intersections with lane assignments shown in Figure 3.2. Under this scenario, the level of service for all movements is not expected to improve through the horizon year of 2046. It is expected that pedestrians and bicyclists will continue to compete for valuable traffic signal "green" time at both intersections long into the future.

3.2.1 North Shore Drive Level of Service (LOS)

The existing intersection is controlled with a traffic signal that is coordinated with the intersection of John Nolen Drive with Broom Street. A single turn lane is provided for the right turn movement onto and from Northshore Drive. A single lane is provided for the northbound to westbound left turn movement. A dual left turn lane is provided for the eastbound to northbound left turn movement. The southbound to westbound right turn movement is a free flow movement with an add-lane upon it's exit from the intersection. As shown in Table 3.1, the existing intersection operates at LOS F under each peak period.

Table 3.1 Existing North Shore Drive LOS

Peak Hour	Parameter	Level of Service Per Movement By Approach						Overall Intersection LOS
		Northbound		Southbound		Eastbound		
		LT	TH	TH	RT	LT	RT	
AM	LOS	F	C	F	A	D	C	F
	Delay (sec)	550	330	122	0	54	21	124
PM	LOS	F	B	F	A	F	D	F
	Delay (sec)	173	10	278	0	131	42	147

The northbound left turn movement and southbound through movement both perform at a LOS F. The eastbound left turn movement operates at a LOS F in the PM peak period. All other movements are expected to operate at a LOS D or better.

3.2.2 Broom Street Level of Service (LOS)

The existing continuous green T-intersection is controlled with a traffic signal that is coordinated with the intersection of John Nolen Drive and North Shore Drive. A single right turn lane is provided for the southbound to westbound movement and a single left turn lane is provided for the eastbound to northbound movement. Dual right and left turn lanes are provided for the eastbound to southbound and northbound to westbound movements. Three through lanes are provided in the southbound direction and two through lanes are provided in the northbound direction. As shown in Table 3.2, the existing intersection operates at LOS F under each peak period.

Table 3.2 Existing Broom Street LOS

Peak Hour	Parameter	Level of Service Per Movement By Approach						Overall Intersection LOS
		Northbound		Southbound		Eastbound		
		LT	TH	TH	RT	LT	RT	
AM	LOS	C	A	F	C	D	A	F
	Delay (sec)	31	1	541	22	47	7	200
PM	LOS	B	A	F	B	F	A	F
	Delay (sec)	17	1	416	19	109	9	142

The southbound through movement is expected to operate at a LOS F. The eastbound left turn movement is anticipated to operate at a LOS F in the PM peak periods. All other movements are expected to operate at a LOS D or better. The conversion from a continuous green T-intersection to a conventional T-intersection is expected to significantly increase the delay of the northbound through movement but will significantly increase the level of comfort and safety of pedestrians crossing John Nolen Drive.

3.3 Study Area Land Uses

The study area, shown in Figure 3.3, contains several different land use and geographical features which is adding complexity to the potential feasibility of constructing an underpass in this location. The study area contains Brittingham Park, Law Park, Lake Monona, and two railroad lines owned by Wisconsin and Southern Railroad (WSOR). The area was created from filled lakebed and in 1937 the areas outside the railroad right-of-way were conveyed to the City of Madison. These conveyances included an agreement that this area would be used for "public park purposes only"

The City of Madison's Law Park contains the Capital City Trail, seasonal fishing/boating pier, grass, trees, and is home to the Mad-City-Ski Team. The ski team offers free water ski shows nearly every Sunday between Memorial Day and Labor Day Weekend. Law Park runs parallel between John Nolen Drive and Lake Monona. Brittingham Park is situated along the south and north side of North Shore Drive extending to Broom Street. The east and west sides of Brittingham Park are bordered by rail lines owned by WSOR. In the area of this study, Brittingham Park contains tennis courts, a basketball court, and an off-leash dog park. Section 4(f) considerations for Brittingham Park and Law Park will apply for any underpass project that receives federal funding or requires approval by an agency of the US Department of Transportation.

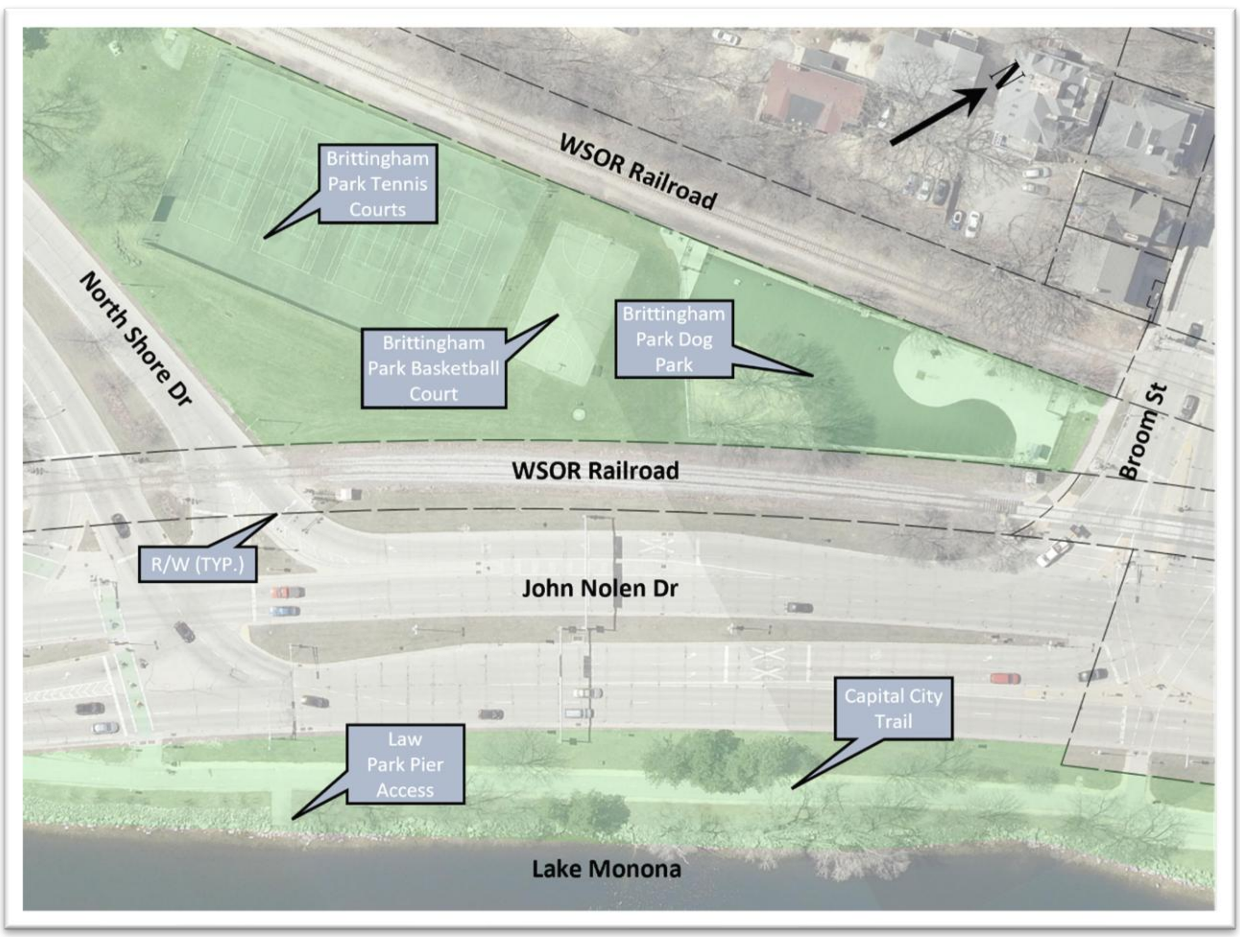


Figure 3.3 Study Area Land Uses

Lake Monona is part of the Yahara Chain of lakes and is roughly 3,300 acres with a mean depth of 27' and a maximum depth 64'. Being part of the Yahara Chain of lakes, it is subject to the State of Wisconsin's statutory mandate to regulate its water elevation. Table 3.3 shows the varying lake level orders to maintain and shows the 100-year flood elevation along with the historic high. Geographically, the study area contains 400' of shoreline that consists of a riprap revetment that is sloped between 2.5:1 and 3:1. The existing shoreline revetment will be replaced to a point just north of the North Shore Drive intersection as part of the City's John Nolen Drive reconstruction project. A Shoreline Analysis Summary Memo was completed for the project and select information from the memo regarding the revetment typical section, wave heights, and ice loading can be found in Appendix B.

Table 3.3 Lake Monona Water Levels

Lake Monona Water Elevations	
Historic High (September 6, 2018)	848.32'
100 Year Flood Elevation	847.50'
Target Summer Maximum (March 1st to October 30th)	845.00'
Target Summer Minimum (March 1st to October 30th)	844.50'
Target Winter Minimum (November 1st to March 1st)	842.00'

Note: Elevations given in NAVD 88 (1991)

WSOR owns and operates rail lines within the study area as shown in Figure 3.3. The rail line running adjacent to North Shore Drive has an established right-of-way of 40-feet centered roughly along the track centerline. WSOR currently runs 2-6 trains daily along this track at a maximum speed of 20 MPH. During the City's reconstruction project of John Nolen Drive, WSOR plans to raise the rail profile 1.5-inches to 5.5-inches across North Shore Drive and approximately 1-inch across Broom Street. WSOR has not shared the intent to modify the rail profile between North Shore Drive and Broom Street. Initial coordination regarding a future grade separated crossing under or adjacent to their rail line was conducted in the fall of 2023. WSOR did not object to the concept of an underpass in the study area when discussed in 2023. See Appendix C for the meeting minutes documenting communication with WSOR.

3.4 Geotechnical Conditions

The study area was created by filling in the Lake Monona shoreline between 1933 and 1966 with various forms of fill. Although historical records vary, this area appears to be the geographical start of a known City of Madison active landfill on the shoreline of Lake Monona between 1933 and the early 1950s that started near the Broom Street intersection and continued to the north. Fir pilings, 40 to 50-feet in length were driven into the lake bottom with a wire mesh to keep debris from floating away. Landfill material consisted of residential refuse, University of Wisconsin-Madison waste, and possible fly ash from Madison Gas & Electric's (MG&E) power plant. From near Broom Street to North Shore Drive, the lake was filled with base material consisting of sand, gravel, brick, and stone. The potential for landfill material is evident from this study's geotechnical borings which are in the vicinity of the proposed underpass. The boring locations are shown in Figure 3.4.

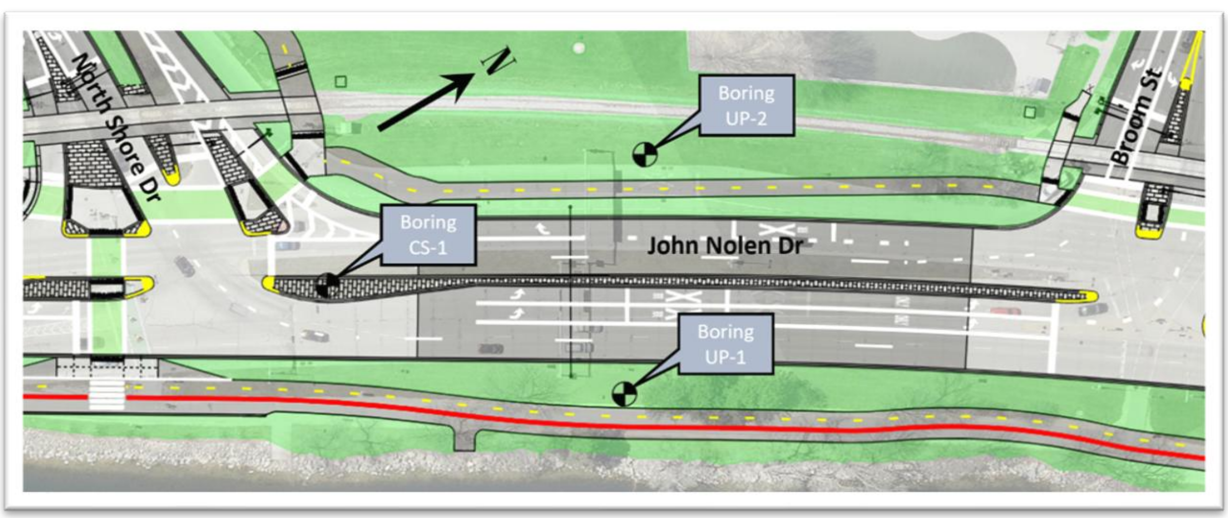


Figure 3.4 Geotechnical Boring Locations

Fill in the vicinity of boring UP-1 potentially includes a high concentration of concrete rubble or boulders as multiple attempts were required to find a location where the borehole could extend through the non-native fill. Below the non-native fill, the native soils consist of a 5-foot to 9-foot layer of clayey silt to lean clay followed by fine to medium sand. Very dense sand was found at depths ranging from 28 feet in boring UP-2 to 43 ft in boring CS-1. Ground water was encountered in the borings at depths of 8.5-feet to 10-feet and are generally expected to coincide with the elevation of Lake Monona. See Appendix D for the geotechnical report.

3.5 Hazardous Materials

The study area is in the vicinity of a closed Wisconsin Department of Natural Resources (WDNR) Leaking Underground Storage Tank (LUST) site. LUST sites are characterized by soil and/or groundwater contamination caused by hazardous substances. LUST sites have the potential to emit explosive vapors; however, over time contaminants such as petroleum breaks down naturally in the environment. During a Phase I/II Environmental Assessment in 1991, an overview of a boring taken at the intersection of John Nolen Drive and North Shore Drive noticed a fuel odor and sheen along with possible cinders and fly ash. Laboratory analysis later confirmed the presence of hydrocarbon fractions similar to No. 2 Fuel Oil. This study's geotechnical report also noted that several samples from boring UP-1 emitted an odor of petroleum and contained cinders.

3.6 Utilities

The study area contains utilities shown in Table 3.4 with locations shown in Figure 3.5:

Table 3.4 Existing Utilities

Utility Name	Utility Service	Facility Description
American Transmission Company (ATC)	Electric	Underground 69kv service inside a 6"-7" steel casing
Madison Gas & Electric	Electric	Coordination is currently ongoing
AT&T	Communications	Underground, 4 – 4" ducts
Charter Communications	Communications	Underground, 4" conduits.
City of Madison	Sanitary	36" cast iron gravity main
Madison Metropolitan Sewerage District (MMSD)	Sanitary	30" ductile iron force main

ATC's facilities crossing through Brittingham Park are contained in a permanent limited easement granted by the City of Madison in 1991. In 2023, utility line openings (ULO) were performed to locate the underground ATC facility crossing North Shore Drive and Broom Street. The line is roughly 7-feet to 8-feet below the existing surface as it crosses North Shore Drive and Broom Street. The closest locate to the study area revealed the electrical line was roughly 5' below the existing surface. The City of Madison's John Nolen Drive reconstruction project will not have a significant impact on the depth of cover over the ATC line and is not expected to be impacted. See Appendix E for details regarding the utility line opening and easement details of ATC's facilities.

MMSD has a single sanitary force main located in the study area. The 30" ductile iron force main was constructed in the early 2000s within a permanent limited easement granted by the City of Madison in 2005. As-builts were available to determine an approximate depth of cover. The depth from the existing surface derived from the as-builts in the study area varies from 5' to 10'. See Appendix F for as-built plans and easement details of MMSD's facilities.

The depths to all other utility facilities were unknown at the time of this study.

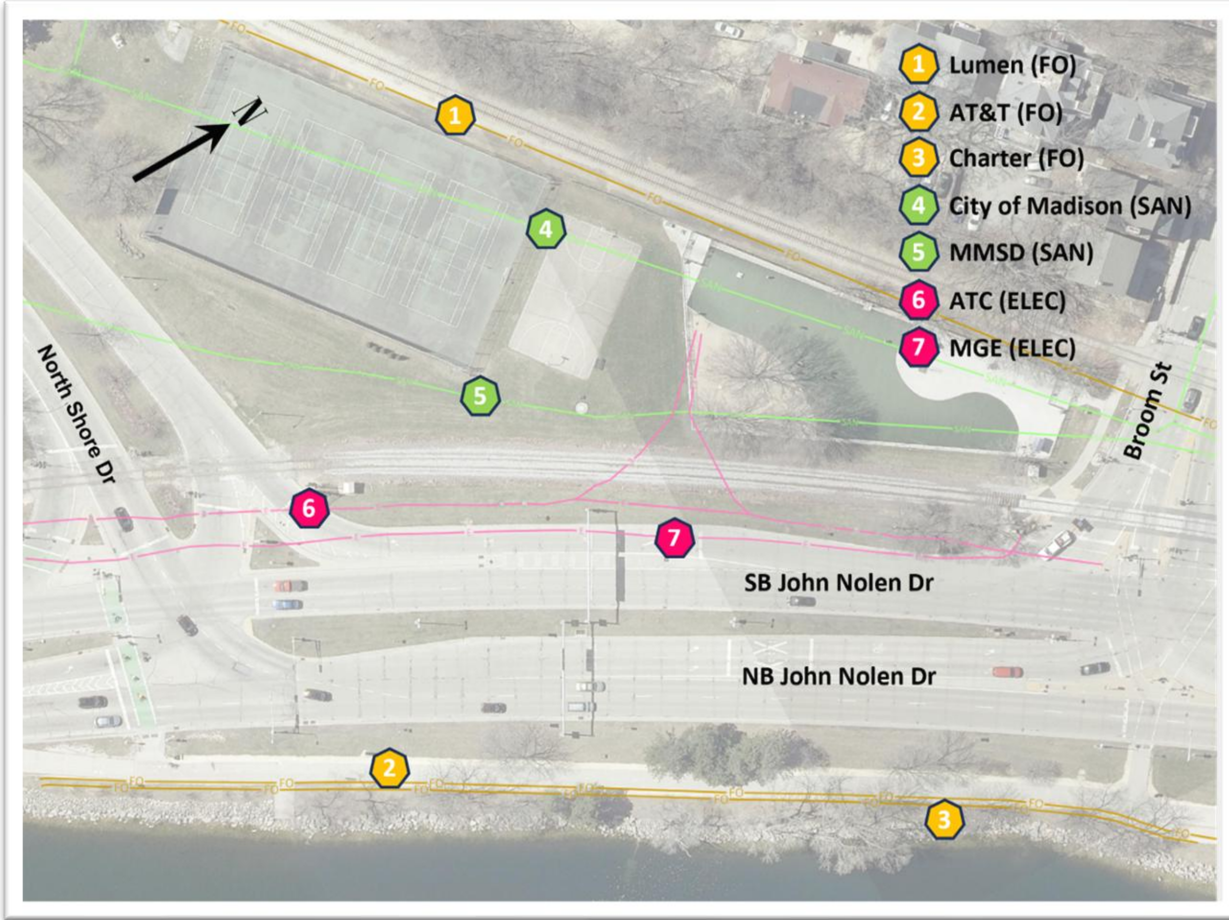


Figure 3.5 Existing Utility Locations

The City of Madison has the intent to install electrical and communications facilities as part of their John Nolen Drive reconstruction project between the intersections of North Shore Drive and Broom Street. The design and plan development for these proposed facilities is currently ongoing.

4 UNDERPASS DESIGN CRITERIA AND DESIGN CONSIDERATIONS

4.1 General Design Criteria

The following general design criteria were used to develop the underpass alternatives:

- Minimum vertical clearance of 8-feet for pedestrian/bicycle facilities. (Wisconsin Bicycle Facility Design Handbook, 4-10)
- Desirable 3-foot horizontal clearance to walls for pedestrian/bicycle facilities. (Wisconsin Bicycle Facility Design Handbook, 4-9)
- Design speed of 18 mph for bicycles. (Wisconsin Bicycle Facility Design Handbook, 4-11)
- Minimum radius of 60-feet for bicycles with a design speed of 18 mph. (Wisconsin Bicycle Facility Design Handbook, 4-15)
- Minimum lateral clearance of 8.5-feet measured from the centerline of track for railroad facilities on tangent track. (WisDOT FDM 17-5-5)
- Maximum vertical profile grade for pedestrian/bicycle facilities of 5%. (WisDOT FDM 11-46.5.2.1)

- Barriers adjacent to the roadway, will be approved vehicle barriers in accordance with the WisDOT Bridge Manual 30.2. Railing on top of cut retaining walls not adjacent to vehicular traffic can be a combination railing or full height steel pedestrian railing with a minimum height of 42-inches.
- Sight distance Category 2 for southbound John Nolen Drive due to a through lane approach to the North Shore Drive intersection becoming a "right turn only" lane. (WisDOT FDM 11-10, Attachment 5.2)
- Sight distance Category 2 for northbound John Nolen Drive due to a two lane non-high speed multi-lane approach to Broom Street with multiple left turn lanes. (WisDOT FDM 11-10, Attachment 5.2)
- Minimum northbound and southbound crest vertical curve K-value of 167 for John Nolen Drive. (WisDOT FDM 11-10, Attachment 5.4)
- Minimum northbound and southbound sag vertical curve K-value of 144 for John Nolen Drive. (WisDOT FDM 11-10, Attachment 5.5)
- Temporary shoring requirements adjacent to a railroad determined per WisDOT Bridge Manual Standard Drawing 38.01.
- All retaining walls were assumed to be cast-in-place (CIP) concrete cantilever with sizing derived from WisDOT Bridge Manual Chapter 14.5.

All alternatives share the same horizontal location between North Shore Drive and Broom Street for the crossing of John Nolen Drive. The size of the proposed underpass concept being analyzed is 8-feet x 20-feet with its top slab acting as the driving surface of John Nolen Drive. This criterion was chosen to minimize the depth of the underpass and surrounding retaining walls. The foundation is comprised of a cast in place reinforced concrete mat foundation over 2-feet of compacted clear stone fill. Part of the underpass is expected to be below water and will be subject to hydrostatic pressure. To minimize continual pumping, the underpass should be designed as a water-tight structure with minimal construction joints and all joints shall include water stops and other water proofing measures. A high-level of aesthetic treatments and features are anticipated to be part of any future underpass improvement project but were not evaluated as part of this feasibility study. Costs for aesthetic treatments and features are included in the cost estimate as placeholders and will need to be further evaluated in greater detail as part of any potential future project. A cross section of the underpass is shown in Figure 4.1.

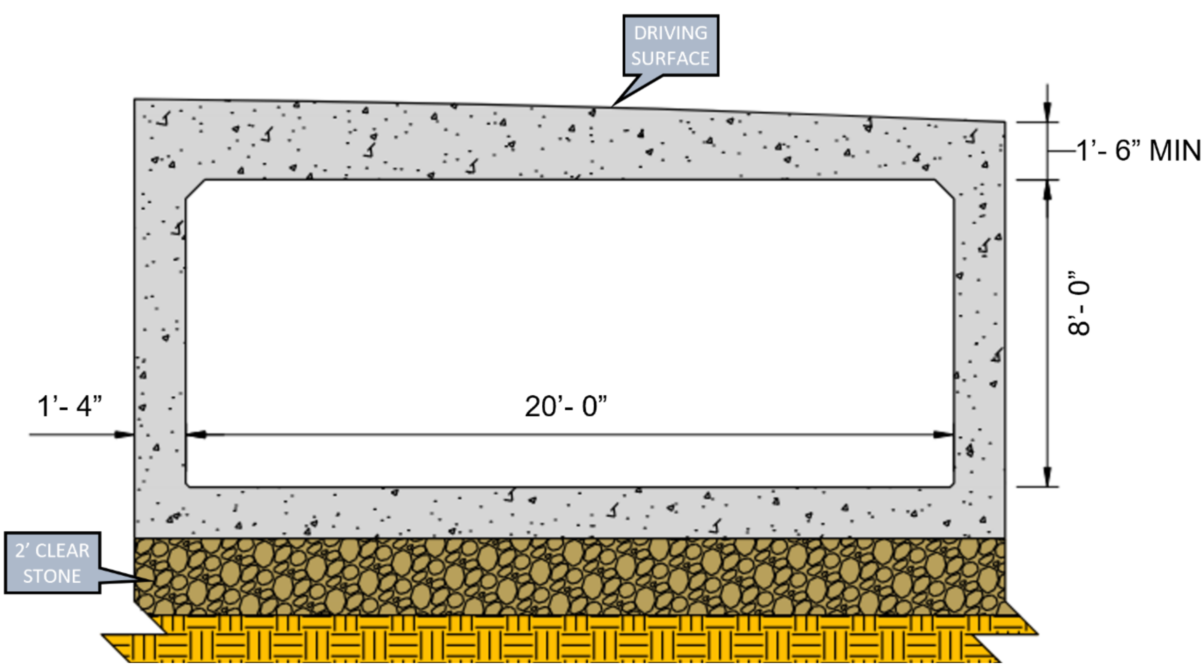


Figure 4.1 Underpass Cross Section

A pumping system would be needed for the underpass to remove water that has infiltrated through the concrete structure and to remove storm water that has collected along the uncovered approaches. The general approach evaluated a solution consisting of various pumping systems. Water was assumed to be collected through storm drains both in the approaches and within the structure. The water then flows by gravitational forces directly to a lift station or underground storage tanks before being discharged into Lake Monona. Storage and pumping facilities could be located in Brittingham Park rather than on the lakeside for aesthetic purposes when viewed from the lake or from the at grade bicycle/pedestrian facilities along John Nolen Drive. Pumping facilities include a lift station, electric utility service, stand-by generator, motor control panel, discharge pipe, and outfall. The use of infiltration to discharge water was dismissed due to known shallow groundwater in the study area. The following potential alternatives were evaluated:

- Pumping Alternative 1 consists of water flowing gravitationally from the structure to a wet well with medium capacity pumps sized to maintain discharge from a 100-year storm event.
- Pumping Alternative 2 consists of water flowing gravitationally from the structure to an underground storage tank system with low capacity pumps to maintain discharge from a 100-year storm event.

Each pumping alternative comes with advantages and disadvantages listed in Table 4.1.

Table 4.1 Pumping Alternatives Comparison

	Pumping Alternative 1	Pumping Alternative 2
Up-Front Costs	Lower – The use of larger pumps with this alternative still requires less up-front cost when compared to Alternative 2.	Higher – The up-front costs are higher ($500K–$900K) due to the construction of the relatively deep elevation to bury of the underground storage tanks.
Constructability Issues	This alternative is expected to have relatively minimal constructability issues.	Storage tanks would have to be constructed below the lowest elevation of the underpass. This may require an additional 10 to 15-feet of excavation below the underpass.
Maintenance Costs	Lower – The annual maintenance cost ($10K-$20K) for the pumps is similar for either alternative.	Higher – The annual maintenance cost ($10K-$20K) for the pumps is similar for either alternative. The underground storage tanks will require additional maintenance for sediment removal.
Electricity Costs	Both alternatives would be relatively similar in annual cost ($15K-$20K)	Both alternatives would be relatively similar in annual cost ($15K-$20K)
TSS Reduction	With no underground storage, the ability remove suspended solids (sediment) is minimal.	The underground storage tanks would provide the ability to remove a percentage of suspended solids (sediment).

Operation and maintenance of the pumping system would require monthly field testing, periodic cleaning of the wet well or storage tanks, and annual fluid replacements.

Direct discharge of storm water into Lake Monona is the most economical solution. Given the potential for hazardous materials in the study area, there is a possibility that contaminated ground water surrounding the underpass will infiltrate into the structure. This may require more intense mitigation measures to control the contaminates.

4.2 Geotechnical, Design, & Constructability Issues

Design and construction of an underpass concept would pose significant factors to consider including but not limited to the presence of the non-native lakeshore fill, underlying compressible clay/silt layer, shallow groundwater, and existing site constraints.

4.2.1 Non-Native Lake Fill

The non-native lake fill appears to consist of concrete rubble, boulders, and potential refuse up to 24-feet in depth. This may hamper excavation and any temporary vertical earth retention system installation such as sheet pile walls or cofferdams. The excavation in this layer may be somewhat irregular due to the size and variability of the debris potentially leading to areas of over excavation. Settlement of the non-native fill is expected to occur but is difficult to accurately determine given the high variability of the subgrade material. The potential for encountering hazardous materials may require special environmental monitoring, handling, and off-site disposal or remediation.

Recommendations include:

- Conducting a Phase II Hazardous Material Assessment.
- Coordination with WDNR during the design phase to determine measures for disposal of any hazardous materials or contaminated water.
- Consideration for leaving any temporary sheet pile in place to minimize settlement concerns from voids created by pulling sheet pile.
- Over-excavation and backfill with engineered fill should be considered to account for any large pieces of rubble encountered during construction.

4.2.2 Underlying Compressible Clay/Silt Layer

This subgrade layer was found in areas closer to Lake Monona and is a continuation of the compressible lacustrine deposits underlying the causeway. This same layer is responsible for the significant settlement that has occurred along the John Nolen Drive causeway. In the area of the underpass, it is mostly confined to the northbound lanes of John Nolen Drive and is thinner than the layer along the causeway. The weight of the underpass will be less than the weight of the soil removed, therefore the net increase in vertical stress and resulting pressure on the underlying soils is theoretically zero. This should result in negligible settlement of the clay/silt layer from the actual underpass. If the profile of John Nolen Drive is raised up to 3-feet, the combination of the compressible clay/silt layer and non-native fill may result in additional settlement estimated to be in the magnitude of approximately 3-inches.

Recommendations include:

- Minimize any raise to the profile of John Nolen Drive to limit additional weight being added to the causeway.
- Incorporating expanded polystyrene foam blocks (Geofoam) which has a unit weight of 2 to 4 lb/ft^3 to offset the weight of fill. Limitations include having to be installed above the water level to avoid buoyancy concerns (keep it from floating) and that these foam blocks are often susceptible to dissolving when this material is accidentally exposed to petroleum.
- Incorporating light weight foam concrete which substitutes foam beads for sand or gravel and has a unit weight of 35 to 70 lb/ft^3 to offset the weight of fill. Limitations include having to be installed above the water level to avoid buoyancy concerns (keep it from floating), but this synthetic material is able to withstand accidental contact from petroleum.

4.2.3 Shallow Groundwater

Geotechnical soil borings in the study area confirm that the ground water table roughly follows the elevation of Lake Monona. This creates several issues regarding the constructability and design of the underpass.

Figure 4.2 illustrates the possible water level that may be encountered during construction and accounted for in the design of a potential underpass. Depending on the underpass option/alternative chosen, water levels around the underpass excavation could reach a depth of 12-feet crossing under the railroad when compared to historic high lake levels.

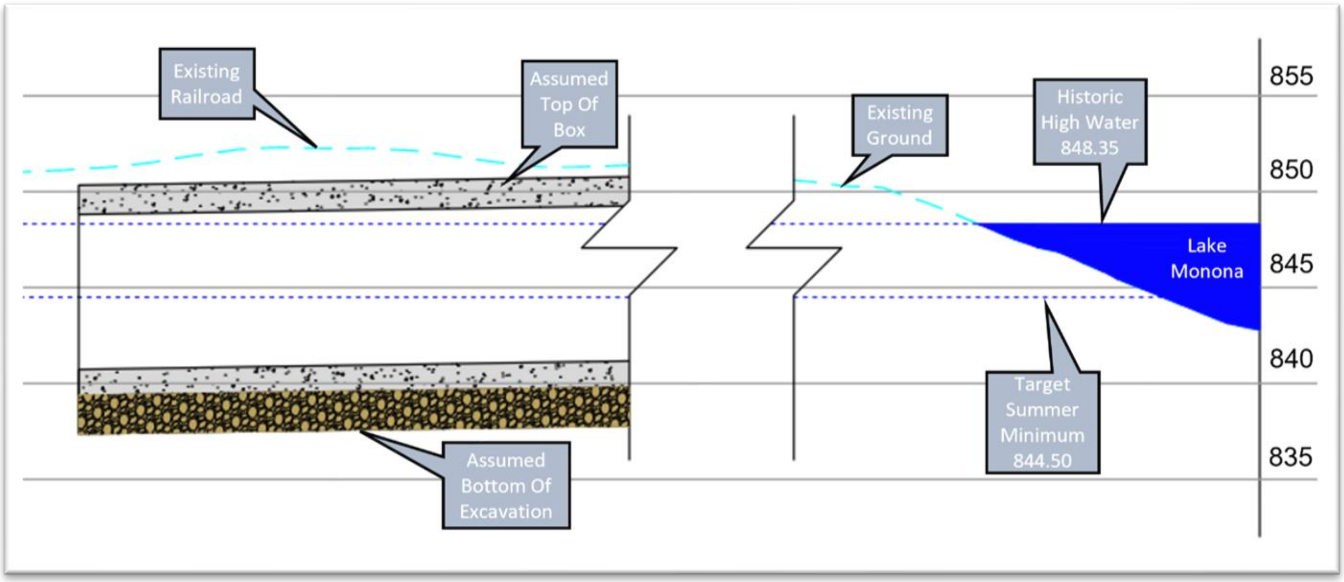


Figure 4.2 Potential Groundwater Elevations

Temporary shoring can be expected to not only limit the amount of excavation but also act as a cofferdam to mitigate high ground water concerns. Multiple sumps and/or wells located within the cofferdam system would be required to keep the site dry until enough of the underpass is constructed to offset any buoyancy loads. Water from the site may be contaminated and may be required to be discharged into the municipal sanitary sewer system. From a design aspect, it is anticipated that the underpass itself will have enough self-weight to resist uplift from hydrostatic forces. The exterior concrete ramps down to the underpass will need to be designed to resist buoyancy forces during normal and high ground water events.

Recommendations include:

- Early coordination during the design process with WDNR regarding disposal of potentially contaminated water and dewatering expectations.
- Coordinate with Dane County to manage Lake Monona to summer minimum water elevation during construction.
- Robust permanent pumping system with well-defined operation and maintenance plan.
- Thickened concrete ramps or uplift anchors to resist hydrostatic forces.
- Installation of pressure relief ports in the underpass walls to allow water to enter during high-water events. This will provide some resistance to offset hydrostatic uplift in an extreme event.

4.2.4 Existing Site Constraints

The existing site contains several notable features to consider during the design phase. The location of the railroad running adjacent to John Nolen Drive crosses North Shore Drive and Broom Street at the south and north end of the study area. The reasonable expectation is that the profile of this rail line cannot be significantly altered or raised. This then fixes the relative elevations between any underpass access points from North Shore Dive and Broom Street. This fact, combined with the closeness of the railroad right-of-way and tracks, makes any option that does not cross underneath the railroad tracks relatively fixed in regards to location and elevation if access is desirable from North Shore Drive and Broom Street. With the railroad profile fixed, the intersection elevations of North Shore Drive and Broom Street remain fixed, thus limiting the profile raise of John Nolen Drive over the underpass. During the preliminary design phase of the City's John Nolen Drive reconstruction project, a conceptual profile alternative of John Nolen Drive was developed to provide a potential raise (approximate maximum of 3.5-feet) in the profile to accommodate an underpass without impacts to the North Shore Drive and Broom Street intersections. This is illustrated in Figure 4.3.

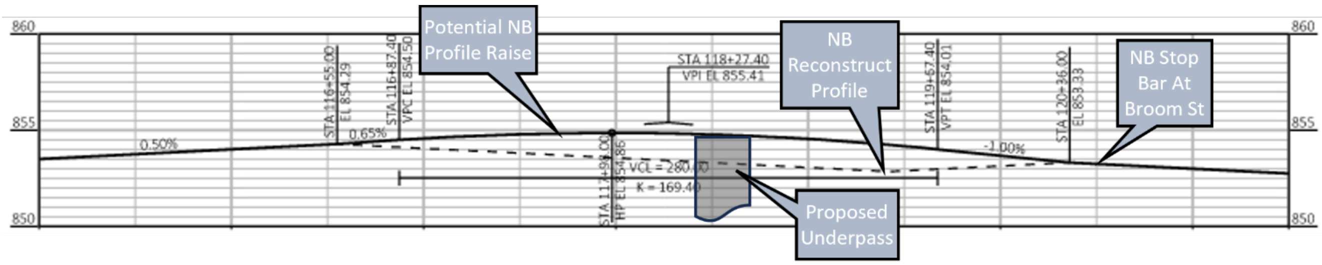


Figure 4.3 Northbound Profile Raise

Lake Monona lies within a Flood Storage District where any development or construction that reduces the floodwater storage capacity must provide compensatory storage within the same Flood Storage District. Any underpass design concept that impedes the boundaries of this district will add significant complexity to the design and permitting process. Finally, the deed restriction requiring the area be used for "park purposes only" is subject to interpretation. The addition of the underpass and paths to Law Park and Brittingham Park could potentially be deemed as acceptable improvements within the deed restriction criteria.

Recommendations include:

- Early coordination with the railroad to coordinate design aspects such as but not limited to geometry, retaining wall locations, temporary shoring, pump system crossings, potential permanent crash barriers. WisDOT recommends a 4-year lead time to obtain concurrence and agreement from the railroad for an improvement project such as an underpass. This time may be shortened if the railroad is in general support of the project.
- Maintain a minimum offset of more than 25-feet from the centerline of track to any retaining wall to minimize the risk for having to include an AREMA designed crash wall/barrier (potentially undesirable aesthetic limitations).
- Confirm that the underpass complies with the historical conveyance of property.

5 UNDERPASS ALTERNATIVES

Conceptual underpass alternatives were derived through coordination with the City of Madison Engineering and Parks Divisions.

5.1 Alternative 1A (H Concept)

Total Estimated Project Let Construction Costs: $24.7 M
Total Estimated Utility Costs (Compensability To Be Determined): $16.4 M
Total Annual Maintenance and Operation Costs: $25,000 to $40,000

Alternative 1A creates surface connections along the east and west side of John Nolen Drive at North Shore Drive and Broom Street. These surface connections then drop below John Nolen Drive to an underpass roughly halfway between North Shore Drive and Broom Street. This alternative is illustrated in Figure 5.1 with design details and cost estimates shown in Appendix G and Appendix I respectively.

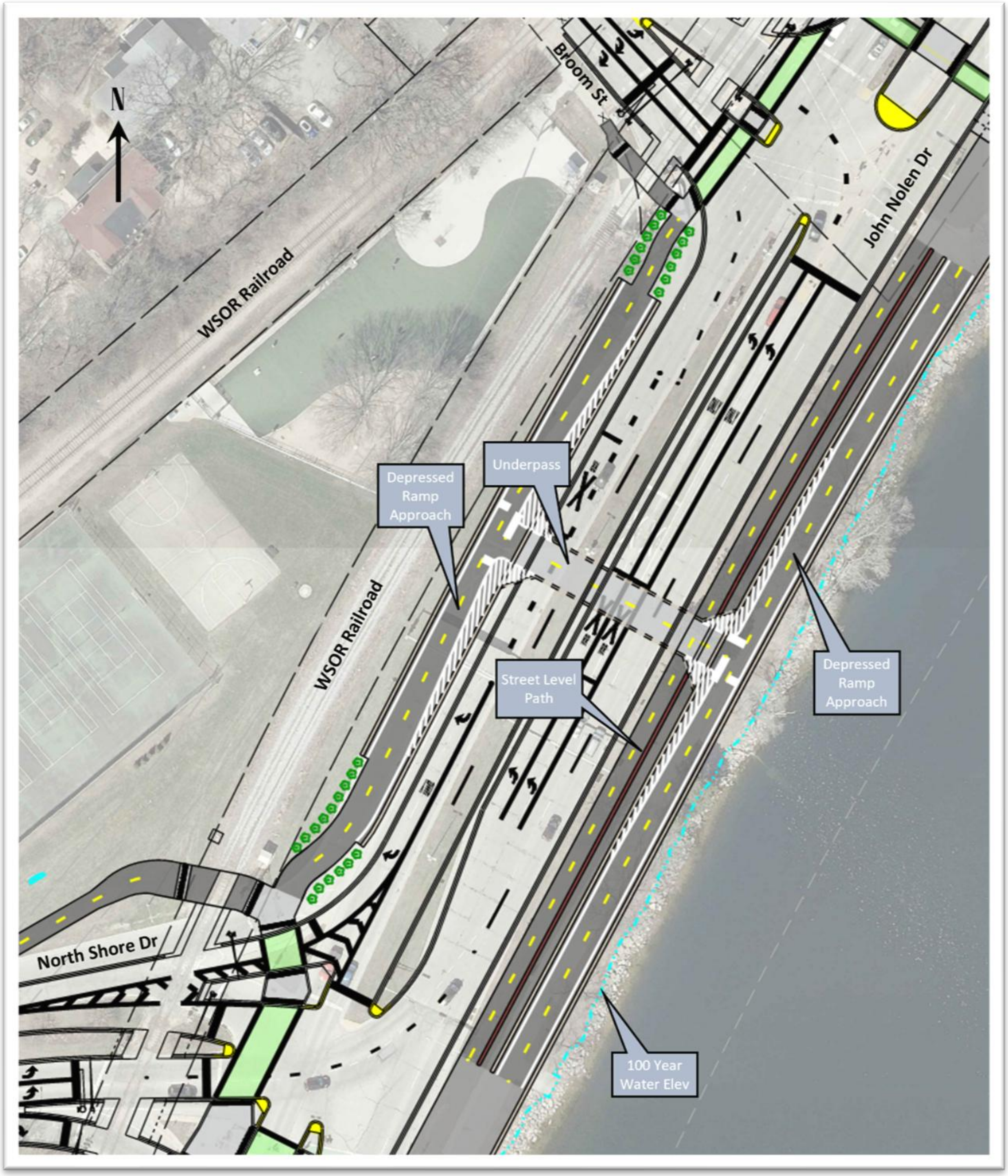


Figure 5.1 Alternative 1A (H Concept)

The profile elevation of the underpass is controlled by the existing railroad elevations at North Shore Drive and Broom Street. From those points, the path would descend to the rectangular underpass located between North Shore Drive and Broom Street. Exposed wall heights combined with a 42-inch crash barrier running adjacent to John Nolen Drive reach an approximate height of 13-feet. The rectangular underpass would then descend to the east side of John Nolen Drive. From there, a path would ascend to the bike and pedestrian surface crossings at North Shore Drive and Broom Street. The width of this approach is limited so that it does not infringe upon the flood storage of Lake Monona (100-year water elevation). Exposed wall heights with an incorporated crash barrier running adjacent to the street level multi-use path would reach approximately 14-feet. Exposed wall heights along Lake Monona that incorporate a 42-inch railing would reach an approximate height of 8-feet. This alternative would also include a multi-use path and walking path separated by a paved buffer at street level running parallel to the east side of John Nolen Drive. Renderings of the proposed underpass are shown in Figure 5.2.

Figure 5.2 Alternative 1A (H Concept) Rendering

This alternative would provide direct unimpeded access to the underpass from Broom Street and North Shore Drive without encroaching into the railroad right-of-way or placing fill in Lake Monona. Approach widths to the underpass were chosen to maximize the area, which could incorporate natural light and aesthetic features. The profile of John Nolen Drive would be raised approximately 3.5-feet from the existing roadway profile. The profile of the underpass slopes towards the lake to maintain the minimum depth of the tunnel structure top slab. This top slab would also function as the driving surface for vehicles on John Nolen Drive. During the design refinement process, an attempt could be made to slope the profile of the underpass towards the railroad to minimize the excavation depth of the structure. A portion of the access from Broom Street may be located within 25-feet of the track centerline which may prompt a request from WSOR for an AREMA designed crash wall. If this is undesirable, the access could be narrowed or potentially moved away from the railroad. This concept alternative is expected to impact the following utilities:

- ATC's 69kv electrical service running along the west side of John Nolen Drive
- MG&E's electrical service running along the west side of John Nolen Drive
- AT&T's fiber optic line running along the east side of John Nolen Drive
- Charter's fiber optic line running along the east side of John Nolen Drive

It can be expected that significant and early coordination with ATC may be required to explore relocation of their facilities. ATC has indicated that the process to design and construct new facilities will likely take 2-years to complete. The City's John Nolen Drive reconstruction project is not expected to impact this utility facility.

The conceptual cost estimate included in Appendix I for this alternative assumes the following notable assumptions and items:

- A portion of the needed roadway fill would use light weight foamed concrete to help mitigate settlement issues.
- The foundation of the structure consists of an estimated 2-foot steel reinforced concrete slab to resist hydrostatic uplift forces. The structure includes the approaches to the rectangular crossing

underneath John Nolen Drive.

- The amount of excavation for the structure would be approximately 50% contaminated, requiring that portion to be trucked to an appropriate offsite location.
- The walls of the structure would be cast in place with an architectural surface treatment that includes the use of custom form liners and multi color staining for aesthetics. A secant wall or other type of cantilever wall may be required.
- All temporary shoring will be left in place below the finished ground line to mitigate the potential of settlement.
- The pump system would be Pumping Alternative 1A

5.2 Alternative 2A (J Concept)

Total Estimated Project Let Construction Costs: $37.5 M
Total Estimated Utility Costs (Compensability To Be Determined): $17.4 M
Total Annual Maintenance and Operational Costs: $25,000 to $40,000

Alternative 2A creates a surface connection along the west side of John Nolen Drive near the North Shore Drive intersection. This surface connection then drops to an underpass in Brittingham Park that travels under the WSOR railroad tracks and John Nolen Drive. On the east side of John Nolen Drive, surface connections are provided to both the North Shore Drive and Broom Street intersections. This alternative is illustrated in Figure 5.3 with design details and cost estimates shown in Appendix H and I respectively.

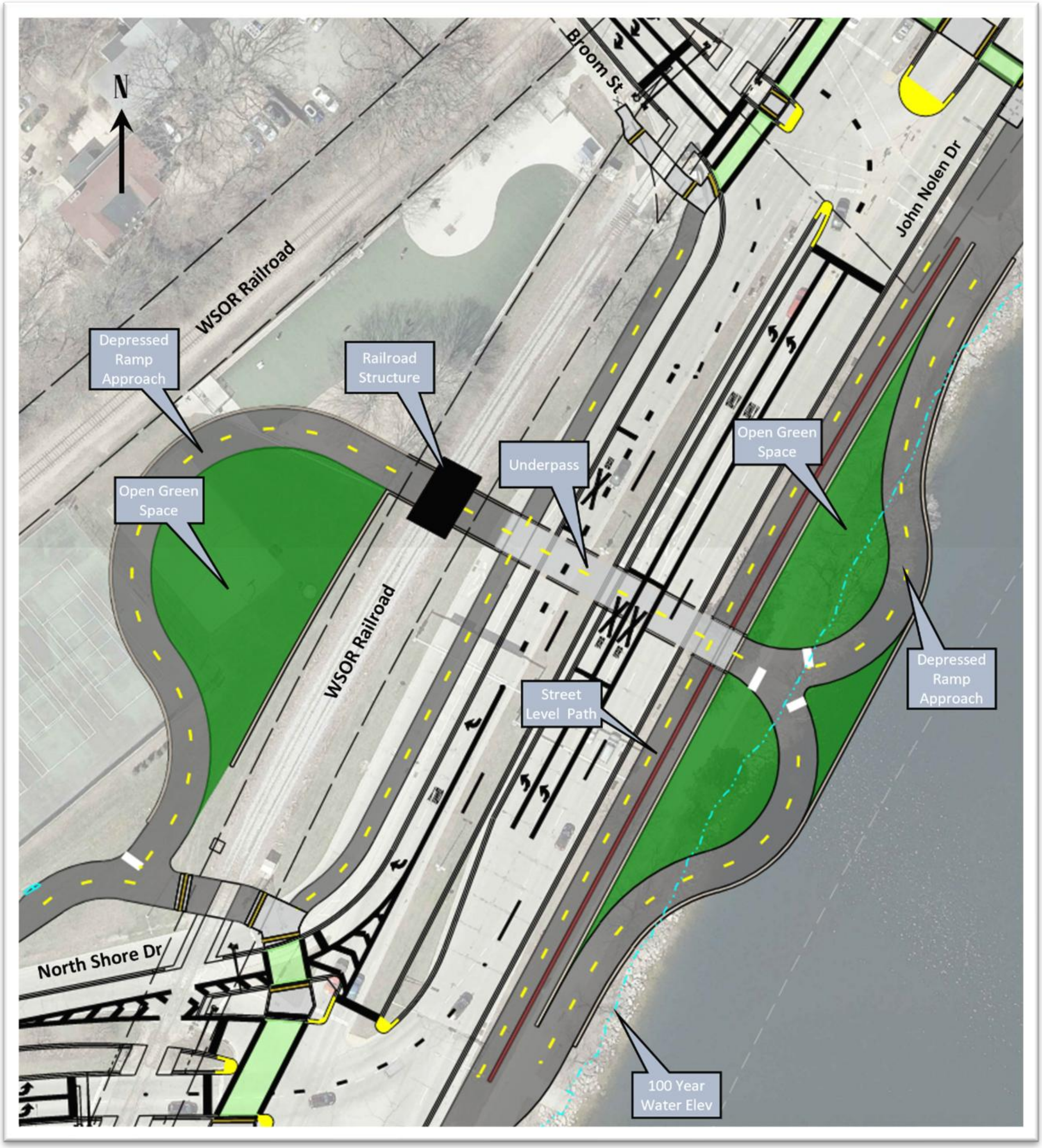


Figure 5.3 Alternative 2A (J Concept)

The path would start from a surface connection along North Shore Drive and descend through Brittingham Park . The exposed wall heights along the north and west side of the path that incorporate a 42-inch railing reach their maximum height of approximately 10-feet near the entrance of the railroad underpass. Along the interior of this loop, the path would descend with no adjacent retaining wall. This would allow for a gradually sloped surface to a retaining wall just outside (and parallel to) the railroad right-of-way, creating an open space with natural light. The path would then ascend at a gradual grade under an assumed steel railroad bridge. A steel bridge was assumed to minimize the depth of structure measured from the top of rail to bottom of steel structure. After passing under the railroad, the underpass would open to natural light with a 3-sided structure (open air concept) before crossing underneath John Nolen Drive. Leaving the underpass, the path would ascend to surface connections at North Shore Drive and Broom Street following a curved alignment. A retaining wall incorporating a 42-inch crash barrier is shown against the multi-use path and walking path at the street level running parallel to the east side of John Nolen Drive. The wall with 42-inch crash barrier reaches a maximum exposed height of approximately 10 to 12-feet. The path would be built upon lake fill and would provide green space between the retaining wall and path. Renderings of the proposed underpass are shown in Figure 5.4.

Figure 5.4 Alternative 2A (J Concept) Rendering

This alternative's west side approach would not include a direct connection between the underpass and Broom Street due to the potential impacts it would have on the existing off-leash dog park. It would be expected that the existing basketball court, one of the existing tennis courts, and a portion of the existing dog park would be impacted. This concept would maintain the existing park connectivity running between the railroad and depressed path. The profile of John Nolen Drive is proposed to remain similar to the existing and that currently planned for the City's John Nolen Drive reconstruction project. This would be possible because of the relatively deep profile elevation needed to clear the railroad. It is expected that refinements to the roadway profile will occur during the design phase of the project.

Along the eastside approach, the path alignment would follow a tightly curved alignment with a relatively gradual downslope to mitigate the amount of fill required in Lake Monona. This could be considered a difficult maneuver for recreational cyclists including those with trailers. An increase in curve radii that extends further into Lake Monona could allow an underpass profile to reach lake level. In this concept, a three-sided underpass structure extending into the lake could include a pile supported path to minimize the lake fill. During design development, the path approaches that encroach into Lake Monona could be evaluated as a boardwalk with a pile supported structure to limit floodwater storage capacity impacts. This is illustrated in Figure 5.5.

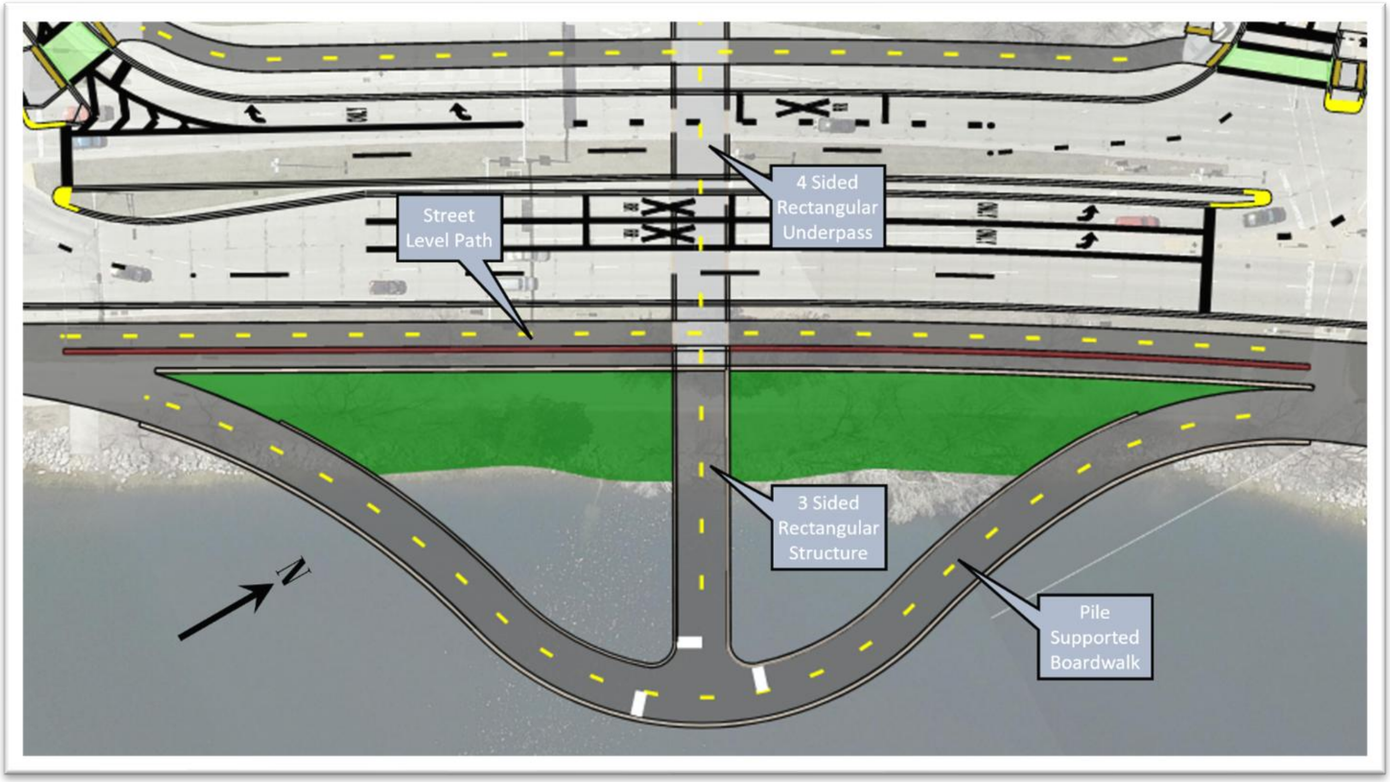


Figure 5.5 Pile Supported Path Concept

This alternative is expected to impact the following utilities:

- ATC's 69kv electrical service running along the west side of John Nolen Drive
- MMSD's 30-inch ductile iron sanitary force main located in Brittingham Park.
- City's 36-inch cast iron sanitary gravity main located in Brittingham Park.
- MG&E's electrical service running along the west side of John Nolen Drive
- AT&T's fiber optic line running along the east side of John Nolen Drive
- Charter's fiber optic line running along the east side of John Nolen Drive

It can be expected that significant and early coordination with ATC and MMSD may be required to explore relocation of their facilities. The City's John Nolen Drive reconstruction project is not expected to impact these utility facilities.

The conceptual cost estimate included in Appendix H for this alternative assumes the following notable assumptions and items:

- The foundation of the structure consists of an estimated 2-foot steel reinforced concrete slab to resist hydrostatic uplift forces. The structure includes the approaches to the rectangular crossing underneath John Nolen Drive and interior green space.
- The interior green space would consist of a minimum of 4-feet of engineered soil above 2-feet of clear stone on top of the steel reinforced concrete slab foundation.
- The amount of excavation for the structure is approximately 20% contaminated, requiring that portion to be trucked to an appropriate offsite location. The percentage is assumed less than Alternative 1A because much of the excavation is native lakebed.
- Excavation below subgrade (EBS) in Lake Monona was approximated at 15-feet and would be replaced by granular backfill.

- The railroad structure would be steel to minimize the depth of the underpass.
- The walls of the structure would be cast in place with an architectural surface treatment that includes the use of custom form liners and multi color staining for aesthetics. A secant wall or other type of cantilever wall may be required.
- All temporary shoring would be left in place below the finished ground line to mitigate the potential of settlement.
- The pumping system would be Pumping Alternative 1A

6 RISK ASSESSMENT

Complex and highly visible projects often present their own set of challenges due to their inherent levels of risk. The likelihood and severity of risk is often hard to determine with certainty but is an important aspect to evaluate at any stage of a project's life. A risk assessment can help identity and evaluate potential issues that may arise with the goal to assign responsibility and further develop the correct steps to mitigate or decrease the severity of those risks.

6.1 Underpass Risk Assessment Matrices

The following is a list of identified risks that have been evaluated based on the likelihood of occurrence and level of severity:

<table>
<tr><td colspan="3" rowspan="4">Risk No. 1 – Undesired Railroad Decision
Alternative 1A: Proximity to the WSOR railroad could require an AREMA crash wall and potentially an OCR hearing. Potential impacts include increased cost to the project, delay to the project, and undesirable aesthetics from such a large crash wall.
Alternative 2A: The decision to add a railroad bridge is out of the City's control and is determined by OCR. Decision may not come until late in the design and planning effort. Without railroad concurrence for a bridge, this alternative is not feasible.</td><td>LOW</td><td>MEDIUM</td><td>HIGH</td></tr>
<tr><td>Ok to proceed</td><td>Take Mitigation Effort</td><td>Investigate Further</td></tr>
<tr><td colspan="3">SEVERITY</td></tr>
<tr><td>Acceptable</td><td>Tolerable</td><td>Undesirable</td></tr>
<tr><td rowspan="3">Potential Mitigation Efforts
Alternative 1A: During the future design process, ensure that underpass elements are located a desirable distance from the railroad.
Alternative 1A/2A: Conduct early coordination with the railroad on design elements they would require and plan on significant time for an OCR decision.</td><td rowspan="3">LIKELIHOOD</td><td>Improbable
Risk is Unlikely to Occur</td><td></td><td></td><td></td></tr>
<tr><td>Possible
Risk is Likely to Occur</td><td></td><td></td><td></td></tr>
<tr><td>Probable
Risk Will Occur</td><td></td><td></td><td></td></tr>
</table>

Risk No. 2 – Differential Settlement

Alternative 1A/2A: The underlying soil that will support either alternative varies across the relatively small project area. This creates a potential scenario where settlement may occur faster near or over Lake Monona where the more compressible soils are located. This could introduce minor to severe degradation of the underpass structure along with the roadway and path infrastructure. This could require more intense maintenance procedures in the future.

Potential Mitigation Efforts

Alternative 1A/2A: Conduct a detailed geotechnical investigation of the underlying soil conditions that will help facilitate engineering best practices to minimize any potential differential settlement.

		LOW	MEDIUM	HIGH
		Ok to proceed	Take Mitigation Effort	Investigate Further
		SEVERITY		
		Acceptable	Tolerable	Undesirable
LIKELIHOOD	**Improbable** Risk is Unlikely to Occur			
	Possible Risk is Likely to Occur			
	Probable Risk Will Occur			

Risk No. 3 – Hydrostatic Forces

Alternative 1A/2A: Due to the shallow ground water in the project area, hydrostatic forces will occur along the sides of the structure and uplift forces will occur along the bottom of the structure. These forces along with the corrosive properties of water may accelerate the structural degradation of the underpass structure. This could lead to increased infiltration of surrounding groundwater into the structure. This may require frequent maintenance and monitoring of the underpass to mitigate any severe impacts.

Potential Mitigation Efforts

Alternative 1A/2A: Hydrostatic forces can be mitigated through proper design practices which may include uplift anchors. Develop a comprehensive plan for long term operation, maintenance, and inspection that includes acceptable funding resources to implement the plan on an annual basis.

		LOW	MEDIUM	HIGH
		Ok to proceed	Take Mitigation Effort	Investigate Further
		SEVERITY		
		Acceptable	Tolerable	Undesirable
LIKELIHOOD	**Improbable** Risk is Unlikely to Occur			
	Possible Risk is Likely to Occur			
	Probable Risk Will Occur			

Risk No. 4 – Hazardous Materials

Alternative 1A/2A: The project area is likely adjacent to or located within a historical landfill. This raises concern that contaminants may migrate outside the project area that are disturbed during construction given the shallow groundwater. After construction, the contaminants could potentially infiltrate through the structure and mix with the stormwater discharge. This may lead to increased project costs to mitigate these issues along with the potential for long term monitoring of the stormwater discharge.

Potential Mitigation Efforts

Alternative 1A/2A: Coordinate with the DNR to conduct a detailed underground hazardous material investigation. If contaminants are found, develop a thorough plan to mitigate the migration of

		LOW	MEDIUM	HIGH
		Ok to proceed	Take Mitigation Effort	Investigate Further
		SEVERITY		
		Acceptable	Tolerable	Undesirable
LIKELIHOOD	**Improbable** Risk is Unlikely to Occur			
	Possible Risk is Likely to Occur			

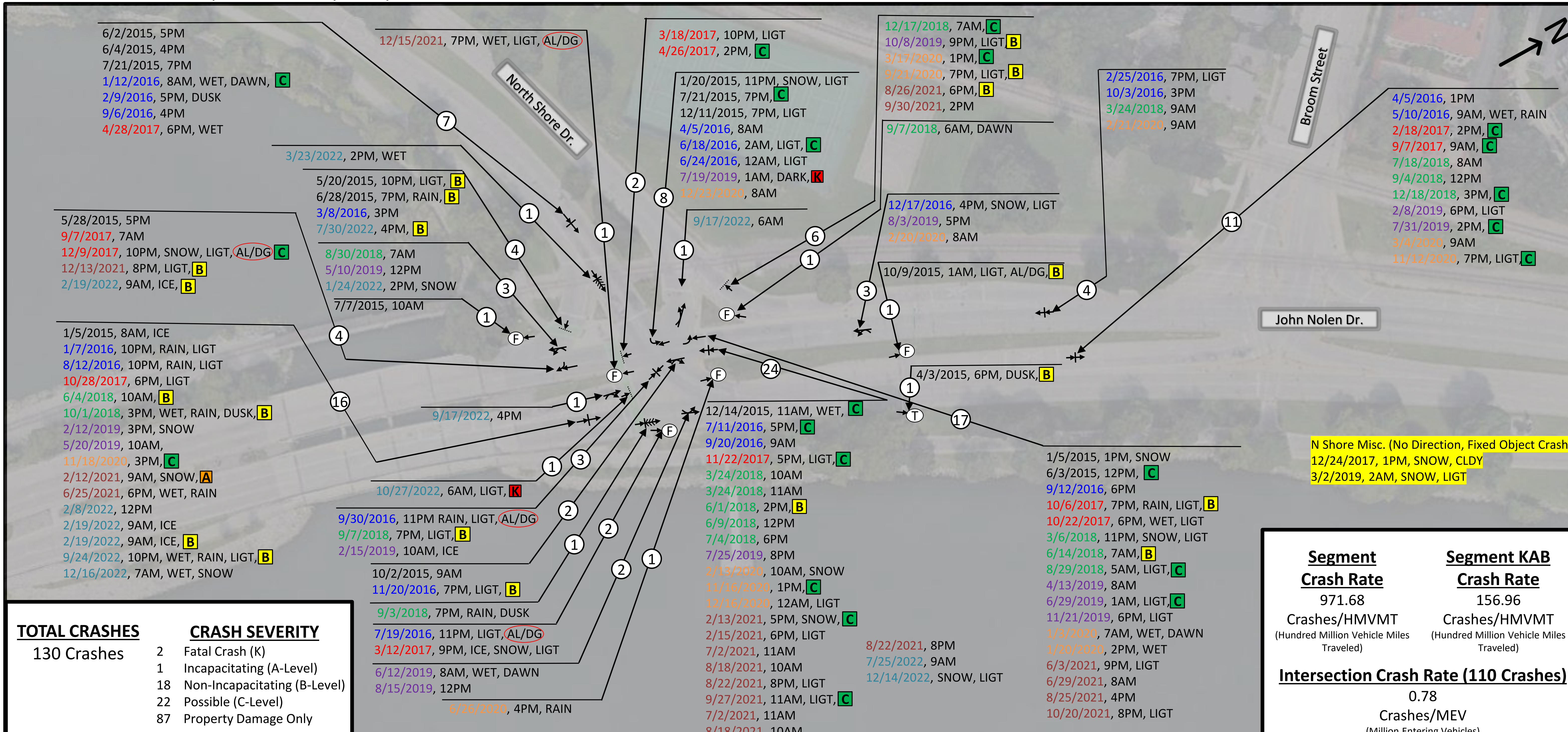
contaminants during construction. Monitor stormwater discharge and develop a contingency plan to mitigate contaminants.		**Probable** Risk Will Occur			

Risk No. 5 – Underused Facility Alternative 1A/2A: Each alternative maintains the existing at-grade crossing therefore allowing bicyclists/pedestrians the choice of using the underpass. Choosing the underpass introduces a downhill/uphill effort to the user along with a trip through an underpass that is expected to lack a desirable amount of natural light. More importantly, the underpass choice creates a much longer route to cross John Nolen Drive when compared to the at grade crossing. This may lead to an underused facility that will minimize the safety benefits of the underpass.			**LOW**	**MEDIUM**	**HIGH**
			Ok to proceed	Take Mitigation Effort	Investigate Further
			SEVERITY		
			Acceptable	**Tolerable**	**Undesirable**
Potential Mitigation Efforts Alternative 1A/2A: Avoid creating a basic utilitarian underpass that has no identity. Develop an underpass design that is aesthetically pleasing and creates an 'experience' for the user. Explore the idea of educating the user about the safety benefits of using the underpass.	**LIKELIHOOD**	**Improbable** Risk is Unlikely to Occur			
		Possible Risk is Likely to Occur			
		Probable Risk Will Occur			

Risk No. 6 – Lake Fill Permitting Alternative 2A: Any filling of Lake Monona, a flood storage district, will require an equal volume of flood storage be constructed within the district. This cannot be created by developing storage on the lake bottom and would likely need to be created along City owned shoreline. The permit is granted by the DNR through coordination with several federal agencies and would likely be a lengthy process. If the permit is not granted, this alternative is not feasible.			**LOW**	**MEDIUM**	**HIGH**
			Ok to proceed	Take Mitigation Effort	Investigate Further
			SEVERITY		
			Acceptable	**Tolerable**	**Undesirable**
Potential Mitigation Efforts Alternative 2A: Coordinate early with the DNR and federal agencies to help understand any specific requirements to reach approval. Early in the design phase, evaluate the use of a pile supported boardwalk to minimize the amount of lake fill and identify potential areas where flood storage could be created.	**LIKELIHOOD**	**Improbable** Risk is Unlikely to Occur			
		Possible Risk is Likely to Occur			
		Probable Risk Will Occur			

APPENDIX A

Crash Diagram



TOTAL CRASHES
130 Crashes

CRASH SEVERITY

2	Fatal Crash (K)
1	Incapacitating (A-Level)
18	Non-Incapacitating (B-Level)
22	Possible (C-Level)
87	Property Damage Only

Segment Crash Rate
971.68
Crashes/HMVMT
(Hundred Million Vehicle Miles Traveled)

Segment KAB Crash Rate
156.96
Crashes/HMVMT
(Hundred Million Vehicle Miles Traveled)

Intersection Crash Rate (110 Crashes)
0.78
Crashes/MEV
(Million Entering Vehicles)
Entering Vehicles: 48,350/day

LEGEND

Crash Types

Moving Vehicle
Backing Vehicle
Pedestrian
Bicyclist
Parked Vehicle
Stop/Yield Sign
Tree
Utility Pole
Fixed Object
Non-Fixed Object
Angle (Right Angle)
Angle (Left-Turn)
Angle (Right-Turn)
Sideswipe-Same
Sideswipe-Opposite
Head-On
Rear-End
Out of Control
Overtake
Overturn

YEAR
2015 BLACK
2016 BLUE
2017 RED
2018 GREEN
2019 PURPLE
2020 ORANGE
2021 MAROON
2022 AQUA

XX/XX/XXXX, XX AM/PM, XXX, XXX
DATE TIME SEE BELOW CRASH FREQUENCY

X = CRASH SEVERITY (SEE DEFINITIONS)
WET = WET PAVEMENT
SNOW = SNOW ON PAVEMENT
ICE = ICE ON PAVEMENT
DAWN = DURING FIRST LIGHT
LIGT = STREET LIGHTS OPERATING (DAYTIME IF BLANK)
AL/DG = ALCOHOL/DRUG INVOLVEMENT

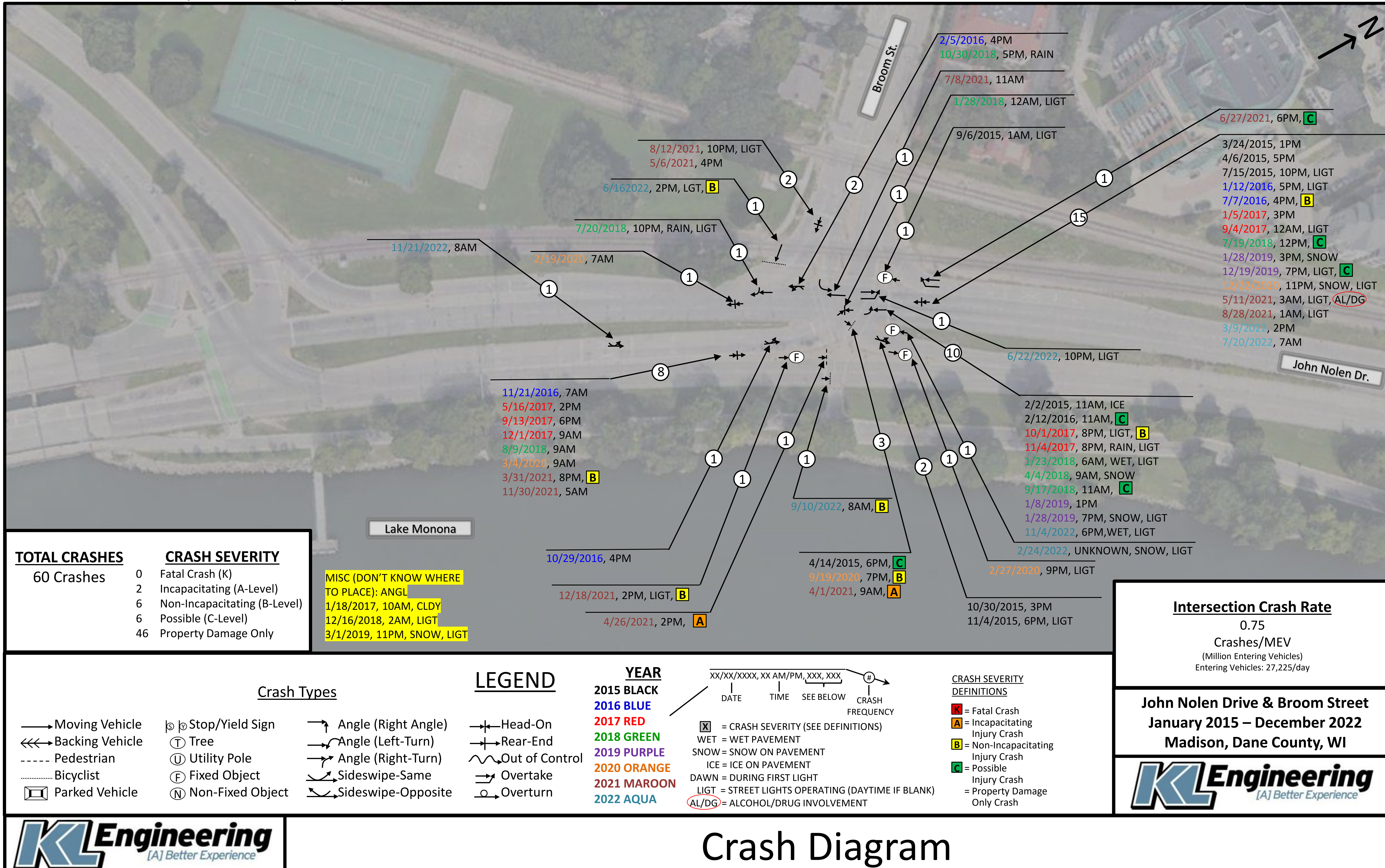
CRASH SEVERITY DEFINITIONS
K = Fatal Crash
A = Incapacitating Injury Crash
B = Non-Incapacitating Injury Crash
C = Possible Injury Crash
= Property Damage Only Crash

John Nolen Drive & North Shore Drive, North Shore Drive to Broom Street
January 2015 – December 2022
Madison, Dane County, WI

KL Engineering [A] Better Experience

KL Engineering [A] Better Experience

Crash Diagram


Broom St.
John Nolen Dr.
Lake Monona
2/5/2016, 4PM
10/30/2018, 5PM, RAIN
7/8/2021, 11AM
1/28/2018, 12AM, LIGT
9/6/2015, 1AM, LIGT
6/27/2021, 6PM, C
3/24/2015, 1PM
4/6/2015, 5PM
7/15/2015, 10PM, LIGT
1/12/2016, 5PM, LIGT
7/7/2016, 4PM, B
1/5/2017, 3PM
9/4/2017, 12AM, LIGT
7/19/2018, 12PM, C
1/28/2019, 3PM, SNOW
12/19/2019, 7PM, LIGT, C
12/22/2020, 11PM, SNOW, LIGT
5/11/2021, 3AM, LIGT, AL/DG
8/28/2021, 1AM, LIGT
3/9/2022, 2PM
7/20/2022, 7AM
8/12/2021, 10PM, LIGT
5/6/2021, 4PM
6/162022, 2PM, LGT, B
7/20/2018, 10PM, RAIN, LIGT
11/21/2022, 8AM
2/19/2020, 7AM
6/22/2022, 10PM, LIGT
11/21/2016, 7AM
5/16/2017, 2PM
9/13/2017, 6PM
12/1/2017, 9AM
8/9/2018, 9AM
3/4/2020, 9AM
3/31/2021, 8PM, B
11/30/2021, 5AM
2/2/2015, 11AM, ICE
2/12/2016, 11AM, C
10/1/2017, 8PM, LIGT, B
11/4/2017, 8PM, RAIN, LIGT
1/23/2018, 6AM, WET, LIGT
4/4/2018, 9AM, SNOW
9/17/2018, 11AM, C
1/8/2019, 1PM
1/28/2019, 7PM, SNOW, LIGT
11/4/2022, 6PM, WET, LIGT
9/10/2022, 8AM, B
10/29/2016, 4PM
2/24/2022, UNKNOWN, SNOW, LIGT
4/14/2015, 6PM, C
9/19/2020, 7PM, B
4/1/2021, 9AM, A
2/27/2020, 9PM, LIGT
12/18/2021, 2PM, LIGT, B
4/26/2021, 2PM, A
10/30/2015, 3PM
11/4/2015, 6PM, LIGT
2
2
1
1
1
1
1
1
1
15
1
10
8
1
1
1
1
3
2
1
1
F
F
F
F
TOTAL CRASHES
60 Crashes
CRASH SEVERITY
0 Fatal Crash (K)
2 Incapacitating (A-Level)
6 Non-Incapacitating (B-Level)
6 Possible (C-Level)
46 Property Damage Only
MISC (DON'T KNOW WHERE TO PLACE): ANGL
1/18/2017, 10AM, CLDY
12/16/2018, 2AM, LIGT
3/1/2019, 11PM, SNOW, LIGT
Intersection Crash Rate
0.75
Crashes/MEV
(Million Entering Vehicles)
Entering Vehicles: 27,225/day
LEGEND
Crash Types
Moving Vehicle
Backing Vehicle
Pedestrian
Bicyclist
Parked Vehicle
Stop/Yield Sign
Tree
Utility Pole
Fixed Object
Non-Fixed Object
Angle (Right Angle)
Angle (Left-Turn)
Angle (Right-Turn)
Sideswipe-Same
Sideswipe-Opposite
Head-On
Rear-End
Out of Control
Overtake
Overturn
YEAR
2015 BLACK
2016 BLUE
2017 RED
2018 GREEN
2019 PURPLE
2020 ORANGE
2021 MAROON
2022 AQUA
XX/XX/XXXX, XX AM/PM, XXX, XXX
DATE
TIME
SEE BELOW
CRASH FREQUENCY
X = CRASH SEVERITY (SEE DEFINITIONS)
WET = WET PAVEMENT
SNOW = SNOW ON PAVEMENT
ICE = ICE ON PAVEMENT
DAWN = DURING FIRST LIGHT
LIGT = STREET LIGHTS OPERATING (DAYTIME IF BLANK)
AL/DG = ALCOHOL/DRUG INVOLVEMENT
CRASH SEVERITY DEFINITIONS
K = Fatal Crash
A = Incapacitating Injury Crash
B = Non-Incapacitating Injury Crash
C = Possible Injury Crash
= Property Damage Only Crash
John Nolen Drive & Broom Street
January 2015 – December 2022
Madison, Dane County, WI
KL Engineering
[A] Better Experience
Crash Diagram

APPENDIX B

John Nolen Drive Costal Analysis

Memo

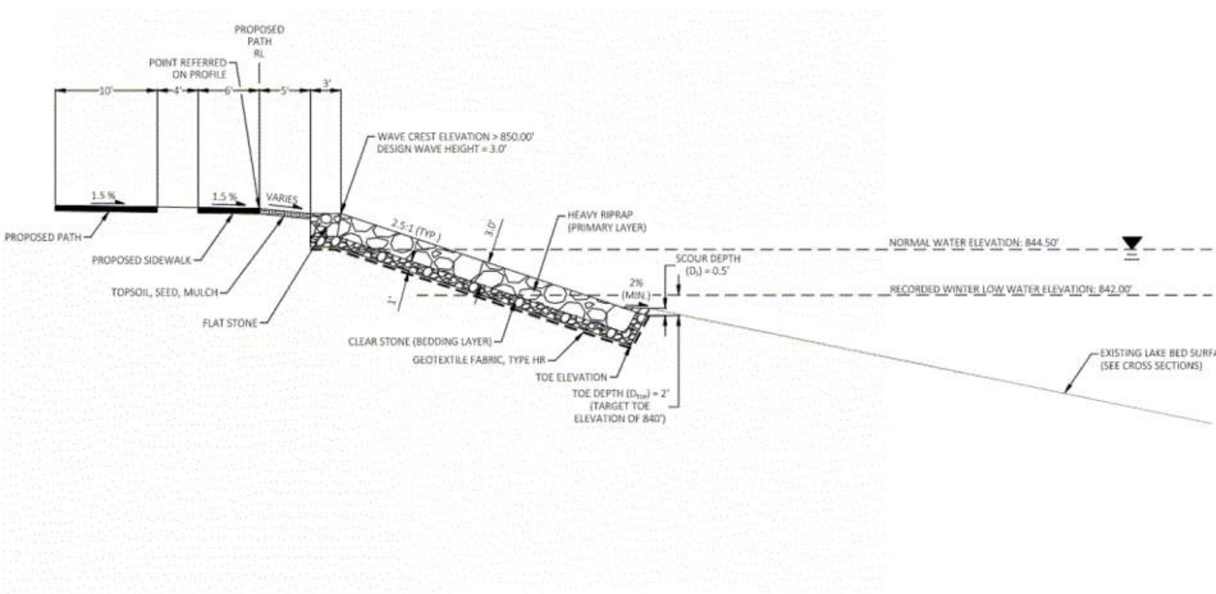
To:	City of Madison - Chris Petykowski, PE
From:	MSA Professional Services, Inc. - Jaime Kurten, PE
Subject:	John Nolen Drive - Shoreline Analysis - City of Madison Preferred
Date:	June 24, 2024

INTRODUCTION

City of Madison is proposing a project to reconstruct John Nolen Drive from Broom Street to East Olin Avenue including the causeway and six bridges between North Shore Drive and Lakeside Street across Lake Monona. Included in the project was a complete review and analysis of the adjacent shoreline including evaluation of the existing revetment and recommendations for proposed revetment.

BACKGROUND AND PREFERRED TYPICAL SECTION

A coastal analysis report was completed by Anchor QEA on April 25, 2024 (Attachment A) which includes wave analysis, design parameters, and a professional recommendation for the revetment design along John Nolen Drive. The City of Madison reviewed the recommended shoreline design and has determined that the typical section as shown below is the preferred cross section for use along the shoreline for John Nolen Drive.



CITY PREFERRED SHORELINE TYPICAL SECTION
OPTION: FIGURE 4-1 EMBEDDED TOE

ATTACHMENT A

30 W. Mifflin Street, Suite 801
Madison, Wisconsin 53703
608.710.4930

ANCHOR QEA

Memorandum

April 25,2024

To: MSA Professional Services, Inc.

From: Anchor QEA, Inc.

Re: Coastal Analysis - John Nolen Drive

Project Overview

In January 2022, Anchor QEA completed a coastal analysis to provide design recommendations for a for a riprap revetment to protect John Nolen Drive and nearby shoreline in Madison, Wisconsin (Anchor QEA 2022). This was completed in support of a project with MSA Professional Services (MSA) and KL Engineering for the City of Madison (City). Subsequent to that analysis, Anchor QEA is providing the additional design recommendations included in this technical memorandum to account for probable ice forces.

The ice force evaluation included analysis of historical records to determine maximum ice thicknesses on Lake Monona and provide design recommendations in accordance with federal standards to limit ice damage to the revetment. The ice thickness analysis was completed using the United States Army Corps of Engineers (USACE) Ice Engineering Manual (USACE 2006) to determine exceedance probabilities of maximum ice thickness for Lake Monona. Based on a 74-year dataset from July 1, 1949, to June 30, 2023, the maximum computed ice thickness was 24.4 inches, and the minimum computed thickness was 7.5 inches. Using a Weibull analysis, the 2% annual chance ice thickness for Lake Monona was determined to be 24-inches.

Anchor QEA understands the City has developed preliminary typical sections for the proposed revetment. Based on the findings of the ice evaluation, Anchor QEA provided comments on the suitability of the proposed design based on the anticipated ice conditions.

Location

The project area is the east side of John Nolen Drive as it crosses Lake Monona between the isthmus and US Route 12/US Route 18 in Madison, WI (Figure 1). This portion of John Nolen Drive is located on a constructed causeway that was built in the 1960s. The revetment provides important protection of the underlying fill material from wave and ice damage.

Figure 1
Location of John Nolen Drive in Madison, Wisconsin

Revetment Design Parameters

The January 2022 memorandum, Appendix B, provided design recommendations based on a variety of design water levels and wave heights (Anchor QEA 2022). The results of that evaluation were built upon for this analysis.

The Rock Manual (CIRIA 2007) provides design guidance to account for ice forces in the design of armor stone revetments. These include:

- The use of widely graded armor stone (riprap) should not be used.
- Where plucking is a concern, the median stone size should exceed the ice thickness.
- Slope should be less than 30 degrees (1.72H:1V) to allow ice to sheets to ride up the slope rather than crush the revetement into the bank.

Anchor previously provided stone size recommendations for a range of revetment design slopes from 1.5:1 to 5:0. Revetment slope does not directly impact required stone sizes for ice calculations, but based on the above guidance, Anchor QEA recommends the proposed design slope be at 2:1 or shallower.

Ice Loading

Lake Monona often freezes over. Typical ice damage to coastal armor includes the following (USACE 2006):

1. **Heaving:** Ice sheets heaving up a slope due to thermal expansion or wind, displacing stones along the slope, or bulldozing the stones into the slope.

2. **Plucking:** A layer of ice forms around revetment stones. The water level rises, lifting the ice sheet and plucking individual stones from the revetment.

Design protection against ice forces is generally based on ice thickness. The USACE Ice Engineering Manual provides guidance for calculating ice accumulation across multiple days in low wind and flow conditions. By calculating the sum of Accumulated Freezing Degree-Days (AFDDs) and assuming an initial ice thickness of 0 inches, Equation 2-10 from the Ice Engineering Manual (USACE 2006) provides an estimate of ice accumulation for a winter season.

$$h_j = \alpha\sqrt{U_j}$$

Where h_j = Ice thickness on day j

U_j = Accumulated freezing degree-days (AFDDs) between the start of ice formation and day j

$$U_j = \sum_{i=1}^{j}(T_m - T_{ai})$$

T_m = Temperature at the water/ice interface (assumed to be 32-degrees Fahrenheit) T_{ai} = Air temperature on day i

$$\alpha = \sqrt{\frac{2k_i}{\rho\lambda}}$$

k_i = *thermal conductivity of ice*

ρ = *ice density*

λ = ice latent heat

The term "α" is a dimensionless coefficient used to describe the ice cover conditions for ice formation. Table 2-2 from the Ice Engineering Manual presents typical α values for a windy lake with no snow, an average lake with snow, an average river with snow, and a sheltered small river. This analysis used an α of 0.6, corresponding to an average lake with snow.

An important assumption used in this equation is that the water temperature at the surface of the lake where ice is forming is 32°F, which is not readily apparent based on air temperature alone. To account for this, the AFDDs were only calculated between the recorded freeze-over and ice-off dates for Lake Monona. The Wisconsin State Climatology Office has kept a record of Lake Monona freeze-over dates since 1851 (WSCO 2024). This record provides the best available estimate of the date at which the lake meets the 32°F assumption to mark the onset of ice formation. In years where there were multiple recorded freeze-over and ice-off dates, the longest continual duration of recorded ice was used.

Hourly air temperatures were obtained from Dane County Regional Airport from July 1, 1949, to June 30, 2023 using the Iowa State University Mesonet (IEM 2024). Assuming the annual recorded freeze-over date of the lake is Day 0 of the start of ice formation for each winter season, the winter season maximum ice thicknesses shown in Figure 2 were computed. Using a Weibull return period analysis, Anchor QEA calculated the ice thicknesses shown in Table 1. Anchor QEA recommends a design ice thickness of 25 inches, corresponding to the 50-year return period (Table 1).

Figure 2
Maximum Annual Ice Thickness

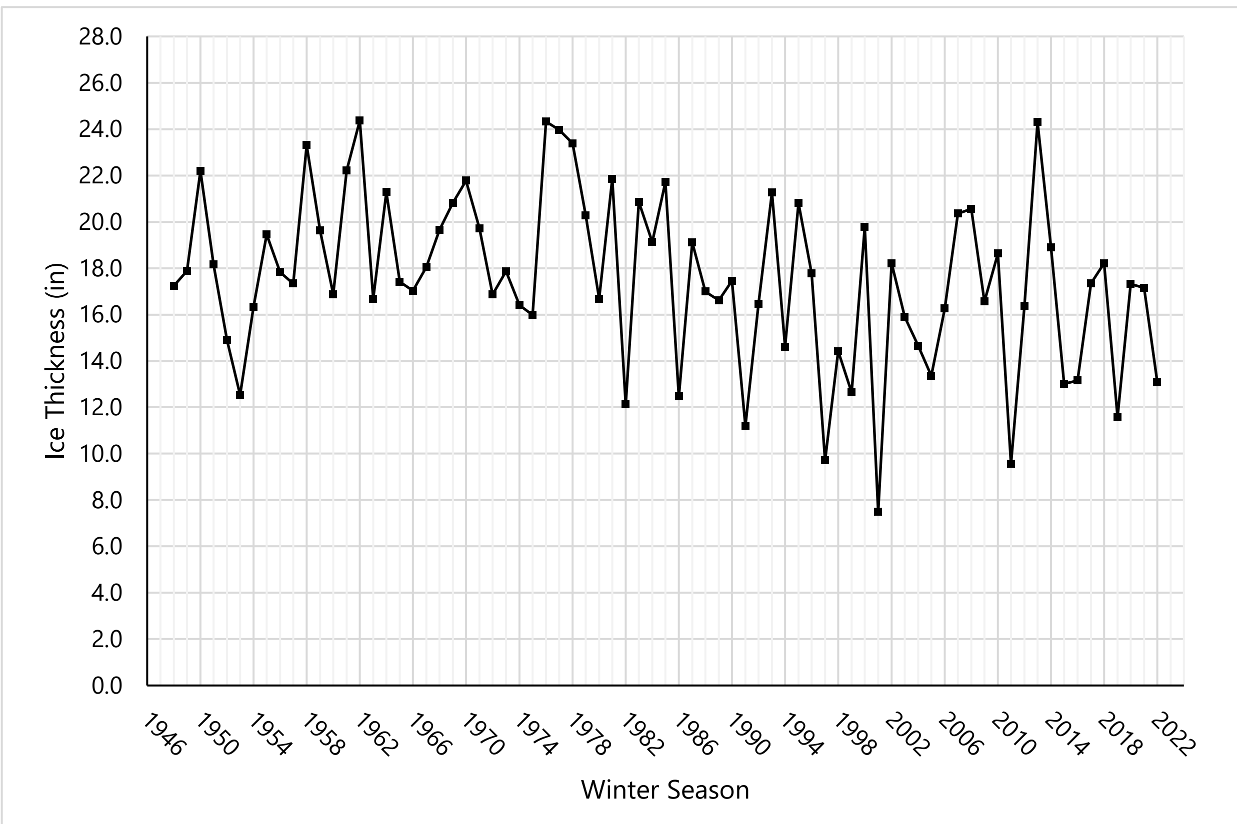


Table 1
Weibull Ice Return Period

Return Period	Ice Thickness (inches)
10-year	22
20-year	24
50-year	25
100-year	26

Revetment Layers

Armor Stone Sizing

Armor stone sizing is sized based on the *Shore Protection Manual* (USACE 1984) and *Coastal Engineering Manual* (USACE 2002) guidelines. While design slope is an important consideration for limiting damage by shoving, it does not directly relate to the required cover layer stone size.

Considering the 50-year design ice thickness, Anchor QEA recommends a primary armor layer gradation with a D_{50} of 24 inches (W_{50} = 1,320 lbs) to protect against plucking, in accordance with guidance stated in the *Rock Manual* (CIRIA 2007). Given the sizing tolerances associated with quarry stone, the difference between this and a D_{50} stone size of 25 inches is negligible. This design assumes a cover armor layer that is at least two armor stones thick and consists of angular quarry stone per USACE recommendations (1984, 2002). Anchor QEA recommends against the use of glacial or fieldstone, as the rounded boulders do not provide adequate stability for this application.

Underlayer Stone Sizing and Thickness

USACE guidelines also dictate the underlayer stone sizing. The *Shore Protection Manual* (USACE 1984) and *Coastal Engineering Manual* (USACE 2002) state that any underlayers should be sized such that D_{15} (cover) ≤ 5 D_{85} (underlayer) where D_{15} and D_{85} are the diameters larger than 15% and 85%, respectively, of other stones in the specified layer. Layer thicknesses should be the greatest of:

- 0.98 ft (0.30 m)
- $2.0\,(\frac{W_{50}}{W_r})^{\frac{1}{3}}$
- $1.25\,(\frac{W_{max}}{W_r})^{\frac{1}{3}}$

where W_{50} is the 50th percentile weight of stone, W_{max} is the weight of the heaviest stone, and W_r is the density of stone in units of lb/ft^3 (typical values for riprap are approximately 165 lb/ft^3). This guidance applies to all stone layers in the structure including the cover armor layer and all subsequent underlayers.

Gradation for rocks used in the rubble layers shall be as follows:

- Primary Cover Layer: 75-125% of the target $W_{50,PrimaryCover}$
- First Underlayer: 70-130% of the target $W_{50,FirstUnderlayer}$
- Second Underlayer: 50-150% of the target $W_{50,SecondUnderlayer}$
- Core and Bedding Layer: 30-170% of the target $W_{50,BeddingLayer}$

Relationships between the sizes of stones relative to the primary cover armor from different layers are provided below:

- First Underlayer $\mathrm{W}_{50,\mathrm{FirstUnderlayer}} = (\frac{1}{10})\, W_{50,PrimaryCover}$
- Second Underlayer: $\mathrm{W}_{50,\mathrm{SecondUnderlayer}} = (\frac{1}{200})\, W_{50,PrimaryCover}$
- Core & Bedding Layer: $\mathrm{W}_{50,\mathrm{BeddingLayer}} = (\frac{1}{4000})\, W_{50,PrimaryCover}$

Using the relationships above, Table 2 provides an approximate range of acceptable stone sizes by weight for each layer and recommended minimum layer thicknesses.

The multi-layered approach is intended to prevent geotextile failures and washout in the revetment. The smaller stones in the underlayer help protect the geotextile layer during and after installation of the primary armor stones. Placement of the larger stones directly on the geotextile can result in punctures and tears in the fabric. The bedding layer also helps distribute the weight of the primary armor stone layer and limit the presence of large void spaces, which both lead tears and washout of material behind the primary armor stones and eventual revetment failure. The smaller stones also provide an additional layer to dissipate wave forces before impacting the native material. This guidance is consistent with USACE design recommendations (USACE 2002).

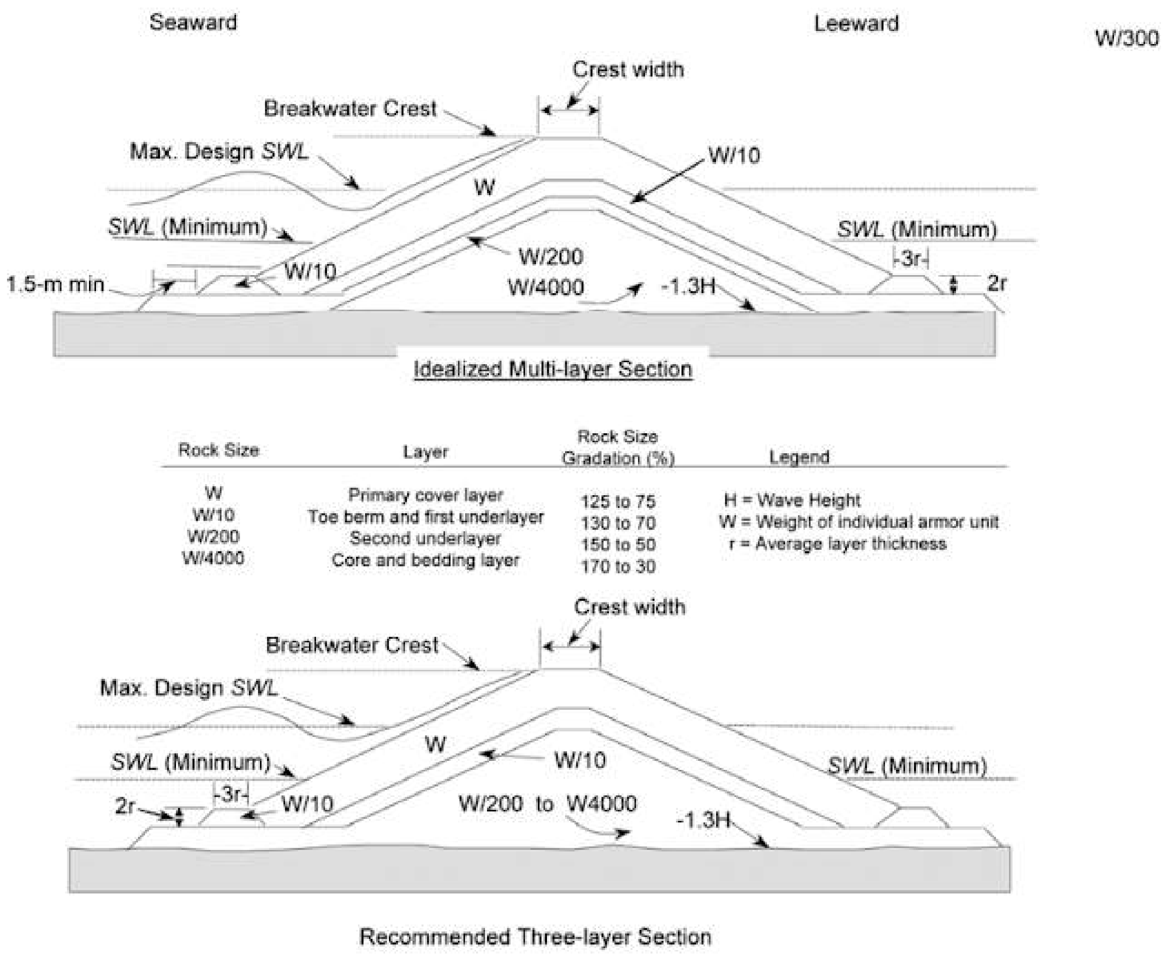
Table 2
Revetment Stone Sizing Based on 50-year Design Ice Thickness

	Layer Stone D_{50} (inches)	Layer Thickness (feet)	Median Stone Weight [lbf]	Min. Stone Weight [lbf]	Max. Stone Weight [lbf]
Primary Cover Layer	24	4.0	1,320	990	1,650
Bedding Layer	11	1.9	130	90	170

Cross Section Schematics

As discussed above, the *Shore Protection Manual* (USACE 1984) and *Coastal Engineering Manual* (USACE 2002) indicate that rubble mound structures shall consist of several layers of stone that are sized to help minimize scour and stone displacement from washout under wave forces. A geotextile filter should also be used to further stabilize the structure. In cross-section schematics, the *Coastal Engineering Manual* (USACE 2002) shows suggestions for stone toe design (Figure 3).

Figure 2
Schematic of an idealized and recommended multi-layer section of a rubble mound breakwater. From *Coastal Engineering Manual* (USACE 2002)



From the *Coastal Engineering Manual* (USACE 2002):

> *The idealized cross section provides more complete use of the range of materials typically available from a quarry, but it is more difficult to construct. The recommended cross section takes into account some of the practical problems involved in constructing submerged portions of the structure.*

Revetment Toe Design

Scour at the toe of a coastal structure is a common failure method. Failure of the toe will lead to instability of the revetment and result in stones sliding down the slope. According to the *Coastal Engineering Manual*, in very shallow water with depth-limited wave heights, the toe should consist of one or two rows of main armor units (USACE 2007). Additionally, due to the concerns of ice damage during winter low water levels, the primary armor layer should be continued through the toe to discourage damage from plucking and heaving.

The *Coastal Engineering Manual* (USACE 2002) recommends toe designs based on the relationship between water depth and design wave heights. Locations where waves are depth-limited and breaking as a result are considered very shallow. The height of waves can be depth-limited as they approach a shallow area. Waves typically begin to break when:

$$\frac{H}{d} = 0.78$$

where *H* is the wave height, and *d* is water depth. For a design wave height of 3 ft, that would indicate the toe berm would cause wave breaking at a depth of approximately 3.75 ft.

The minimum required elevation to achieve toe stability is set based on the lower of two criteria: scour and wave height. In conditions where scour is expected, the *Coastal Engineering Manual* provides several options for toe design (**Figure 4**) where the primary design variable "d_s" represents scour depth. The *Coastal Engineering Manual* recommends conservatively estimating scour depth to be equal to the maximum wave height at the structure toe. Given the 100-year wave height of 3-feet, Anchor QEA set d_s = 3.5 to provide a factor of safety of 1.15.

The *Coastal Engineering Manual* (USACE 2002) also indicates the minimum depth of the toe foundation can be located as a relation to design wave heights. As shown in Figure 3, the base should extend to a minimum depth of:

$$d_{Toe} = 1.3 \cdot H_{design}$$

where d_{toe} is the depth of the toe foundation and H_{design} is the design wave height. For the 100-year wave, this corresponds to a depth of approximately 3.9 ft below the water surface.

The minimum depth computed with Figure 3 provides a deeper elevation than Figure 4, and thus is the controlling depth for the toe design. Based on the winter low water level of 842.0 feet NAVD 88, the bed of the proposed toe should be placed at elevation 838.1 ft NAVD88. To protect against scour, the primary armor should be extended over the front of the toe to shield the toe and native material from ice and wave forces, which satisfies the required depth for d_s.

Each of these toe designs (Figure 4) should be sufficient for scour protection. Anchor QEA recommends Option 4. However, if alternatives are preferred, any shown should provide sufficient scour protection, assuming they follow typical design guidance. Given the choice between Option 1 and Option 2, the former is more conservative and would be the suggested design, but both would likely be sufficient assuming acceptable geotechnical conditions.

Figure 4
***Coastal Engineering Manual* Recommended Toe Configurations**

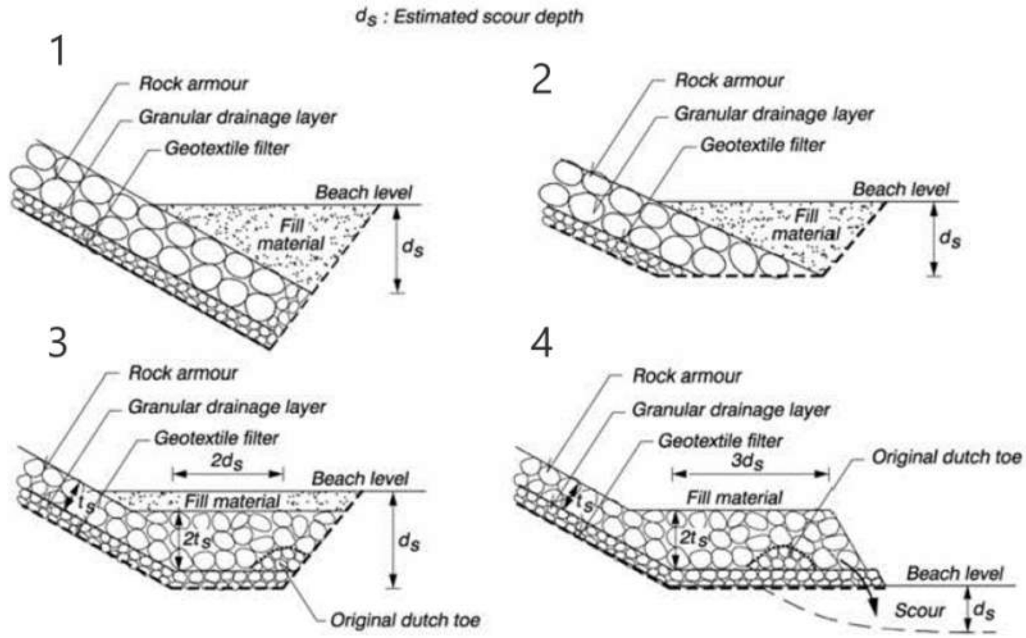
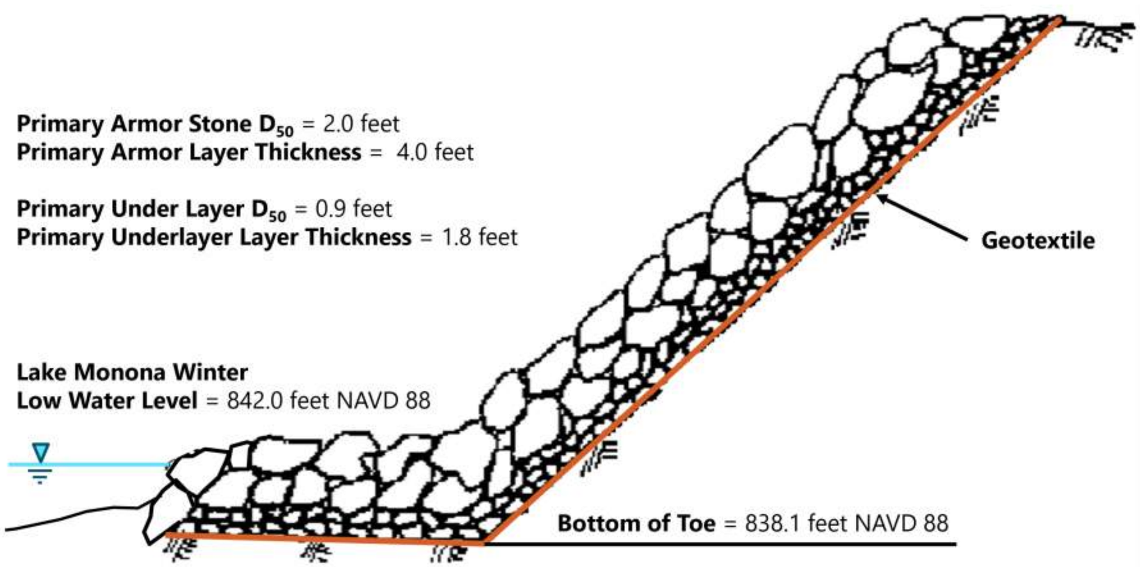


Figure 5 shows a schematic section of the proposed revetment at the design winter low water level according to Option 4 of Figure 4.

Figure 5
Schematic of Proposed Revetment Section



Note: Not to scale

Geotextile Fabric

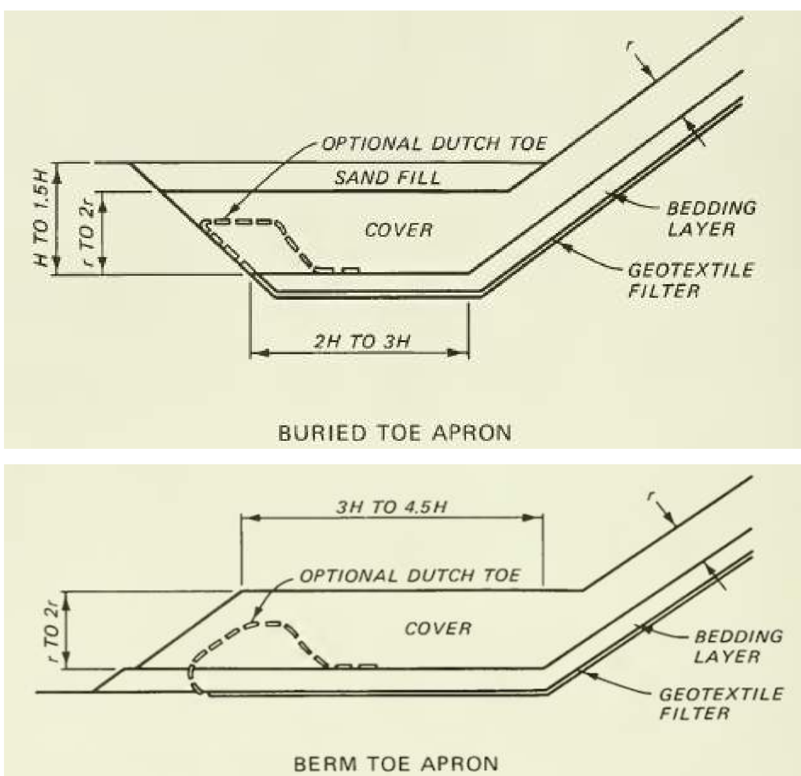
Anchor QEA recommends using geotextile filter fabric between the last underlayer and the lakebed to prevent scour. This fabric helps hold fine lakebed or coastal sediments in place behind the revetment, preventing undercutting and revetment failure. The upslope and downslope ends of the fabric also need to be protected from scour themselves.

Toe Protection

The *SPM* (USACE 1984) provides recommendations for geotextile installation at the toe of a rubble mound structure and potential designs shown in Figure 6:

> *If a geotextile filter is used beneath the toe apron of a revetment...the geotextile should not be extended to the outer edge of the apron. It should stop about a meter from the edge to protect it from being undermined. As an alternative, the geotextile may be extended beyond the edge of the apron, folded back over the bedding layer and some of the cover stone, and then buried in cover stone and sand to form a Dutch toe.* (USACE 1984)

Figure 6
Potential "Dutch Toe" Designs



Source: USACE *Shore Protection Manual* (1984)

Geotechnical Analysis

A geotechnical analysis of the site is not part of the current scope of work for Anchor QEA. It is important that the existing soils be evaluated for suitability before designs are finalized. If soils are not capable of supporting the weight of the revetment, there is a risk of structural failure. The design recommendations detailed above have been provided under the assumption that existing soils are sufficiently stable for installation of the revetment. If geotechnical evaluations show otherwise, the suggested design parameters may require revision.

Review of Revetment Design

The City had previously developed typical sections of the proposed revetment at three locations along the southern and central portions of the John Nolen Drive causeway. These are included in Appendix A. After reviewing these typical sections Anchor QEA has the following comments on the 60% design's suitability as it relates to the ice design analysis completed herein:

1. Based on the results of this analysis and USACE design recommendations, the proposed riprap does not extend far enough to adequately protect against ice damage. Lake level 3B from the plans, which is the minimum of winter minimums from the past 10 years, is approximately at elevation 842.4 ft NAVD88. The typical sections of Alignment 1 and Alignment 2 do not extend to a low enough elevation to provide protection when Lake Monona is at elevation 3B. This would likely result in erosion to the toe of the revetment due to ice shove and wave action that could cause the revetment to fail. Anchor QEA recommends that the City incorporate the design suggestions provided herein and include primary armor stone to elevation 838.1 ft NAVD88.

2. The plans call out the use of heavy rip-rap glacial field stone; Anchor QEA recommends against the use of glacial or fieldstone, as the rounded boulders do not provide adequate stability for this application. Angular stone is recommended as it provided better interlocking and resistance to motion.

Revetment Design Recommendation

The recommended revetment typical section for John Nolen Drive is based from the options shown Figure 4 and governed by scour depth at the toe of a coastal structure which is a common failure method. The baseline preferred typical section references Figure 4-1. While the preferred typical section is the recommendation, due to the varying site conditions along the causeway, the typical section may need to shift to other options in Figure 4 as needed. See Appendix C for the preferred typical section.

References

Anchor QEA 2022. "Memorandum: Coastal Analysis - John Nolen Drive." CIRIA 2007, "The Rock Manual. The use of rock in hydraulic engineering (2nd edition)" C683, CIRIA, London. Available at: http://www.kennisbank-waterbouw.nl/rockmanual

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WSCO (Wisconsin State Climatology Office) 2024. "History of Ice Freezing and Thawing on Lake Monona" Available at: https://climatology.nelson.wisc.edu/first-order-station-climate-data/madison-climate/lake-ice/history-of-ice-freezing-and-thawing-on-lake-monona/. Accessed February 2024.

Appendix B – Coastal Analysis Memorandum

30 W. Mifflin Street, Suite 801
Madison, Wisconsin 53703
608.710.4930

Memorandum

January 2022

To: MSA Professional Services, Inc.

From: Anchor QEA, LLC

Re: Coastal Analysis - John Nolen Drive

Project Overview

Anchor QEA performed a coastal analysis for John Nolen Drive in Madison, Wisconsin. The analysis included evaluating the nearshore wave climate and providing design recommendations for a riprap revetment to protect the Drive and nearby shoreline in support of a project with MSA Professional Services (MSA) for the City of Madison.

The wave analysis used wind, fetch, and bathymetric information to determine wave heights and recurrence intervals at the Drive shoreline. Wind data was obtained from Truax Field on Madison's east side and fetch measurements were made using orthophotographs and GIS software. Bathymetry data was provided following a survey in fall 2021. Fetch-limited wave heights were calculated for the period 1948-2021, and statistical analysis showed the 1% annual chance maximum wave height to be approximately 3 ft.

Another component of this coastal analysis was evaluation of the water surface elevation (WSE) along John Nolen Drive. FEMA produced a Flood Insurance Study for the greater Madison area that includes a Base Flood Elevation (BFE) for Lake Monona. The BFE is the 1% annual chance flood elevation and serves as a benchmark for design.

Anchor QEA understands that MSA wants to steepen the revetment to widen the causeway while maintaining existing ground elevations. There is also a desire to reuse the existing stone. We have reviewed the US Army Corps of Engineers (USACE) recommendations for riprap armor stone sizing, revetment layer thickness, geotextile utilization, and toe dimensions for the proposed revetment on John Nolen Drive in Madison, Wisconsin. USACE has published two major compilations of coastal engineering guidelines based on decades of coastal research. The first was the *Shore Protection Manual* (*SPM*), published in 1984, with the *Coastal Engineering Manual* (*CEM*) following it in 2002. We have compiled this summary for your review.

Physical Setting

Location

The project area is the east side of John Nolen Drive as it crosses Lake Monona between the isthmus and US Route 12/US Route 18 (colloquially, the "Beltline") in Madison, WI (Figure 1). Due to the limited fetch lengths on Lake Monona, the Drive causeway is subject to a low energy wave environment, with the largest waves likely coming from the Northeast.

Figure 1
Location of John Nolen Drive in Madison, Wisconsin

Coastal Analysis

Anchor QEA performed a wind-fetch analysis to determine the local nearshore wave conditions. For this report, "fetch" is defined as the distance of open water between the eastern shoreline of the John Nolen Drive causeway and the nearest shoreline in a given direction. As wind blows across the open water, it creates waves, with higher wind speeds and longer fetches producing larger waves. Coastal research has determined relationships between fetch length, wind speeds, and wave heights, which were used during the wind-fetch analysis discussed below.

Wind Data

Historic wind data was downloaded from the Iowa State University Mesonet. The data was taken from the Traux Field station on the east side of Madison at the Dane County Regional Airport. Hourly wind speed and directional data is available for the period from 1948 to present day.

Fetch Measurements

Anchor QEA used aerial orthophotographs to determine fetch measurements. GIS software was used to determine the fetch distances between the drive and the nearest shoreline at 5° increments.

Wave Height Calculation

Computer analysis provided an estimate of wave heights. A script in GNU Octave processed wind directional data to assign fetch distance for each hourly data point, then used equations for fetch-limited wave propagation developed by Young & Verhagen (1996):

$$\epsilon = 3.64 \cdot 10^{-3} \left\{ \tanh(A_1) \tanh\left[\frac{B_1}{\tanh(A_1)} \right] \right\}^{1.74}$$

where ε is the non-dimensional wave energy, $A_1 = 0.493\delta^{0.75}$, $B_1 = 3.13 \cdot 10^{-3}\chi^{0.57}$

$$\chi = \frac{gx}{U_{10}^2}$$

where χ is the non-dimensional fetch, g is the acceleration due to gravity, x is the fetch distance, and U_{10} is the wind speed measured at 10 m above the surface.

$$\nu = 0.133 \left\{ \tanh(A_2) \tanh\left[\frac{B_2}{\tanh(A_2)} \right] \right\}^{-0.37}$$

where ν is the non-dimensional wave frequency, $A_2 = 0.331\delta^{1.01}$, $B_2 = 5.215 \cdot 10^{-4}\chi^{0.73}$

The depth to the toe of the existing revetment was determined using bathymetric data provided by MSA and flood elevations reported on a FEMA Flood Insurance Study (FIS) developed for Dane County.

The equations account for depth- and fetch-limited wave growth and are well-suited to analysis of wind-wave propagation at John Nolen Drive.

Revetment Design Parameters

Anchor QEA was also tasked with providing design parameters for a riprap revetment to protect John Nolen Drive from waves. Standard practice dictates the use of the 1% annual chance wave height (commonly referred to as the 100-year wave height) as the design wave. The design development then considers wave runup and armor stone sizing. For this analysis, Anchor QEA analyzed an array of different water levels and wave recurrence intervals. Table 1 below shows the analyses performed.

Table 1
Wind-Wave Analyses Performed on the John Nolen Drive Causeway

Water Level Description	ft [NAVD88]	10-yr Wave	50-yr Wave	100-yr Wave
Normal Water Level	844.5	X	X	
10% Annual Chance	846.2	X	X	
2% Annual Chance	847.1	X	X	
1% Annual Chance	847.5	X	X	X

Note: The "X" indicates which analyses were performed.

The toe elevation of the existing revetment was determined using bathymetric data and determined to be approximately 830 ft above the North American Vertical Datum of 1988 (NAVD88). Table 2 shows the depth to toe measurements used in the analysis for each water level.

Table 2
Depth to Toe Measurements for Each Water Level Used in the Analysis.

Water Level Description	ft [NAVD88]	Depth to Toe [ft]
Normal Water Level	844.5	14.50
10% Annual Chance	846.2	16.20
2% Annual Chance	847.1	17.10
1% Annual Chance	847.5	17.50

Recurrence Intervals

The Gringorten plotting position was used for analysis of recurrence intervals. This is a statistical method that allows researchers to estimate recurrence intervals using an incomplete dataset. In this instance, only 74 years of wind data have been recorded, so the record does not contain the 100 years of data required to directly measure the 100-year event. The Gringorten plotting position uses the available 74 years of data to estimate events outside the available data record.

The plotting position ranks annual maximum wave heights and then uses the following equation:

$$T = \frac{m + 0.12}{n - 0.44}$$

where T is the recurrence interval in years, m is the length of the period of record, and n is the rank of the wave event.

Wave Runup

Anchor QEA used the USACE *SPM* (1984) to determine wave runup heights with different riprap revetment designs. The *SPM* includes data to estimate runup heights based on revetment type, slope, and incoming wave characteristics.

Revetment Armor Stone Sizing

The *SPM* (USACE 1984) also provides guidelines for selecting coastal armor stone. Dimensions of stones are recommended based on the incoming wave heights, revetment slope, and stability requirements. Per *SPM* Equation 7-116:

$$W = \frac{w_r \cdot H^3}{K_D (S_r - 1)^3 \cdot \cot(\theta)}$$

Where W is the weight of the exterior armor layer, w_r is the specific weight of the armor stones, H is the design wave height, K_D is an empirically determined stability coefficient, S_r is the specific gravity of armor stones, and θ is the structural slope as measured from horizontal.

Results

Wave Characteristics

Coastal wave analysis used wind data to predict wave heights at the shoreline. Maximum wind speeds reached 58 mph (25 m/s) and maximum fetch measurements were nearly 18,000 ft (approximately 3.4 miles) to the northeast.

The BFE is listed as 847.5 ft above the North American Vertical Datum of 1988 (NAVD88). The BFE is the estimated 1% annual chance still water elevation. Wave runup must be added to the BFE to determine the crest height of the proposed revetment. Lakebed elevations were subtracted from the BFE to determine depth of the toe. Nearshore depths were found to be approximately 17.5 ft (5.33 m) during the 1% annual chance flood. Maximum annual wave heights calculated for each year (1948-2021) are shown in Table 3.

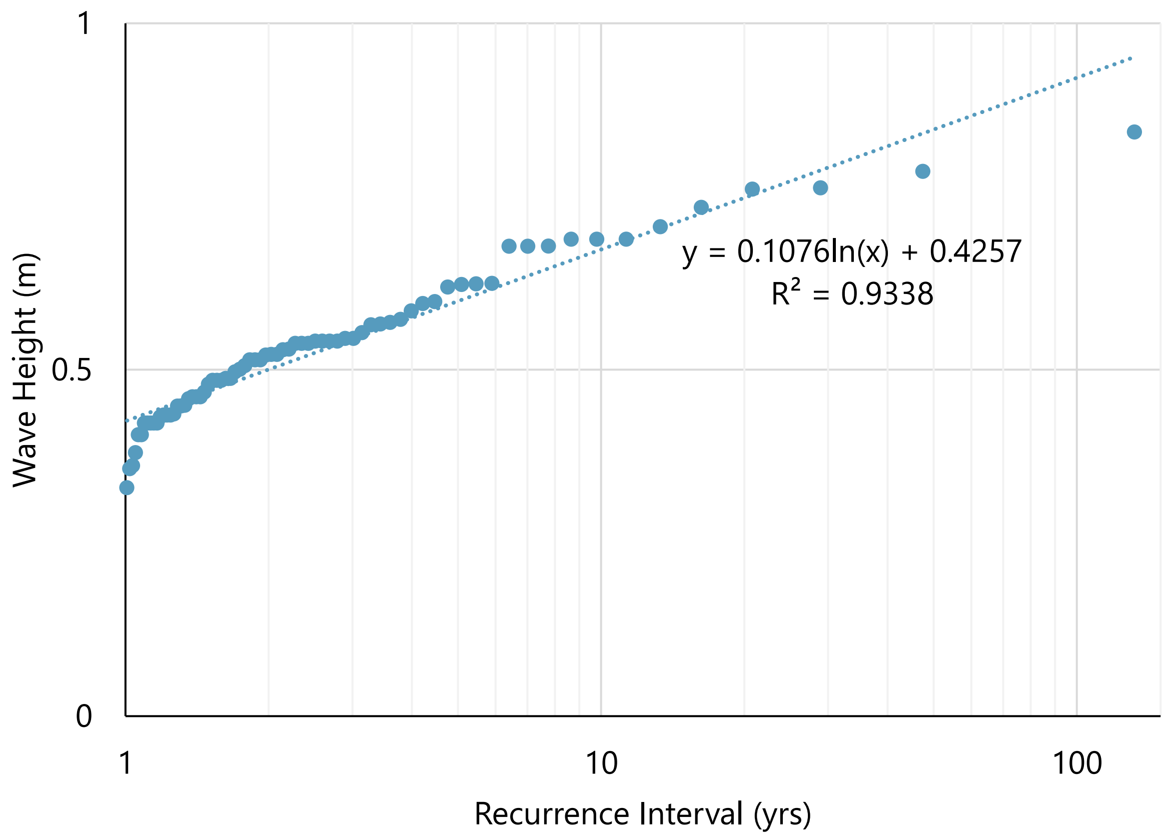
Table 3
Annual Calculated Maximum Wave Heights Sorted by Year for the 1% AC Flood Elevation.

Year	Max Calculated Wave Height [ft]
1948	2.50
1949	2.22
1950	2.26
1951	2.26
1952	2.26
1953	1.92
1954	1.71
1955	1.79
1956	2.05
1957	1.64
1958	1.79
1959	2.22
1960	1.82
1961	1.53
1962	1.39
1963	1.47
1964	1.47
1965	1.33
1966	1.19
1967	1.25
1968	1.08
1969	1.71
1970	1.17
1971	1.69
1972	1.59
1973	2.58
1974	1.39
1975	1.66
1976	1.88
1977	1.59
1978	1.50
1979	1.39
1980	1.42
1981	1.76
1982	1.85
1983	1.78
1984	1.78

Year	Max Calculated Wave Height [ft]
1985	1.59
1986	1.39
1987	1.86
1988	1.43
1989	1.39
1990	2.41
1991	1.69
1992	1.69
1993	1.86
1994	2.04
1995	1.76
1996	1.51
1997	1.73
1998	1.74
1999	2.23
2000	2.03
2001	1.43
2002	1.33
2003	1.78
2004	1.51
2005	1.43
2006	2.32
2007	1.95
2008	1.57
2009	1.43
2010	1.63
2011	1.96
2012	1.51
2013	2.50
2014	2.77
2015	2.05
2016	1.60
2017	1.60
2018	1.78
2019	1.47
2020	1.71
2021	1.76

The ranked heights were then plotted using the Gringorten plotting position and a best-fit line was calculated (Figure 2).

Figure 2
John Nolen Drive wave heights and recurrence intervals



Note: This analysis uses a depth to toe measurement of 17.5 ft (5.33 m) for the 1% AC flood elevation

Using the best-fit logarithmic equation, the expected 1% annual chance wave height was approximately 3 ft (0.92 m).

Revetment Layers

Armor Stone Sizing

Armor stone cover layers are sized based on *SPM* (USACE 1984) and *CEM* (USACE 2002) guidelines. Given potential design slopes ranging from 1.5H:1V to 5.0H:1V, crest elevations and cover stone weights for the 1% AC water level and 100-yr wave are shown in Table 4. Crest elevations, cover stone weights, and layer thicknesses for all the analyses listed in Table 1 can be found in the appendix. This design assumes a cover armor layer that is at least two armor stones thick and consists of angular quarrystone per USACE recommendations (1984, 2002). Anchor QEA recommends against the use of glacial or fieldstone, as the rounded boulders do not provide adequate stability for this application.

Table 4
Revetment Stone Sizing and Crest Elevations for a Range of Slopes for the 1% AC Flood Elevation and 100-yr Wave

Design Slope [H:V]	Wave Runup [ft]	Crest Elevation [ft NAVD88]	Cover Stone Weight [lbf]	Cover Stone Dia [ft]
1.5:1	2.95	850.45	420	1.57
2.0:1	2.76	850.26	320	1.43
2.5:1	2.62	850.12	250	1.32
3.0:1	2.30	849.80	210	1.25
4.0:1	2.03	849.53	160	1.14
5.0:1	1.48	848.98	130	1.06

Note: The weight calculated for the riprap armor stones is the W_{50}, or the weight of stones that are heavier than 50% of the sample (i.e. the median weight).

Anchor QEA understands that MSA prefers reusing the existing stone to the extent possible and to also steepen the revetment. The steeper revetment would allow for a wider causeway while maintaining existing ground elevations without moving the existing revetment toe further into the lake. Based on USACE guidance (1984, 2002), this should not pose a significant hazard with respect to slope stability, provided the existing stones meet the applicable size requirements for design conditions.

As an approximation of stone size, the USACE (1984) cites a relationship between stone weight and stone diameter to be:

$$D_{50} = 1.15\,\left(\frac{W_{50}}{W_r}\right)^{\frac{1}{3}}$$

where D_{50} is the median diameter of stone in units of ft, W_{50} is the median weight in units of lb as defined above, and W_r is the density of stone in units of lb/ft^3 (typical values for riprap are approximately 165 lb/ft^3). Stones of sufficient size are typically supplied by weight rather than by diameter, so this relationship is reported simply as a potential means of field verification of stone size. Anchor QEA recommends performing a field verification of current stone sizes to determine if the existing stone can be used for the desired design slope, water level, and wave height.

Underlayer Stone Sizing and Thickness

USACE guidelines also dictate the underlayer stone sizing. The *SPM* (USACE 1984) and *CEM* (USACE 2002) state that any underlayers should be sized such that D_{15} (cover) ≤ 5 D_{85} (underlayer) where

D_{15} and D_{85} are the diameters larger than 15% and 85%, respectively, of other stones in the specified layer. Layer thicknesses should be the greatest of:

- 0.98 ft (0.30 m)
- $2.0\ (\frac{W_{50}}{W_r})^{\frac{1}{3}}$
- $1.25\ (\frac{W_{max}}{W_r})^{\frac{1}{3}}$

where W_{50} is the 50th percentile weight of stone, W_{max} is the weight of the heaviest stone, and W_r is the density of stone in units of lb/ft^3 (typical values for riprap are approximately 165 lb/ft^3). This guidance applies to all stone layers in the structure including the cover armor layer and all subsequent underlayers.

Gradation for rocks used in the rubble layers shall be as follows:

- Primary Cover Layer: 75-125% of the target $W_{50,PrimaryCover}$
- Toe Berm and First Underlayer: 70-130% of the target $W_{50,FirstUnderlayer}$
- Second Underlayer: 50-150% of the target $W_{50,SecondUnderlayer}$
- Core and Bedding Layer: 30-170% of the target $W_{50,BeddingLayer}$

Relationships between the sizes of stones relative to the primary cover armor from different layers are provided below:

- Toe Berm & First Underlayer $\mathrm{W}_{50,\mathrm{FirstUnderlayer}} = (\frac{1}{10})\ W_{50,PrimaryCover}$
- Second Underlayer: $\mathrm{W}_{50,\mathrm{SecondUnderlayer}} = (\frac{1}{200})\ W_{50,PrimaryCover}$
- Core & Bedding Layer: $\mathrm{W}_{50,\mathrm{BeddingLayer}} = (\frac{1}{4000})\ W_{50,PrimaryCover}$

Using the relationships above, Table 5 provides an approximate range of acceptable stone sizes by weight for each layer and each slope, and layer thicknesses are provided in Table 6.

Table 5
Ranges of Acceptable Stone Sizes by Weight for Each Layer and Slope for the 1% AC flood Elevation and 100-yr Wave

	Primary Cover Layer			Toe Berm & First Underlayer		
Slope	Min. Stone Weight [lbf]	Median Stone Weight [lbf]	Max. Stone Weight [lbf]	Min. Stone Weight [lbf]	Median Stone Weight [lbf]	Max. Stone Weight [lbf]
1.5:1	315	420	525	29.4	42	54.6
2.0:1	240	320	400	22.4	32	41.6
2.5:1	187.5	250	312.5	17.5	25	32.5
3.0:1	157.5	210	262.5	14.7	21	27.3

4.0:1	120	160	200	11.2	16	20.8
5.0:1	97.5	130	162.5	9.1	13	16.9
	Second Underlayer			**Core and Bedding Layer**		
Slope	**Min. Stone Weight [lbf]**	**Median Stone Weight [lbf]**	**Max. Stone Weight [lbf]**	**Min. Stone Weight [lbf]**	**Median Stone Weight [lbf]**	**Max. Stone Weight [lbf]**
1.5:1	1.05	2.1	3.15	0.033	0.11	0.187
2.0:1	0.8	1.6	2.4	0.024	0.08	0.136
2.5:1	0.625	1.25	1.875	0.018	0.06	0.102
3.0:1	0.525	1.05	1.575	0.015	0.05	0.085
4.0:1	0.4	0.8	1.2	0.012	0.04	0.068
5.0:1	0.325	0.65	0.975	0.009	0.03	0.051

Table 6
Approximate Thicknesses for Each Layer and Slope for the 1% AC Flood Elevation and 100-yr Wave

Slope	Primary Cover Layer [ft]	Toe Berm & 1st Underlayer [ft]	2nd Underlayer [ft]	Bedding Stone [ft]
1.5:1	3.19	1.01	0.98	0.98
2.0:1	2.79	0.98	0.98	0.98
2.5:1	2.46	0.98	0.98	0.98
3.0:1	2.26	0.98	0.98	0.98
4.0:1	1.97	0.98	0.98	0.98
5.0:1	1.78	0.98	0.98	0.98

APPENDIX C

WSOR Meeting Minutes

MEETING MINUTES

Project I.D. 5992-11-20/21
City of Madison, John Nolen Drive
(Lakeside St – Broom St.)
Local Street
Dane County

WSOR Coordination Meeting, October 5, 2023

- AGENDA ITEMS ARE SHOWN IN BLACK TEXT
- MEETING NOTES ARE SHOWN IN BLUE TEXT
- ACTION ITEMS ARE SHOWN IN RED TEXT

1. Introductions

- Meeting attendees included Aaron Steger (KL), Dan Ryan (KL), Brian St. Vincent (KL), Brent Marsh (WSOR), Aaron Canton (City of Madison)

2. Project Update
    a. Project Limits & Scope
        i. Phase 1 – Lakeside Street to Broom Street
        ii. Phase 2 – Olin Avenue to Lakeside Street
    b. Project Schedule Phase 1
        i. Draft ER – November 2023
        ii. 60% Plans – November 2023
        iii. Public Hearing – January 2023
        iv. 90% Plans – May 2024
        v. PS&E – August 1, 2024

- Project schedule was noted by KL with construction anticipated in 2025 and 2026. KL noted that this meeting will cover Phase 1.

3. Northshore Drive Crossing (Crossing ID 177817F)
    a. Intersection and Crossing Geometry
    b. Roadway Profile, Rail Profile, & Rail Superelevation
    c. Railroad Gates, Signals, & Bungalow
    d. Conduit Crossings
    e. Drainage
    f. Utilities and Easements
    g. Proposed Railroad Work
    h. Other Topics

- KL described and illustrated the new intersection geometry and crossing (attached). WSOR noted that the new pedestrian crossings should be within 25' of the existing crossing. WSOR noted that there was an issue on a recently constructed pedestrian crossing due to this issue. There was some conversation as to where the new crossing should be measured from. If the pedestrian crossing on the south side of North Shore Drive were moved closer to the road, KL asked if the existing concrete panel could be moved to the new location along the rail crossing. WSOR noted that because the panels were relatively new, they could be moved to a new location. KL and the City of Madison will utilize internal resources to decide what point to measure the new crossing distance from and move if necessary.
- WSOR noted that the new pedestrian crossings may not be adequately positioned to utilize the proposed roadway warning lights. OCR may determine that the new trail crossing will require their own warning lights.
- KL noted the potential need to move the existing WSOR railroad bungalow to improve bicycle sight distance. KL noted that the new bungalow location shown (attached) is 12 feet from the centerline of the track. At that

distance, it falls partially on the City of Madison right of way. WSOR noted that it may be able to be moved closer than 12 feet to remain on WSOR right of way. KL noted that some grading would still occur on City of Madison right of way if moved inside of WSOR right of way. WSOR will determine the appropriate offset from the center of the track that will keep the new bungalow in the WSOR right of way.

- KL noted and illustrated the new roadway and rail profile (attached) with no objection from WSOR. KL and the City of Madison noted that the raise in rail profile was not required from a roadway perspective. WSOR noted that they would like to raise the rail to improve their rail profile. KL noted that the raise in the WSOR profile could be accommodated with the new roadway profile. WSOR noted that they would like to apply superelevation to the rails when they raise them. WSOR will provide the superelevation rate for KL to incorporate into their roadway design. KL will proceed with the roadway design accommodating the new rail profile.
- KL explained that the roadway project will include communication and electrical conduits that will need to cross the railroad. KL noted that these conduits can be directionally bored, or a casing could be jacked. WSOR noted that any conduits would have to cross 15 feet under the bottom of rail. WSOR noted that if a casing was used the requried depth would be less. WSOR will provide the minimum depth and type of casing required to cross the rail line.
- KL noted that the project will not require any storm sewer crossings at this location. KL asked WSOR if there were any known drainage issues at the crossing and WSOR stated that they did not know of any.
- KL noted that there was a 69KV ATC electrical line located near the railroad right of way and that it may conflict with proposed roadway signals/lights and railroad signals/gates. KL noted that they did not have any information regarding any potential easement the railroad may have granted ATC. KL and the City of Madison explained that it was anticipated that ULOs will be conducted to locate the ATC line. WSOR agreed to search for any easement records they may have and forward to the City of Madison and KL.
- KL explained and illustrated the potential railroad signal and gate foundations (attached) they received from WisDOT. WSOR agreed that the details were correct. KL noted that it appeared there were a couple foundation options and will use the largest foundations when determining any potential underground conflicts.

4. Lakeside to North Shore Drive
    a. Rail Switch Power
    b. Drainage and Ditching
    c. Fencing – Currently proposed at 8’ from back of curb
    d. Other Topics

- KL noted that during the preliminary design phase, it was determined that a pull over location could not be adequately provided at the railroad switch located roughly halfway between the middle and southern rail structures along the causeway. During the project’s utility coordination phase (Winter 2023-2024), KL will engage MG&E about running power to the switch to keep it free from snow and ice in lieu of providing a pull over for railroad access.
- KL informed WSOR that the intention was not to drain any runoff from the new roadway into the ditch between the road and rail line.
- KL explained to the City of Madison that WSOR had requested a fence be placed between the roadway and the rail line. WSOR noted that the existing guardrail acts as a deterrent for people to access their rail line. To compensate for the loss of guardrail, a fence is proposed. KL explained the current location of the proposed fence is 8-feet from the proposed back of curb. WSOR did not have an opinion on what type of fence should be used. The City of Madison will determine what type of fence will be utilized.

5. North Shore Drive to Broom Street
    a. Path Location
    b. Drainage and Ditching

   c. Fencing
   d. Plantings
   e. Other Topics

- KL explained that a 10' path will be constructed between John Nolen Drive and the WSOR right of way. WSOR did not express any concern with the exception that the roadway project installs a permanent fence between the path and the WSOR right of way to discourage anyone from crossing the rail line to access Brittingham Park. The City of Madison expressed some concerns due to aesthetic reasons. The City of Madison will determine potential options/alternatives and will coordinate with WSOR.
- KL inquired about how many trains use the rail line adjacent to the new path. WSOR stated that 2-6 trains utilize the rail daily at a maximum speed of 20 MPH.

6. Broom Street (Crossing ID 177818M)
   a. Intersection and Crossing Geometry
   b. Roadway Profile, Rail Profile, & Rail Superelevation
   c. Railroad Gates, Signals, & Bungalow
   d. Conduit Crossings
   e. Drainage
   f. Utilities and Easements
   g. Proposed Railroad Work
   h. Other Topics

- KL described and illustrated the new intersection geometry and crossing (attached). WSOR noted that the pedestrian crossing on the north side of Broom Street should be within 25' of the existing crossing. WSOR noted that there was an issue on a recently constructed pedestrian crossing due this issue. There was some conversation as to where the new crossing should be measured from. KL noted that the distance was being driven by developing 2 distinct pedestrian curb ramps which is an improvement from the non-existent curb ramps being utilized today. KL and the City of Madison will utilize internal resources to decide what point to measure the new crossing distance from and move if necessary.
- KL noted and illustrated the new roadway and rail profile (attached) with no objection from WSOR. WSOR noted that they would like to raise the rail profile 1-2 inches to improve their rail profile. WSOR will determine the needed rail profile rise and superelevation.
- KL asked if the existing concrete panels could be moved to a new location along the rail crossing. WSOR noted that because the panels were relatively new, they could be moved to a new location.
- KL explained that the roadway project will include communication and electrical conduits that will need to cross the railroad. KL noted that these conduits can be directionally bored, or a casing could be jacked. WSOR noted that any conduits would have to cross 15 feet under the bottom of rail. WSOR noted that if a casing was used the required depth would be less. WSOR will provide the minimum depth and type of casing required to cross the rail line.
- KL asked WSOR if there were any known drainage issues at the crossing and WSOR stated that they did not know of any. WSOR noted that they had recently dome some ditch work on the north side of Broom Street to help with drainage. KL explained that a new storm sewer crossing is required and would likely follow the same structure type that was installed this construction season under the adjacent WSOR rail line. WSOR noted that any structure crossing under the rail line must be designed to AREMA standards. It was understood by all parties that the construction of this box will require an open cut of the existing rail line.
- WSOR noted that they will be replacing the existing bungalow in the same location because it is obsolete. The City of Madison noted that they did not need to move the bungalow for bicycle sight reasons.

MEETING MINUTES

Project I.D. 5992-11-20/21
City of Madison, John Nolen Drive
(Lakeside St – Broom St.)
Local Street
Dane County

7. Underpass Feasibility Study **(Potential Future Project)**
   a. The H-Concept would depress the multi-use path between the railroad and John Nolen Drive to a point roughly halfway between Northshore Drive and Broom Street. At that point, pedestrians and bicyclists would cross underneath John Nolen Drive to a depressed path along the lake. No impacts to rail facilities would be anticipated with this concept.

- KL explained that they were currently developing a feasibility study that was intended to give guidance on any future crossing. KL explained that an underpass is currently not part of this roadway project.

- KL explained and illustrated this concept (renderings attached) and noted that the walls closest to the rail line were outside of the WSOR right of way, but a short portion of the wall was inside the required 25-foot clearance required by WSOR. WSOR noted that the portion of underpass wall located within the 25-foot clearance would require an AREMA designed crash wall. Areas outside the 25-foot clearance would not require a crash wall. KL noted that this concept would have minimal to no impact to the existing rail line.

   b. The T-Concept would construct a new path through Brittingham Park and allow pedestrians and bicyclists to cross underneath the WSOR rail line and John Nolen Drive roughly halfway between North Shore Drive and Broom Street. Anticipated impacts to the rail facilities would include constructing an underpass of the rail line.

- KL explained that this concept would not require any raise of the existing rail profile.
- KL explained that they were currently looking at this concept and inquired about WSORs typical rail section. KL explained that they were currently accounting for 11-inches of ballast, 7.5-inch tie depth, and 6.5-inch rail height. WSOR concurred with this section but explained that there may be a way to reduce the ballast and tie depth. KL also explained that the current width of the underpass being evaluated was 20-feet. WSOR will look at the ballast and tie option and offer guidance.
- WSOR noted that any underpass would need to be designed to AREMA standards.
- KL asked WSOR if they currently had any crossings like this and WSOR was not aware of any.
- WSOR mentioned that at a recent conference there may have been some examples like this. WSOR agreed to forward any relevant information regarding these locations from the conference.
- WSOR recommended looking at the Park Street viaduct crossing and the Wingra Creek Path crossing.

8. Construction Staging
   a. Spring/Summer/Fall 2025 – Traffic switched to north bound side of John Nolen Drive. Construct southbound John Nolen Drive including Broom Street and North Shore Drive. Intersections will be constructed under a closed condition with only thru movements allowed along John Nolen Drive. Intersections shall not be closed concurrently. Prior to the intersections closing, the existing railroad crossing will be utilized. After the intersections have been constructed, the new railroad crossing will be utilized.

- KL noted that during this stage WSORs contractor will have to mobilize twice to complete the railroad work. Once when Broom Street is closed and once when North Shore Drive is closed.
- WSOR noted that no obstructions can be within 25-feet of the railroad centerline. KL stated that this information will be included in the contract's special provisions.

   b. Winter 2025-2026 – Traffic moved to their respective sides with intersections open utilizing temporary pavement in the median of John Nolen Drive. Broom Steet and North Shore Drive will be open, and the new railroad crossing will be utilized.

   c. Spring/Summer/Fall 2026 – Traffic switched to the new south bound side. Construct northbound side. Broom Steet and North Shore Drive will be open, and the new railroad crossing will be utilized.

APPENDIX D

Geotechnical Report

CGC, Inc.

Construction • Geotechnical
Consulting Engineering/Testing

GEOTECHNICAL MEMORANDUM

TO: Mr. Aaron Steger, P.E., KL Engineering

FROM: Alex J. Bina, P.E., CGC, Inc.
William W. Wuellner, P.E., CGC, Inc.

DATE: April 3, 2024

Re: Proposed John Nolen Drive Underpass
North Shore Drive and Broom Street
City of Madison, Dane County, Wisconsin
CGC Project No. C21330

Construction • Geotechnical Consultants, Inc. (CGC) has completed the geotechnical exploration program for the project referenced above. The purpose of this report is to provide a summary of subsurface conditions encountered and provide preliminary geotechnical recommendations regarding underpass design and construction. An electronic copy of this report is provided for your use, and we can provide a paper copy upon request.

Description of Proposed Underpass

Details of the proposed underpass below John Nolen Drive are still in the conceptual/planning phase, but we understand that it would likely be a cast-in-place reinforced concrete structure constructed in two stages (below the northbound lanes and below the southbound lanes) so that two-way traffic can be accommodated during construction. The JND underpass may extend as deep as about 12 ft below the new pavement elevation. This would involve raising grades as much as about 3 ft above existing elevations on the approaches and would result in the base of the underpass extending several feet or more below the normal water level of Lake Monona (EL 945.6 ft, USGS datum). To avoid the necessity of permanently and continually dewatering below the base, the underpass will need to be designed and constructed as a watertight structure. Similar provisions will be required for the portions of the approaches for the bike/pedestrian path that are also constructed below lake level.

Traffic is expected to traverse directly on top of the underpass; that is, the underpass roof will essentially act as a bridge deck. A separate underpass may be constructed below the adjacent railroad track, with little or no grade change being allowed to the track elevations. Although the following discussion mainly addresses issues and recommendations related to the JND underpass, similar comments would apply to the railroad culvert/underpass.

Subsurface Conditions near the Proposed Underpass

Three supplemental borings were recently completed by America's Drilling Company (ADC; under subcontract to CGC) on February 13 and15, 2024 at the intersection of North Shore Drive (Boring CS-1) and the proposed underpass (Borings UP-1 and UP-2). The standard penetration test (SPT) soil borings extended to depths of 50 to 55 ft below grade. The borings were located in shoulders or medians (i.e., non-paved areas) at locations mutually selected by the project team Boring logs and a boring location plan are attached in Appendix A.

A generalized soil profile found at the three boring locations includes the following strata in descending order:

- 18 to 32 ft of ***fill*** or ***possible fill*** consisting of a thin topsoil layer, followed by a miscellaneous fill comprised of sand with varying silt, clay and gravel contents; layers of clay with organics and possible cinders; and zones with substantial concrete rubble and other debris. Much of this material reportedly dates to lake fill placed decades ago to extend the lakeshore beyond its original limits. The fill in the vicinity of Boring UP-1 apparently includes a higher concentration of concrete rubble or boulders, as multiple attempts were required to find a location where the borehole could extend through this layer. Possible petroleum odors were noted in several of the samples.
- Below the fill/possible fill strata is a 5 to 9-ft layer of ***clayey silt to lean clay***. This layer is soft/loose and is related to the much thicker stratum of lacustrine clay/silt deposits found further out in the lake below the JND causeway. This layer was not encountered in Boring UP-2, the boring location farthest inland from the lakeshore.
- The underlying soil layers are typically ***fine to medium sand*** with varying silt and gravel contents and extend to the maximum depths explored. The uppermost 5 to 10 ft of these layers are loose to medium dense but are shortly followed by very dense sand at depths ranging from about 28 ft in UP-2 to 43 ft in CS-1.

Groundwater was encountered in the boreholes at depths of 8.5 to 10 ft during or shortly after drilling. Long-term water levels are expected to coincide with the elevation of Lake Monona.

Key Geotechnical Issues

The key geotechnical issues impacting the design and construction of the proposed underpass include the following:

- **Non-Engineered Lakeshore Fill** – The existing fill poses several challenges including:
  - Its thickness at up to 24 ft in Boring UP-1 makes its removal impractical.
  - The presence of apparent concrete rubble, boulders and other debris will hamper excavation and sheet pile (earth retention) installation.
  - The potential for encountering contamination during excavation may require special environmental monitoring, handling and off-site disposal costs.
  - Excavations into this layer will likely be somewhat irregular ('ragged') due to the size and variability of some of the components such as boulders, concrete and other debris.

- **Underlying Compressible Clay/Silt Layer** – This layer was encountered in Borings CS-1 and UP-1 but not in UP-2. The layer is a continuation of the compressible lacustrine deposits underlying the causeway which is responsible for most of the settlement that has occurred below John Nolen Drive. Fortunately, the layer in the vicinity of the underpass is on the margin of the lake deposits and is thinner and somewhat less compressible than deposits further from the lakeshore. While potential settlement in the layer must be addressed, its lesser thickness will limit the magnitude of settlement when compared to the historic causeway fill.

- **Shallow Groundwater** – Due to the proximity to the lake and the porous connection through the miscellaneous shoreline fill, excavations below lake level will need to be dewatered to allow construction to proceed 'in the dry'. Furthermore, the underpass and entry slabs below lake level will need to be designed to resist hydrostatic uplift forces under maximum high-water conditions.

- **Site Constraints** – The need to maintain two-way traffic on JND and the limited area available for construction will require earth retention (e.g., sheeting or shoring) to maintain near vertical excavation slopes. The underpass will need to be constructed in two stages, with the railroad underpass likely requiring a third stage.

Discussion and Recommendations

Based on our understanding of the conceptual designs being discussed for the proposed underpass, we offer the following preliminary recommendations to address the potential issues presented above.

1. Excavation Support

We anticipate that a sheet pile cofferdam will be required for temporary support of the excavation (in stages) and to act as a groundwater cutoff to aid in dewatering the site. Because of the rubble-sized material in the existing fill, heavy-duty sheet pile may be required, and in some locations, it may be necessary to pre-excavate to remove obstructions. To reduce the risk of inducing settlement after the underpass is completed, we recommend that the sheet pile be cut off at lake level with the remaining lower portions left in place. The design of the cofferdam will be the contractor's responsibility and should be performed by a licensed professional engineer with experience in similar, challenging conditions.

2. Foundation Recommendations

Because the underpass will require excavation to a substantial depth, on the order of about 12 ft or more below existing site grades, the weight of the underpass will be less than the weight of the soil removed. As a result, the net increase in stress and resulting pressure on the underlying soils caused by the weight of the underpass itself is theoretically zero. For this reason, it is our opinion that the expected settlement would be negligible and the underpass can be supported on a cast-in-place reinforced concrete mat foundation. However, because of the variability of the existing fill which will remain in place below the base of the underpass and to create more uniform bearing conditions, we recommend a minimum 2-ft undercut/over-excavation followed by replacement with compacted stone fill. Deeper excavation may be required to remove oversized or irregular pieces of debris or degradable fill material (e.g., tree stumps, wood timber, large metal objects, etc.) present at the base of the minimum undercut excavation. The base of the undercut excavation should first be thoroughly compacted with a backhoe-mounted vibratory plate compactor prior to fill placement. An open-graded stone fill (e.g., 1-in. clear stone) is recommended to assist in dewatering (discussed below) the base. To prevent future migration of fines into the stone layer, the replacement fill should be underlain on the bottom, sides and edges with a non-woven geotextile.

3. Embankment Settlement

As noted above, while the anticipated settlement of the underpass is theoretically negligible due to minimal increase (or net decrease) in applied stress, an increase in applied stress will occur alongside of the underpass structure, where as much as 3 ft of fill will be required to establish pavement subgrade elevations. Therefore, based on up to 3 ft of grade-raise fill being required alongside the underpass, we estimate total settlement of the *native soils* on the order of 0.5 to 1.5 in. at UP-2 and UP-1, respectively. Additional settlement of the non-engineered fill layer is expected to occur but is difficult to accurately estimate given the significant variability in composition across the embankment. We have estimated that the additional settlement of the surficial fill may be equal to the settlement of the native soils at each location. Therefore, total settlements on the order of 1 to 3 in. are estimated at UP-2 and UP-1, respectively.

The greatest settlement is expected below the northbound lanes where the layer of soft/loose lacustrine clay/silt is thicker compared to the southbound lanes where the compressible layer was not encountered. To reduce the potential for differential settlement between the underpass and the pavement approaches, as well along the length of the culvert, we recommend incorporating either Geofoam or lightweight foam concrete (LWFC) below the pavement section near the underpass. Geofoam is expanded polystyrene (EPS) foam blocks with a unit weight of 2 to 4 lb/cu ft. It is nearly weightless and easy to install. However, it dissolves if exposed to a petroleum spill and would therefore require a membrane to protect its surface in this application. Also, being nearly weightless, it should be placed above the maximum lake level to prevent it from floating. LWFC is a lightweight concrete with foam beads substituted for sand and gravel to reduce its unit weight to 35 to 70 lb/cu ft. It is resistant to petroleum spills but like Geofoam must be prevented from floating if its unit weight is less than 62.4 lb/cu ft.

We anticipate that these lightweight fill options would only be required within about 50 to 100 ft of each side of the underpass, and its thickness could likely be tapered away from the underpass to minimize the potential for differential settlement. Details on the thickness, length and type of lightweight fill can be determined once the proposed roadway grades at the underpass are established.

4. Groundwater Control and Hydrostatic Uplift Considerations

Provided a sheet pile cofferdam (or similar earth retention) is employed for groundwater cutoff and a minimum 2-ft clear stone layer is placed below the base of the underpass, we anticipate that temporary dewatering can likely be performed by pumping from multiple sumps and/or wells located within the cofferdam. Temporary dewatering will be required until the watertight structure is completed with sufficient deadweight to offset buoyancy. Due to the presence of miscellaneous fill possibly including cinders, fly ash and burned/degraded municipal waste, groundwater discharge from the dewatering operation should be closely monitored for potential contamination. Sediment control and discharge permits will likely be required and may involve disposal in sanitary sewers rather than storm sewers. We recommend that an environmental consultant be consulted.

To avoid the need to dewater the underpass continually and permanently after completion, we anticipate that it will be designed as a water-tight structure. As such, waterstops will be required across all construction joints, including the entry/exit slabs at each end of the underpass. To handle potential wave overtopping during extreme events, as well as to accommodate normal precipitation, water entering the underpass will need to be removed by pumping (i.e., grades will be too deep for gravity drainage). Therefore, sumps, pumps and electrical equipment should be included in the design.

Because the water-tight underpass and exterior slabs will extend several feet or more below lake level, they will need to be designed to resist hydrostatic uplift forces. We anticipate that the underpass itself will have sufficient dead weight once the walls and roof are in place, but the exterior slabs may not. In these cases, the slabs may need to be thickened or uplift anchors installed to provide sufficient resistance to uplift. Helical piers may be appropriate for this purpose, but as with the sheet pile cofferdam, some pre-excavation may be needed to remove obstructions prior to their installation. As a precaution against extreme high-water events, pressure relief ports can be installed in the culvert walls at the anticipated high-water elevation. In case of an extreme, unanticipated high-water event, the ports would allow water to enter the underpass, thereby offsetting the hydrostatic uplift pressure and preventing the slabs from heaving.

* * * * *

We trust this report addresses your present needs. General limitations regarding the conclusions and opinions presented in this report are discussed in Appendix B. If you have any questions, please contact us.

Sincerely,

CGC, Inc.

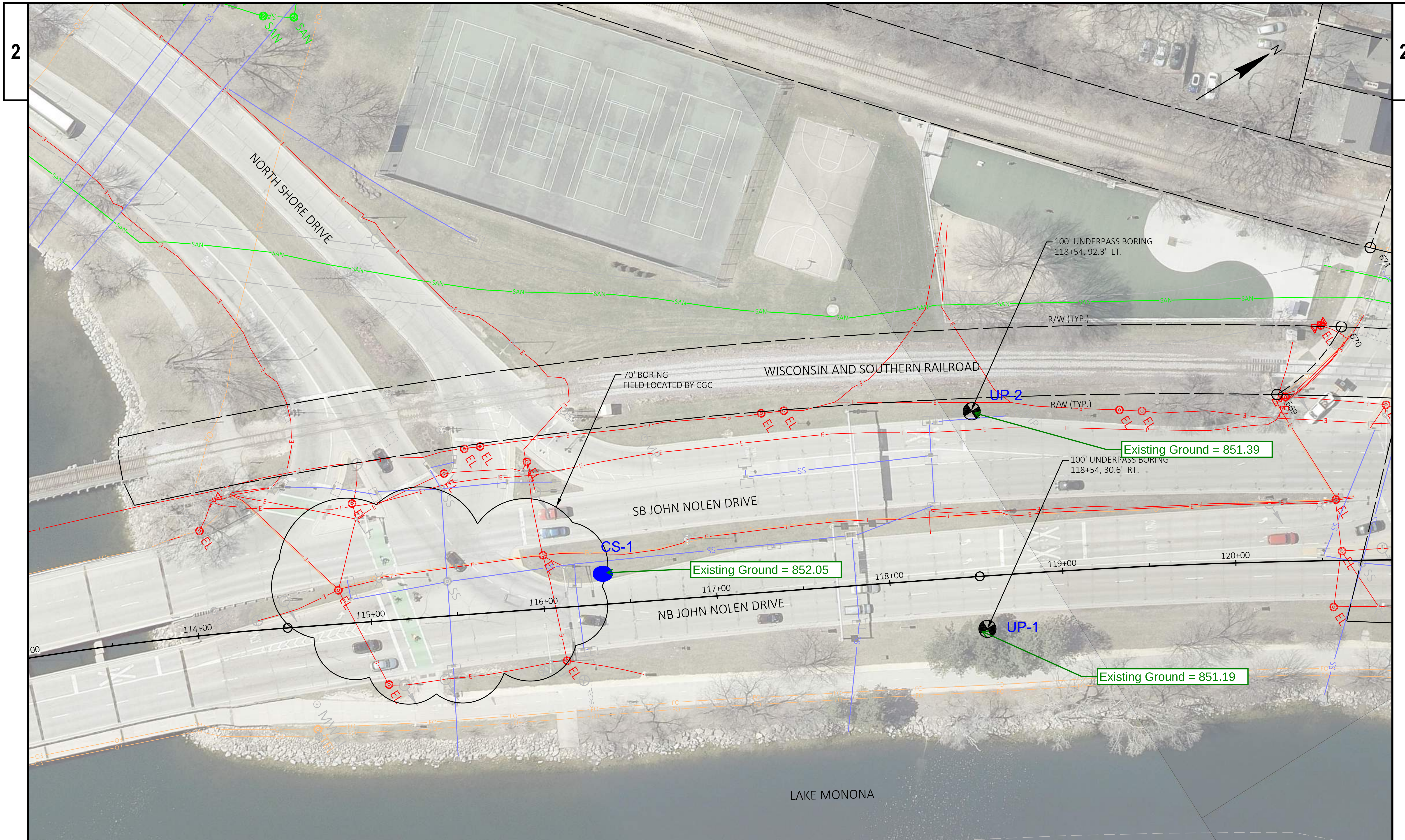
Alex J. Bina, P.E.
Consulting Professional

William W. Wuellner, P.E.
Senior Geotechnical Engineer

Encl: Appendix A - Soil Boring Location Exhibit
Soil Boring Logs (3)
Log of Test Boring – General Notes
Unified Soil Classification System
Appendix B - Document Qualifications

APPENDIX A

SOIL BORING LOCATION EXHIBIT
SOIL BORING LOGS (3)
LOG OF TEST BORING – GENERAL NOTES
UNIFIED SOIL CLASSIFICATION SYSTEM



PROJECT NO: 5992-11-20	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	UNDERPASS AND PAVEMENT SOIL BORINGS	SHEET	E

LOG OF TEST BORING

CGC Inc.

Project: John Nolen Drive Causeway
Location: Madison, WI

Boring No.: CS-1
Surface Elevation (ft): 852.05
Job No.: C21330
Sheet 1 of 1

2921 Perry Street, Madison, WI 53713 (608) 288-4100, FAX (608) 288-7887

SAMPLE / VISUAL CLASSIFICATION and Remarks / SOIL PROPERTIES

No.	TYPE	Rec (in.)	Moist	N	Depth (ft)	Visual Classification and Remarks	qu (qa) (tsf)	W	LL	PL	LOI
					0–0.7	8± in. TOPSOIL Fill					
1		8	M	12		FILL: Brown to Grayish-Brown Silty Sand, Some Gravel, Little Clay and Scattered Organics					
2		8	M/W	6							
3		6	W	9		Slight Chemical or Petroleum Odor in S-3 and S-4					
4		8	W	11							
5		5	W	16		FILL: Dark Brown to Gray Clay with Some Gravel, Scattered Organics and Possible Cinders					
6		5	W	12							
7		10	W	6		Soft/Loose, Tan to Gray Lean CLAY with Very Thin Fine Sand Seams (CL) (Pushed Shelby Tube from 35'-37.5'-No Recovery)	(0.25)	34.2	34	16	
8		10	W	22		Medium Dense, Light Brown to Gray Fine SAND, Trace to Little Silt, With Few Very Thin Silt Seams/Lenses (SP/SP-SM)					
9		1	W	50/1"		Very Dense, Tan to Light Brown with White Inclusions, Fine SAND, Little to Some Silt, Little Gravel (SP-SM/SM)					
10		2	W	50/5"							
11		12	W	50/3"	55						

End of Boring at 55 ft

Borehole Backfilled with Bentonite Chips

WATER LEVEL OBSERVATIONS

While Drilling ∇ 10.0' Upon Completion of Drilling

Time After Drilling				24 Hours
Depth to Water				9'
Depth to Cave in				20'

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/13/24 End 2/13/24
Driller ADC Chief DB Rig D-50
Logger PB Editor AJB
Drill Method 2.25" HSA 0-23.5'; Autohammer; 3 7/8" RB w/DM 23.5 to 55'

LOG OF TEST BORING

CGC Inc.

Project: John Nolen Drive Causeway
Location: Madison, WI

Boring No.: UP-1
Surface Elevation (ft): 851.19
Job No.: C21330
Sheet 1 of 1

2921 Perry Street, Madison, WI 53713 (608) 288-4100, FAX (608) 288-7887

SAMPLE No.	TYPE	Rec (in.)	Moist	N	Depth (ft)	VISUAL CLASSIFICATION and Remarks	qu (qa) (tsf)	W	LL	PL	LOI
						6± in. TOPSOIL Fill					
1	■	13	M	11		FILL: Dark Brown to Grayish-Brown Silty Sand, Some Gravel, Little Clay and Scattered Organics					
2	■	10	M	7	5						
3	■	3	M	45		FILL: Light Brown Fine to Medium Sand, Trace Silt and Gravel. Concrete Rubble Intermixed Near 7 ft					
4	■	17	W	11	10		(1.25)	29.7			
5	■	1	W	12		FILL: Dark Brown to Gray Clay with Some Gravel, Scattered Organics and Possible Cinders					
6	■	0	W	12	15	Limited Sample Recovery - Concrete Fragments in Tip of Sampling Spoon. Augered Through Apparent Rubble Fill From S-5 to S-6; Pounded Spoon No Recovery, Auger Cuttings Included Concrete Fragments.					
7	■	10	W	12	20						
8	■	4	W	9	25	FILL: Brown to Grayish-Brown Silty Sand, Some Gravel, Little Clay		27.3			3.1
9	■	18	W	6	30	Loose, Gray Clayey SILT with Shell Fragments and Fibers (ML). Fewer Shell Fragments and Fibers in S-9					
10	■	12	W	25	35	Medium Dense, Light Brown to Gray Fine SAND, Trace to Little Silt, With Few Very Thin Silt Seams/Lenses (SP/SP-SM)					
11	■	2	W	50/5"	40	Very Dense, Gray to Brown Fine to Coarse GRAVEL, Little Silt and Sand (GP-GM)					
12	■	3	W	50/3"	45	Very Dense, Tan to Light Brown with White Inclusions, Fine SAND, Little to Some Silt, Little Gravel (SP-SM/SM)					
13	■	1	W	50/1"	50						
14	■	0	W	50/1"	55	No Recovery at S-14					
					60	End of Boring at 55 ft					
					65	Borehole Backfilled with Bentonite Chips					
					70	*Soil Description within Upper 20 ft Based on Composite of 3 Boring Locations within 15 ft Area. Multiple Attempts Made to get Auger Through Rubble Fill.					

WATER LEVEL OBSERVATIONS

While Drilling ▽ 8.5'			Upon Completion of Drilling	
Time After Drilling				30 Mins.
Depth to Water				7' ▼
Depth to Cave in				23.5'

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/13/24 End 2/13/24
Driller ADC Chief KD Rig CME-55
Logger TH Editor AJB
Drill Method 2.25" HSA 0-20'; Autohammer; 3 7/8" RB w/DM 20 to 55'

LOG OF TEST BORING

CGC Inc.

Project: John Nolen Drive Causeway
Location: Madison, WI

Boring No.: UP-2
Surface Elevation (ft): 851.39
Job No.: C21330
Sheet 1 of 1

2921 Perry Street, Madison, WI 53713 (608) 288-4100, FAX (608) 288-7887

SAMPLE No.	TYPE	Rec (in.)	Moist	N	Depth (ft)	VISUAL CLASSIFICATION and Remarks	qu (qa) (tsf)	W	LL	PL	LOI
						6± in. TOPSOIL Fill					
						FILL: Brown to Grayish-Brown Silty Sand, Some Gravel, Little Clay					
1	■	8	M	10	5						
2	■	8	W	18	10						
3	■	6	W	24	15	Medium Dense, Brown to Tan Silty Fine to Medium SAND, Some Gravel, Little Clay (SM; Possible Fill)		10.0			
						Very Dense at 14.5 ft, Probable Cobble in Tip of Spoon					
4	■	8	W	10	20	Loose to Medium Dense, Light Brown Fine to Medium SAND, Trace Silt, Little Gravel (SP)					
5	■	5	W	14	25						
6	■	5	W	50/5"	30	Very Dense, Brown Fine to Medium SAND, Little to Some Silt, Some Gravel (SP-SM/SM)					
7	■	10	W	50/5"	35						
8	■	10	W	50/5"	40	Very Dense, Tan to Light Brown with White Inclusions, Fine SAND, Little to Some Silt, Little Gravel (SP-SM/SM)					
9	■	1	W	50/3"	45						
10	■	2	W	50/4"	50	Orangish-Brown Coloration in S-10					
						End of Boring at 50 ft					
					55	Borehole Backfilled with Bentonite Chips					
					60						
					65						
					70						

WATER LEVEL OBSERVATIONS

While Drilling ▽ 8.5' Upon Completion of Drilling ______
Time After Drilling: 30 Mins.
Depth to Water: 11' ▼
Depth to Cave in: 12'

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/15/24 End 2/15/24
Driller ADC Chief KD Rig CME-55
Logger PB Editor AJB
Drill Method 2.25" HSA; Autohammer

CGC, Inc.

LOG OF TEST BORING

General Notes

DESCRIPTIVE SOIL CLASSIFICATION

Grain Size Terminology

Soil Fraction	Particle Size	U.S. Standard Sieve Size
Boulders	Larger than 12”	Larger than 12”
Cobbles	3” to 12”	3” to 12”
Gravel: Coarse	¾” to 3”	¾” to 3”
Fine	4.76 mm to ¾”	#4 to ¾”
Sand: Coarse	2.00 mm to 4.76 mm	#10 to #4
Medium	0.42 to mm to 2.00 mm	#40 to #10
Fine	0.074 mm to 0.42 mm	#200 to #40
Silt	0.005 mm to 0.074 mm	Smaller than #200
Clay	Smaller than 0.005 mm	Smaller than #200

Plasticity characteristics differentiate between silt and clay.

General Terminology

Physical Characteristics
Color, moisture, grain shape, fineness, etc.
Major Constituents
Clay, silt, sand, gravel
Structure
Laminated, varved, fibrous, stratified, cemented, fissured, etc.
Geologic Origin
Glacial, alluvial, eolian, residual, etc.

Relative Density

Term	“N” Value
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	Over 50

Relative Proportions Of Cohesionless Soils

Proportional Term	Defining Range by Percentage of Weight
Trace	0% - 5%
Little	5% - 12%
Some	12% - 35%
And	35% - 50%

Consistency

Term	q_u-tons/sq. ft
Very Soft	0.0 to 0.25
Soft	0.25 to 0.50
Medium	0.50 to 1.0
Stiff	1.0 to 2.0
Very Stiff	2.0 to 4.0
Hard	Over 4.0

Organic Content by Combustion Method

Soil Description	Loss on Ignition
Non Organic	Less than 4%
Organic Silt/Clay	4 – 12%
Sedimentary Peat	12% - 50%
Fibrous and Woody Peat	More than 50%

Plasticity

Term	Plastic Index
None to Slight	0 - 4
Slight	5 - 7
Medium	8 - 22
High to Very High	Over 22

The penetration resistance, N, is the summation of the number of blows required to effect two successive 6” penetrations of the 2” split-barrel sampler. The sampler is driven with a 140 lb. weight falling 30” and is seated to a depth of 6” before commencing the standard penetration test.

SYMBOLS

Drilling and Sampling

CS – Continuous Sampling
RC – Rock Coring: Size AW, BW, NW, 2”W
RQD – Rock Quality Designation
RB – Rock Bit/Roller Bit
FT – Fish Tail
DC – Drove Casing
C – Casing: Size 2 ½”, NW, 4”, HW
CW – Clear Water
DM – Drilling Mud
HSA – Hollow Stem Auger
FA – Flight Auger
HA – Hand Auger
COA – Clean-Out Auger
SS - 2” Dia. Split-Barrel Sample
2ST – 2” Dia. Thin-Walled Tube Sample
3ST – 3” Dia. Thin-Walled Tube Sample
PT – 3” Dia. Piston Tube Sample
AS – Auger Sample
WS – Wash Sample
PTS – Peat Sample
PS – Pitcher Sample
NR – No Recovery
S – Sounding
PMT – Borehole Pressuremeter Test
VS – Vane Shear Test
WPT – Water Pressure Test

Laboratory Tests

q_a – Penetrometer Reading, tons/sq ft
q_a – Unconfined Strength, tons/sq ft
W – Moisture Content, %
LL – Liquid Limit, %
PL – Plastic Limit, %
SL – Shrinkage Limit, %
LI – Loss on Ignition
D – Dry Unit Weight, lbs/cu ft
pH – Measure of Soil Alkalinity or Acidity
FS – Free Swell, %

Water Level Measurement

▽- Water Level at Time Shown
NW – No Water Encountered
WD – While Drilling
BCR – Before Casing Removal
ACR – After Casing Removal
CW – Cave and Wet
CM – Caved and Moist

Note: Water level measurements shown on the boring logs represent conditions at the time indicated and may not reflect static levels, especially in cohesive soils.

CGC, Inc.

Madison - Milwaukee

Unified Soil Classification System

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

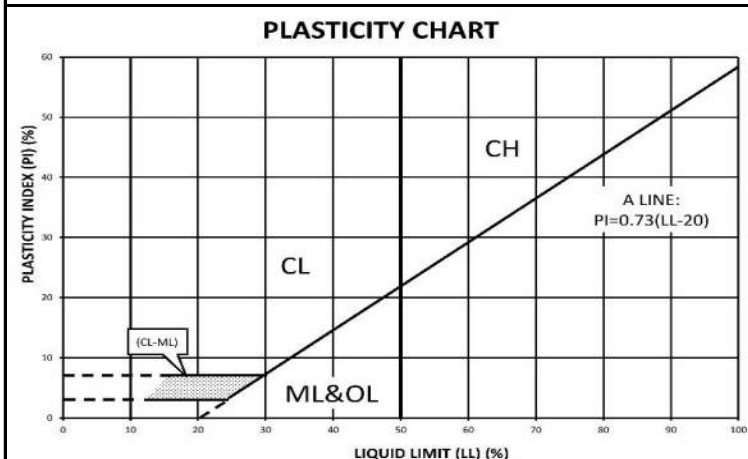
COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size)		
		Clean Gravels (Less than 5% fines)
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
		Gravels with fines (More than 12% fines)
	GM	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
		Clean Sands (Less than 5% fines)
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
		Sands with fines (More than 12% fines)
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)		
SILTS AND CLAYS Liquid limit less than 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

LABORATORY CLASSIFICATION CRITERIA

GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limts below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limts above "A" line or P.I. greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for GW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
SC	Atterberg limits above "A" line with P.I. greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent ………………………………………….. GW, GP, SW, SP
More than 12 percent ………………………..………………… GM, GC, SM, SC
5 to 12 percent …………………..….... Borderline cases requiring dual symbols



APPENDIX B

DOCUMENT QUALIFICATIONS

APPENDIX B
DOCUMENT QUALIFICATIONS

I. GENERAL RECOMMENDATIONS/LIMITATIONS

CGC, Inc. should be provided the opportunity for a general review of the final design and specifications to confirm that earthwork and foundation requirements have been properly interpreted in the design and specifications. CGC should be retained to provide soil engineering services during excavation and subgrade preparation. This will allow us to observe that construction proceeds in compliance with the design concepts, specifications and recommendations, and also will allow design changes to be made in the event that subsurface conditions differ from those anticipated prior to the start of construction. CGC does not assume responsibility for compliance with the recommendations in this report unless we are retained to provide construction testing and observation services.

This report has been prepared in accordance with generally accepted soil and foundation engineering practices and no other warranties are expressed or implied. The opinions and recommendations submitted in this report are based on interpretation of the subsurface information revealed by the test borings indicated on the location plan. The report does not reflect potential variations in subsurface conditions between or beyond these borings. Therefore, variations in soil conditions can be expected between the boring locations and fluctuations of groundwater levels may occur with time. The nature and extent of the variations may not become evident until construction.

II. IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes. While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. *No one except you* should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one - not even you* - should apply the report for any purpose or project except the one originally contemplated.

READ THE FULL REPORT

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, *do not rely on a geotechnical engineering report* that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes - even minor ones - and request an assessment of their impact. *CGC cannot accept responsibility or liability for problems that occur because our reports do not consider developments of which we were not informed.*

SUBSURFACE CONDITIONS CAN CHANGE

A geotechnical engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

MOST GEOTECHNICAL FINDINGS ARE PROFESSIONAL OPINION

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgement to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ - sometimes significantly - from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A REPORT'S RECOMMENDATIONS ARE NOT FINAL

Do not over-rely on the confirmation-dependent recommendations included in your report. *Those confirmation-dependent recommendations are not final*, because geotechnical engineers develop them principally from judgement and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *CGC cannot assume responsibility or liability for the report's confirmation-dependent recommendations if we do not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical engineering report. Confront that risk by having CGC participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

DO NOT REDRAW THE ENGINEER'S LOGS

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

GIVE CONSTRUCTORS A COMPLETE REPORT AND GUIDANCE

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

READ RESPONSIBILITY PROVISIONS CLOSELY

Some clients, design professionals, and constructors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineer's responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

ENVIRONMENTAL CONCERNS ARE NOT COVERED

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

OBTAIN PROFESSIONAL ASSISTANCE TO DEAL WITH MOLD

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

RELY ON YOUR GEOTECHNICAL ENGINEER FOR ADDITIONAL ASSISTANCE

Membership in the Geotechnical Business Council (GBC) of Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with CGC, a member of GBC, for more information.

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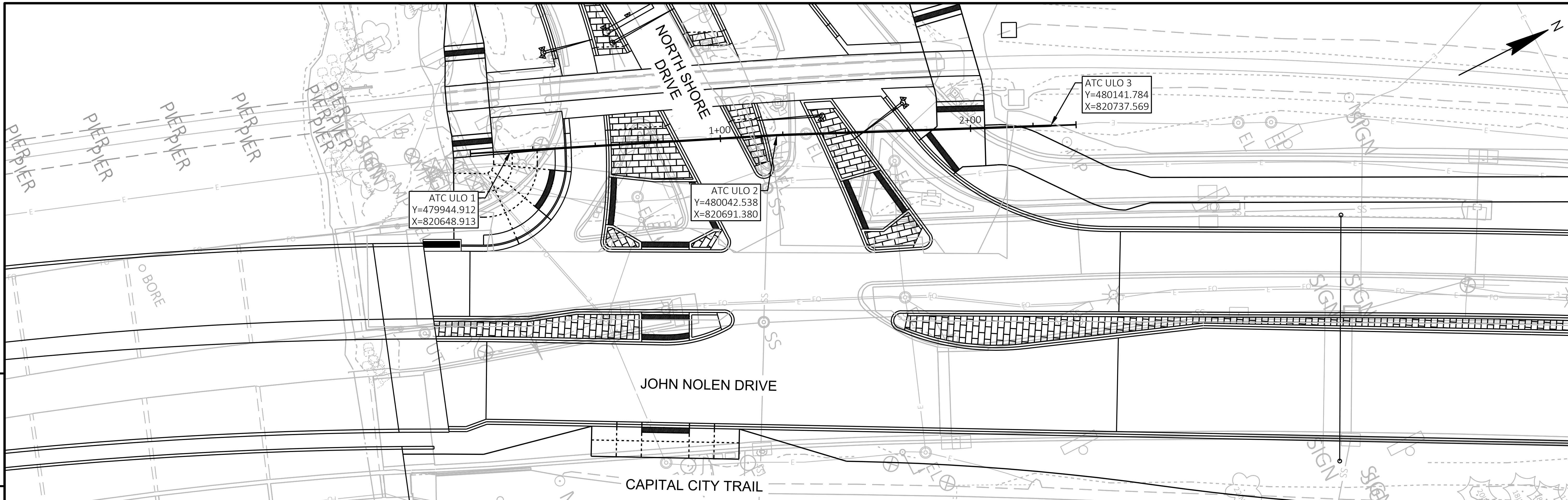
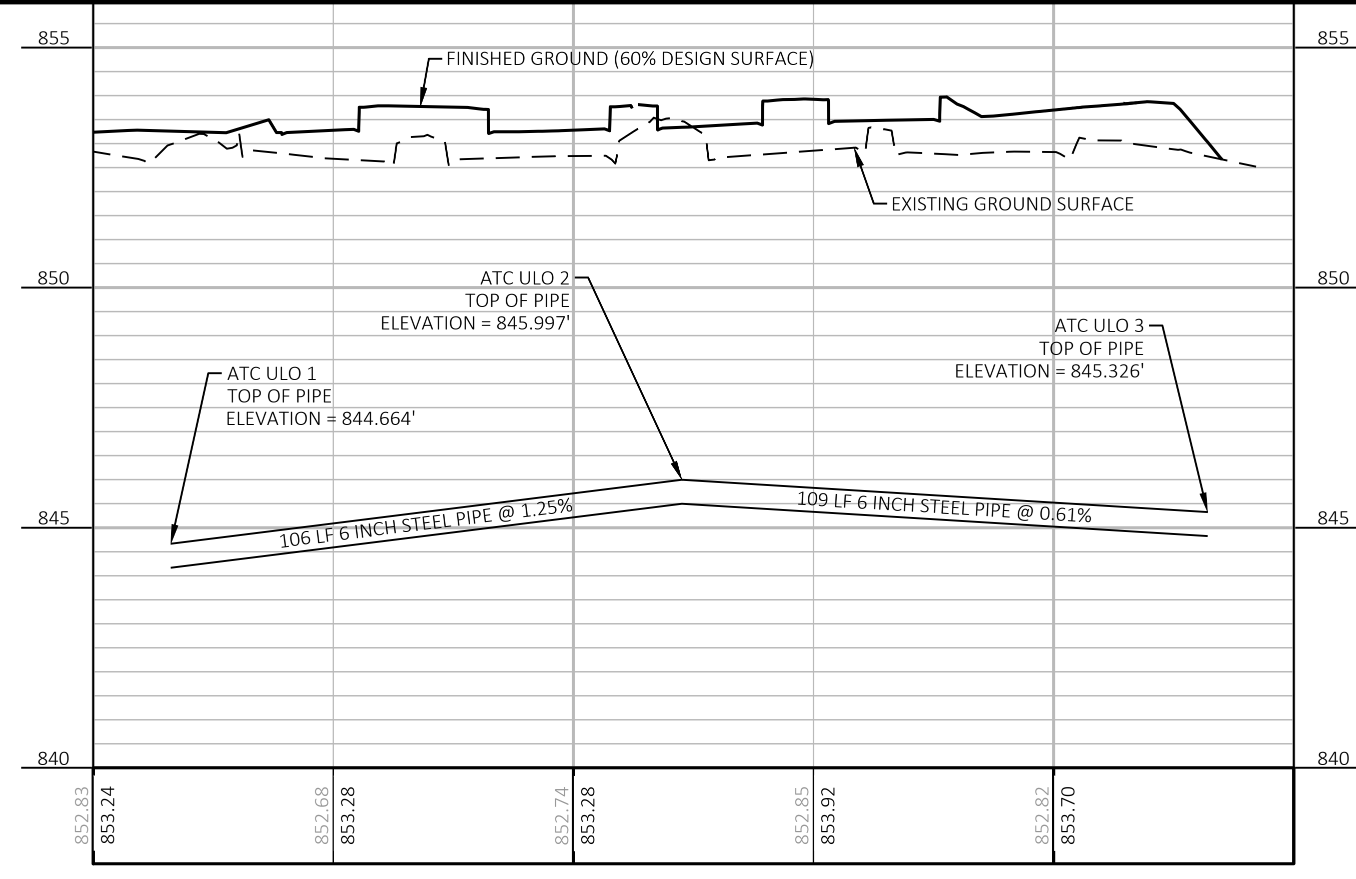
Geotechnical Business Council
of the Geoprofessional Business Association
8811 Colesville Road, Suite G 106
Silver Spring, MD 20910

APPENDIX E

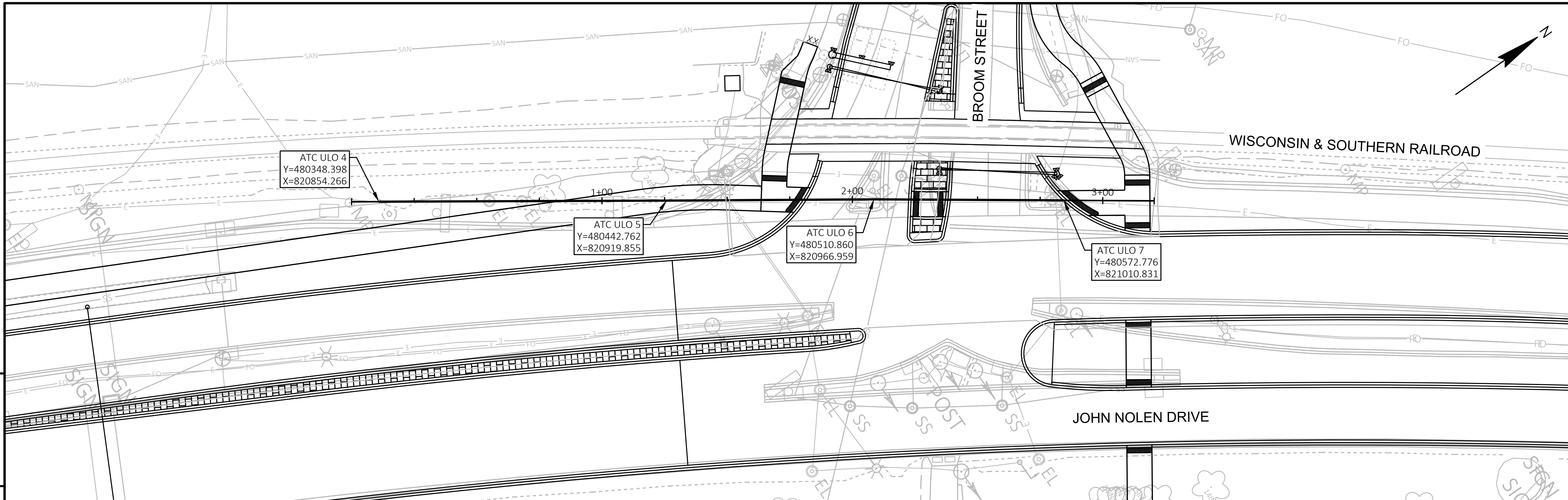
ATC Utility Line Opening (ULO) Data and Easement

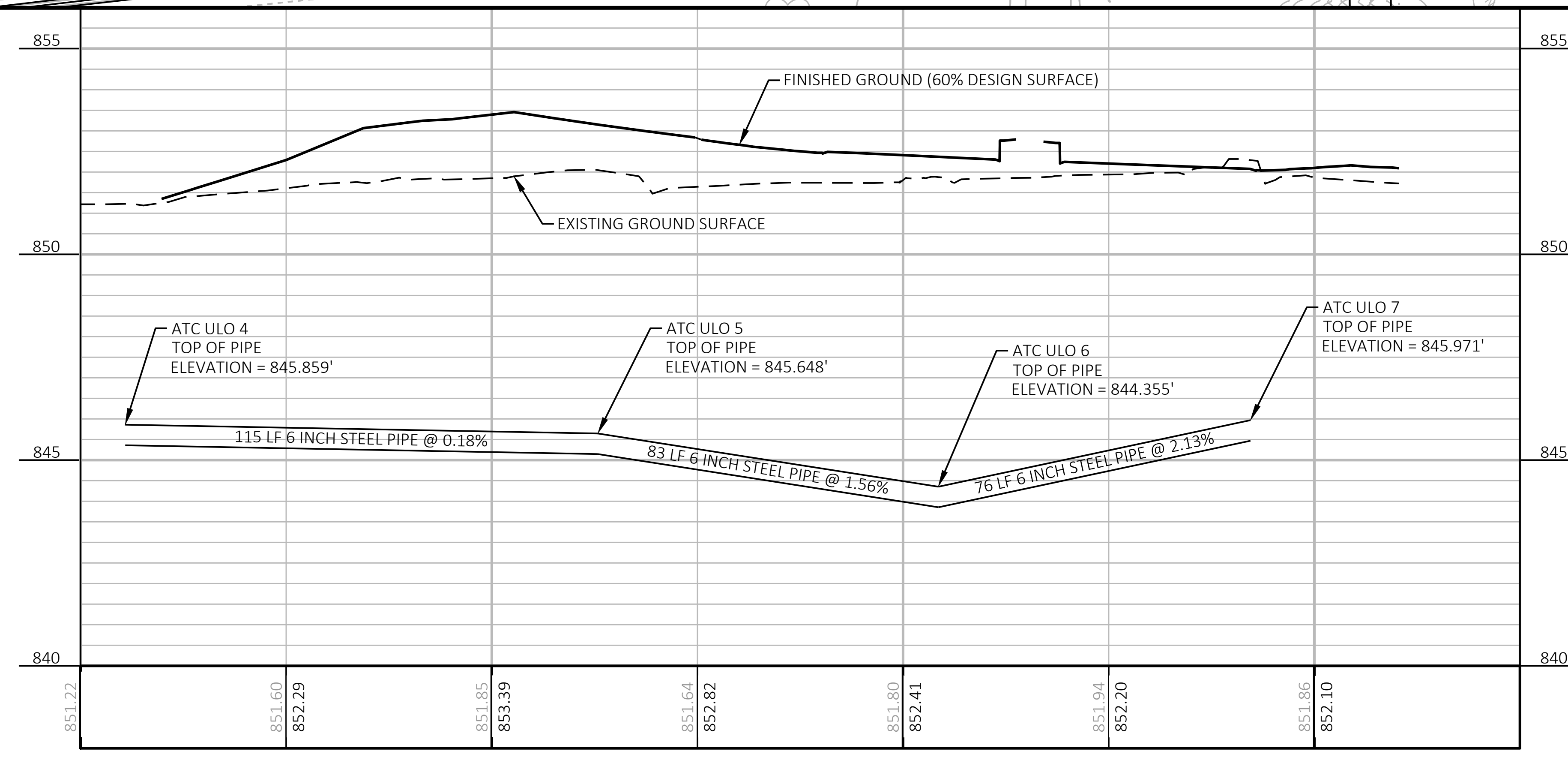




PROJECT NO: 5992-11-21	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ATC - NORTH SHORE DRIVE	SHEET	E

FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\PIPENETWORKS\ULO\ULO-ATC.DWG
LAYOUT NAME - ATC-NSD
PLOT DATE : 12/22/2023 11:20 AM PLOT BY : JACK HAFEMANN PLOT NAME : PLOT SCALE : 1 IN:40 FT
WISDOT/CADDS SHEET 44





PROJECT NO: 5992-11-21	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ATC - BROOM STREET	SHEET E

FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\PIPENETWORKS\ULO\ULO-ATC.DWG
LAYOUT NAME - ATC-BROOM
PLOT DATE : 12/22/2023 11:21 AM
PLOT BY : JACK HAFEMANN
PLOT NAME :
PLOT SCALE : 1 IN:40 FT
WISDOT/CADDS SHEET 44

UNDERGROUND ELECTRIC EASEMENT

KNOW ALL MEN BY THESE PRESENTS that the City of Madison, a municipal corporation located in Dane County, Wisconsin, hereinafter called Grantor, being the owner of the property hereinafter described, in consideration of the sum of ONE ($1.00) DOLLAR and other good and valuable consideration, the receipt whereof is hereby acknowledged, does grant, sell, set over and convey unto Madison Gas and Electric Company, a Wisconsin corporation, its successor and assigns, hereinafter called Grantee, a permanent underground electric easement with the right to survey, construct, bury, maintain, inspect, operate, move, remove, and replace an underground electric transmission line and an underground electric distribution system together with the necessary footings, manholes, and underground accessories and appurtenances as may be selected by Grantee along, under, and through the following described land (being a strip of land 15 to 30 feet in width and 140± feet in length across the land described):

A permanent easement for underground electric utility purposes located in part of the NE 1/4 of Section 23, Town 7 North, Range 9 East, City of Madison, Dane County, Wisconsin, described as follows:

Commencing at concrete monument with brass cap being a meander corner on the East line of Section 23 and N00°30'10"E, 521.81 feet from the East 1/4 corner of Section 23; thence N00°30'10"E, 86.76 feet to the southeast line of the Soo Line Railroad; thence S46°00'24"W, 361.73 feet to the point of curvature of a 5,750.15 foot radius curve; thence 277.99 feet along the arc of said curve to the right having a central angle of 02°46'12" and a long chord bearing S47°23'30"W, 277.96 feet, the point of beginning; thence continuing 35.36 feet along the arc of said curve having a central angle of 00°21'08" and a long chord bearing S48°57'10"W, 35.36 feet to a point on the arc of a 69.00 foot radius curve, the center of the circle of said curve bears S28°41'05"E from said point; thence 65.97 feet along the arc of said 69.00 foot radius curve concave to the south having a central angle of 54°46'39" and a long chord bearing N88°42'14"E, 63.48 feet to the point of tangency of said curve; thence S64°00'34"E, 46.54 feet to the point of curvature of a 69.00 foot radius curve; thence 37.25 feet along the arc of said curve to the right having a central angle of 30°55'57" and a long chord bearing S48°05'57"E, 36.80 feet to a point on the northwest line of the Chicago and North Western Railroad said point on the arc of a 4,428.00 foot radius curve, the center of the circle bears S59°21'35"E from said point; thence 30.14 feet along the arc of said 4,428.00 foot radius curve concave to the southeast having a central angle of 00°23'24" and a long chord bearing N30°50'07"E, 30.14 feet to a point on the arc of a 69.00 foot radius curve, the center of the circle bears N04°09'24"E from said point; thence 26.98 feet along the arc of said curve concave to the northwest having a central angle of 22°24'19" and a long chord bearing N74°38'27" W, 26.81 feet to the point of tangency of said curve; thence N64°00'34"W, 58.10 feet to the point of curvature of an 84.00 foot radius curve; thence 44.71 feet along the arc of said curve to the left having a central angle of 30°29'54" and a long chord bearing N79°09'23"W, 44.19 feet to the point of beginning.

Together with this permanent easement is included a temporary construction easement being a 25 foot strip of land adjacent to the north and south sides of the permanent easement. This construction easement will terminate upon completion of construction and installation of the underground electrical utility.

The easement strip is further identified by the attached print marked Exhibit A-1.

City of Madison

The underground electric transmission line shall have the following specifications and characteristics:

Space will be allocated within the easement for two (2) underground high-voltage circuits of 69,000 volts plus or minus 10 percent (10%). Each circuit will be comprised of three (3) cables, one (1) per phase. Each circuit will be encased within a 5-9/16 inch O.D. pipe.

16

Said grant of permanent easement shall be subject to the following conditions:

1. Grantee shall give to the City of Madison Parks Department at least thirty days notice in writing before entering upon the Grantor's property for construction purposes or for the purpose of making necessary repairs, except for emergency repairs.

2. The work of construction and maintenance shall be done and completed in good and workmanlike manner at the sole expense of Grantee. Said work shall be done in such manner as in no way to interfere with or endanger the use of the property.

3. Scheduling of all construction on the site must be approved in writing by the City of Madison Parks Department prior to initiation of any activity on the site.

4. The area disturbed as a result of this easement shall be restored by Grantee in kind to the satisfaction of the City of Madison Parks Department.

5. Grantee shall comply with all applicable laws, including, but not limited to, any laws, standards, regulations, or permit requirements relating to environmental pollution or contamination or to occupational health and safety.

6. Grantee and its subcontractors shall be liable to and hereby agrees to indemnify, defend and hold harmless the Grantor and its officers, officials, agents and employees against all claims against any of them for personal injury or wrongful death or property damage including that which may be sustained by them or caused by any error, omission, negligent act or tortious act of Grantee or its subcontractors in the execution or performance of work under this easement.

7. Grantee may enter upon the easement area for any of the purposes hereinabove set forth and to trim or remove from the easement area any structure, tree, or object which, in the opinion of the Grantee, might interfere with or endanger said transmission line. No additional compensation will be paid for the trimming and removal of structures, trees, or objects subsequent to the initial construction. Grantee may not use any lands of Grantor outside of the easement area for any purpose, including ingress to and egress from the right-of-way, without the express written consent of the Grantor.

8. Grantee shall pay Grantor for all damages to sidewalks, lawns, and vegetation caused by exercising the rights herein conferred, and not otherwise reasonably repaired or replaced by the Grantee.

9. Grantee shall not have the right to erect any fence or buildings on the easement area.

10. Grantor reserves the right to cultivate, use, and occupy the easement area except that within said easement area Grantor shall not:

    - erect or emplace any permanent structures or improvements.
    - plant any trees.
    - change the surface grade.
    - interfere with or endanger the transmission line or the use thereof.
    - create any hazard to Grantee or any other person.

11. The rights conferred upon Grantor under Section 182.017(7)(c) through (h), Wisconsin Statutes (1979) (a copy of which Grantor acknowledges having received) are hereby specifically reserved and retained.

12. Grantee shall install, or cause to be installed, no substance, material, or improvement which would be classified as an environmental hazard by the state or federal government without the express written consent of the Grantor.

City of Madison

13. If Grantee does not initiate construction of the underground electric transmission line described herein within five (5) years from the execution date of this easement, or, if Grantee abandons said line, Grantee's right title and interest conveyed herein shall immediately revert to Grantor. Grantee shall notify Grantor in writing at least sixty (60) days in advance of Grantee's intended date of abandonment. Grantee shall remove all improvements installed therein and restore the grounds to a condition acceptable to the City of Madison Parks Department, where upon Grantee shall then immediately execute and deliver to Grantor a quit claim deed conveying said easement back to Grantor.

IN WITNESS WHEREOF, the undersigned hereunto sets hand and seal this 30th day of August, 1991.

CITY OF MADISON

By: Paul Soglin

Paul R. Soglin, Mayor

State of Wisconsin)
)ss.
County of Dane)

Personally came before me this 30th day of August, 1991, the above named Paul R. Soglin, Mayor, to me known to be the person who executed the foregoing instrument and acknowledged the same.

Pamela Williamson
Notary Public, State of Wisconsin
My Commission: exp. 2-27-94

IN WITNESS WHEREOF, the undersigned hereunto sets hand and seal this 28 day of August, 1991.

CITY OF MADISON

By: André Blum

Andre Blum, City Clerk

State of Wisconsin)
)ss.
County of Dane)

Personally came before me this 28 day of August, 1991, the above named Andre Blum, City Clerk, to me known to be the person who executed the foregoing instrument and acknowledged the same.

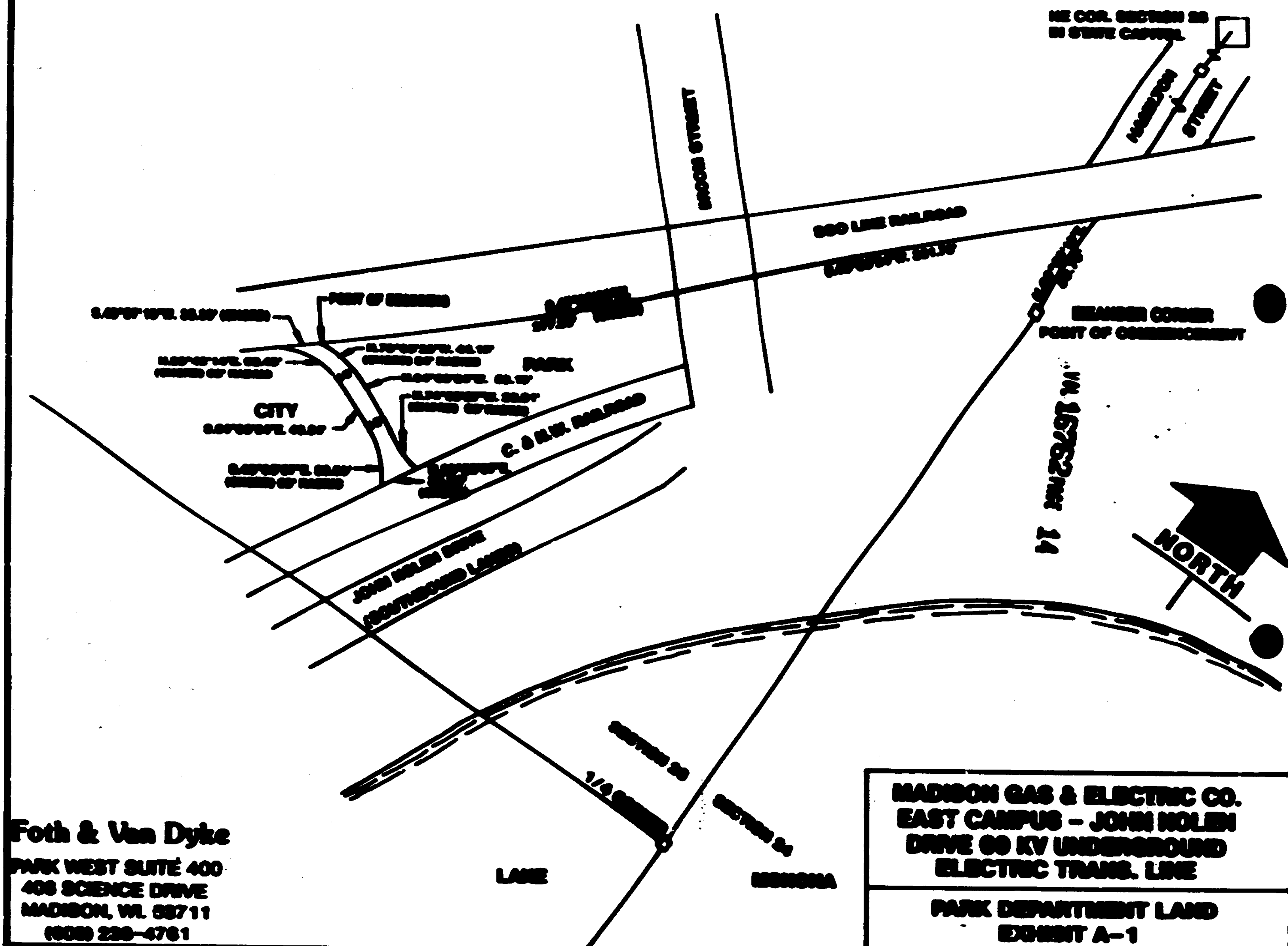
Diane J. Dahlert
Notary Public, State of Wisconsin
My Commission: 8-21-94

Resolution No. 48,115, ID Number 9491, adopted August 20, 1991, authorizes the Mayor and City Clerk to execute the foregoing easement, City of Madison Grantor, and Madison Gas and Electric, Grantee.

This easement document is a corrected version of the easement document previously recorded as Document No. 2257918 in Liber 14747, Pages 44-47, inclusive, and is intended to be the easement document which prevails.

City of Madison

This instrument drafted by
City of Madison
Real Estate Section



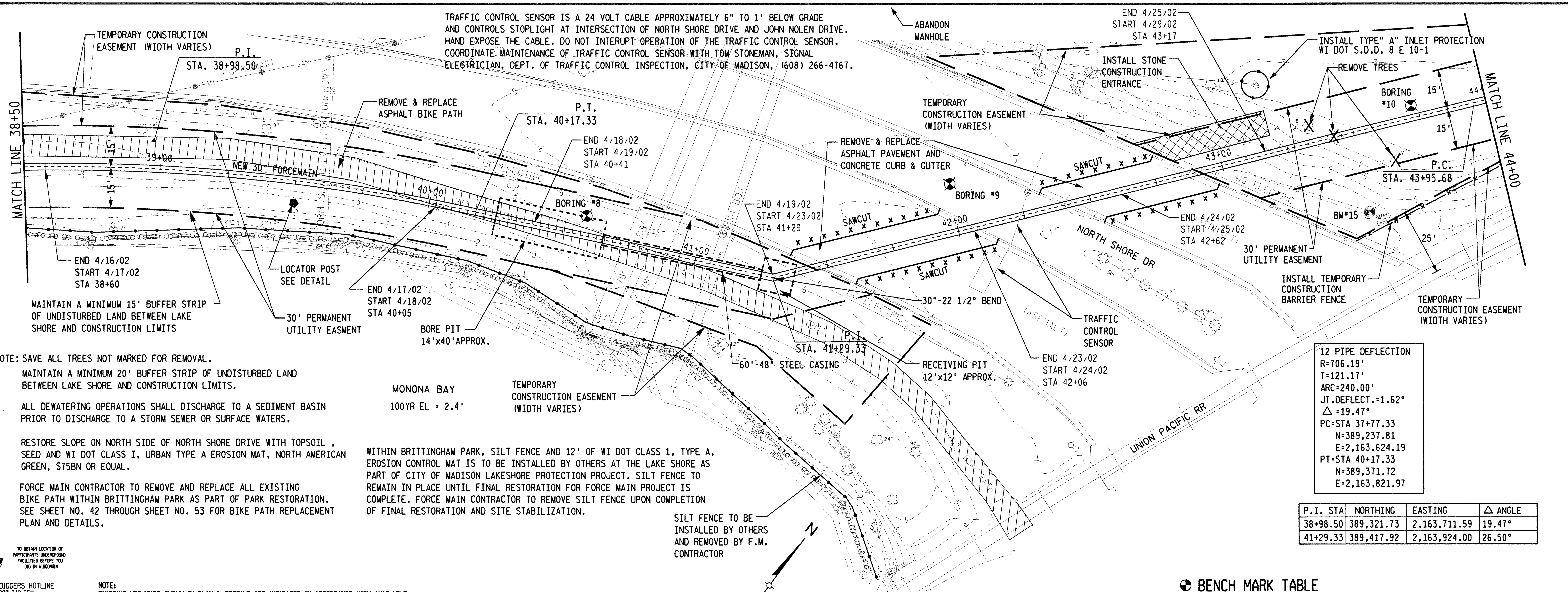
Foth & Van Dyke
PARK WEST SUITE 400
406 SCIENCE DRIVE
MADISON, WI. 53711
(608) 238-4761

MADISON GAS & ELECTRIC CO.
EAST CAMPUS - JOHN NOLEN
DRIVE 69 KV UNDERGROUND
ELECTRIC TRANS. LINE

PARK DEPARTMENT LAND
EXHIBIT A-1

APPENDIX F

MMSD Sanitary Force Main As-Builts and Easement



NOTE: SAVE ALL TREES NOT MARKED FOR REMOVAL.

MAINTAIN A MINIMUM 20' BUFFER STRIP OF UNDISTURBED LAND BETWEEN LAKE SHORE AND CONSTRUCTION LIMITS.

ALL DEWATERING OPERATIONS SHALL DISCHARGE TO A SEDIMENT BASIN PRIOR TO DISCHARGE TO A STORM SEWER OR SURFACE WATERS.

RESTORE SLOPE ON NORTH SIDE OF NORTH SHORE DRIVE WITH TOPSOIL, SEED AND WI DOT CLASS I, URBAN TYPE A EROSION MAT, NORTH AMERICAN GREEN, S75BN OR EQUAL.

FORCE MAIN CONTRACTOR TO REMOVE AND REPLACE ALL EXISTING BIKE PATH WITHIN BRITTINGHAM PARK AS PART OF PARK RESTORATION. SEE SHEET NO. 42 THROUGH SHEET NO. 53 FOR BIKE PATH REPLACEMENT PLAN AND DETAILS.

WITHIN BRITTINGHAM PARK, SILT FENCE AND 12' OF WI DOT CLASS 1, TYPE A, EROSION CONTROL MAT IS TO BE INSTALLED BY OTHERS AT THE LAKE SHORE AS PART OF CITY OF MADISON LAKESHORE PROTECTION PROJECT. SILT FENCE TO REMAIN IN PLACE UNTIL FINAL RESTORATION FOR FORCE MAIN PROJECT IS COMPLETE. FORCE MAIN CONTRACTOR TO REMOVE SILT FENCE UPON COMPLETION OF FINAL RESTORATION AND SITE STABILIZATION.

12 PIPE DEFLECTION
R=706.19'
T=121.17'
ARC=240.00'
JT.DEFLECT.=1.62°
Δ =19.47°
PC=STA 37+77.33
N=389,237.81
E=2,163,624.19
PT=STA 40+17.33
N=389,371.72
E=2,163,821.97

P.I. STA	NORTHING	EASTING	Δ ANGLE
38+98.50	389,321.73	2,163,711.59	19.47°
41+29.33	389,417.92	2,163,924.00	26.50°

TO OBTAIN LOCATION OF PARTICIPANTS UNDERGROUND FACILITIES BEFORE YOU DIG IN WISCONSIN

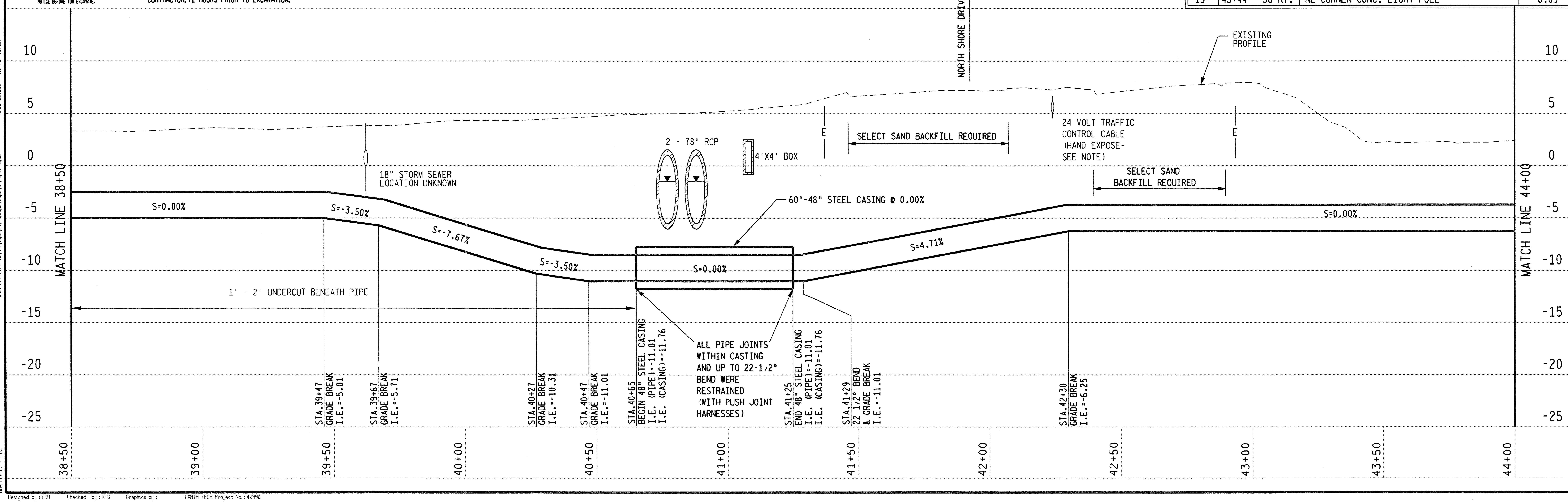
CALL DIGGERS HOTLINE
1-800-242-8511
TOLL FREE
FAX-A-LOCATE 1-800-338-3860
TDD (FOR HEARING IMPAIRED) 1-800-542-2289
WIS. STATUTE 182.0175 (1974)
REQUIRES MIN. OF 3 WORK DAYS
NOTICE BEFORE YOU EXCAVATE.

NOTE:
EXISTING UTILITIES SHOWN, IN PLAN & PROFILE, ARE INDICATED IN ACCORDANCE WITH AVAILABLE RECORDS. OTHER UTILITIES MAY ALSO BE PRESENT. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING EXACT LOCATIONS & ELEVATIONS OF ALL UTILITIES, INCLUDING SEWER AND WATER FROM THE OWNERS OF THE RESPECTIVE UTILITIES. ALL UTILITY OWNERS SHALL BE NOTIFIED BY THE CONTRACTOR, 72 HOURS PRIOR TO EXCAVATION.

SCALE 0' 10' 20' 40'

BENCH MARK TABLE

NO.	STATION	DESCRIPTION	ELEV.
15	43+44 - 36 RT.	NE CORNER CONC. LIGHT POLE	8.09



Designed by: EDH Checked by: REG Graphics by: EARTH TECH Project No.: 42990

NO			REVISIONS	DRN	CHK	DATE

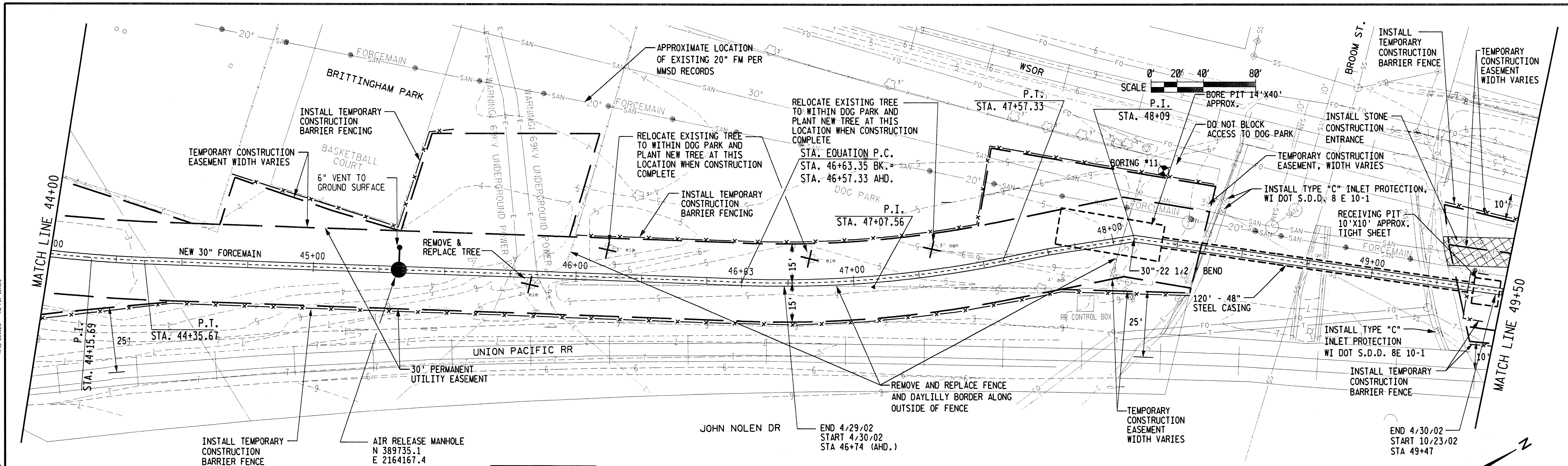
OFFICE NAME
DRN DBM
DES EDH
CHK REG
APP
Copyright © EARTH TECH

AS BUILT

MADISON METROPOLITAN SEWERAGE DISTRICT

CROSS TOWN FORCE MAIN REPLACEMENT

DATE JANUARY, 2002
PROJECT NO 42990
FILENAME M-12490
SHEET NO 18
DRAWING NO 42990pp8.dgn



P.I. STA	NORTHING	EASTING	△ ANGLE
44+15.69	389,640.06	2,164,104.71	4.87°
47+07.56	389,886.90	2,164,271.52	13.36°
48+09	389,980.93	2,164,303.53	18.07°

2 PIPE DEFLECTION
R=470.98'
T=20.01'
ARC=40.00'
JT.DEFLECT.=2.43°
△ =4.87°
PC=STA 43+95.68
N=389,624.51
E=2,164,092.11
PT=STA 44+35.67
N=389,656.62
E=2,164,115.94

5 PIPE DEFLECTION
R=428.80'
T=50.23 '
ARC=100.00'
JT.DEFLECT.=2.67°
△ =13.36°
PC=STA 46+57.33 AHD.
N=389,845.28
E=2,164,243.40
PT=STA 47+57.33
N=389,933.89
E=2,164,289.25

NOTE: SAVE ALL TREES NOT MARKED FOR REMOVAL.

COMPLY WITH UNION PACIFIC RR SHORING REQUIREMENTS. SEE DETAIL.

ALL DEWATERING OPERATIONS SHALL DISCHARGE TO A SEDIMENT BASIN PRIOR TO DISCHARGE TO A STORM SEWER OR SURFACE WATERS.

STA 44+75 TO STA 49+50, RR FLAGMAN REQUIRED.

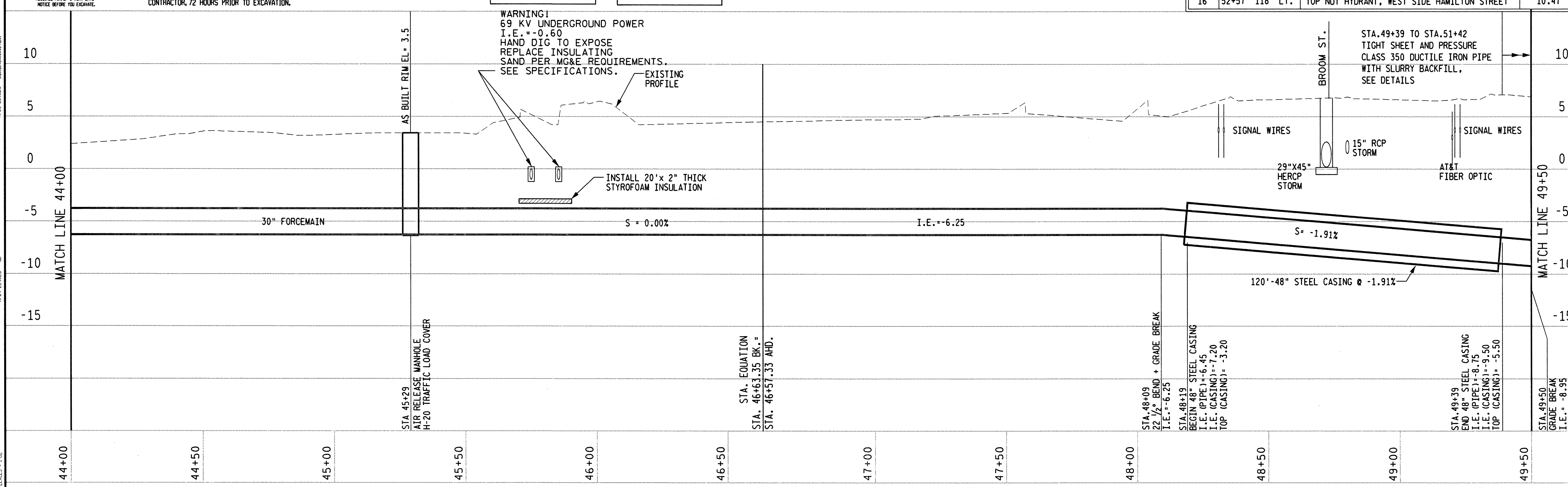
TO OBTAIN LOCATION OF PARTICIPANTS' UNDERGROUND FACILITIES BEFORE YOU DIG IN WISCONSIN

CALL DIGGERS HOTLINE
1-800-242-8511
TOLL FREE
FAX-A-LOCATE 1-800-338-3860
TDD (FOR HEARING IMPAIRED) 1-800-542-2289
WIS. STATUTE 182.0175 (1974) REQUIRES MIN. OF 3 WORK DAYS NOTICE BEFORE YOU EXCAVATE.

NOTE:
EXISTING UTILITIES SHOWN, IN PLAN & PROFILE, ARE INDICATED IN ACCORDANCE WITH AVAILABLE RECORDS. OTHER UTILITIES MAY ALSO BE PRESENT. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING EXACT LOCATIONS & ELEVATIONS OF ALL UTILITIES, INCLUDING SEWER AND WATER FROM THE OWNERS OF THE RESPECTIVE UTILITIES. ALL UTILITY OWNERS SHALL BE NOTIFIED BY THE CONTRACTOR, 72 HOURS PRIOR TO EXCAVATION.

BENCH MARK TABLE

NO.	STATION	DESCRIPTION	ELEV.
16	52+57 118' LT.	TOP NUT HYDRANT, WEST SIDE HAMILTON STREET	10.47



Designed by: EDH Checked by: REG Graphics by: EARTH TECH Project No.: 42990

NO	REVISIONS	DRN	CHK	DATE

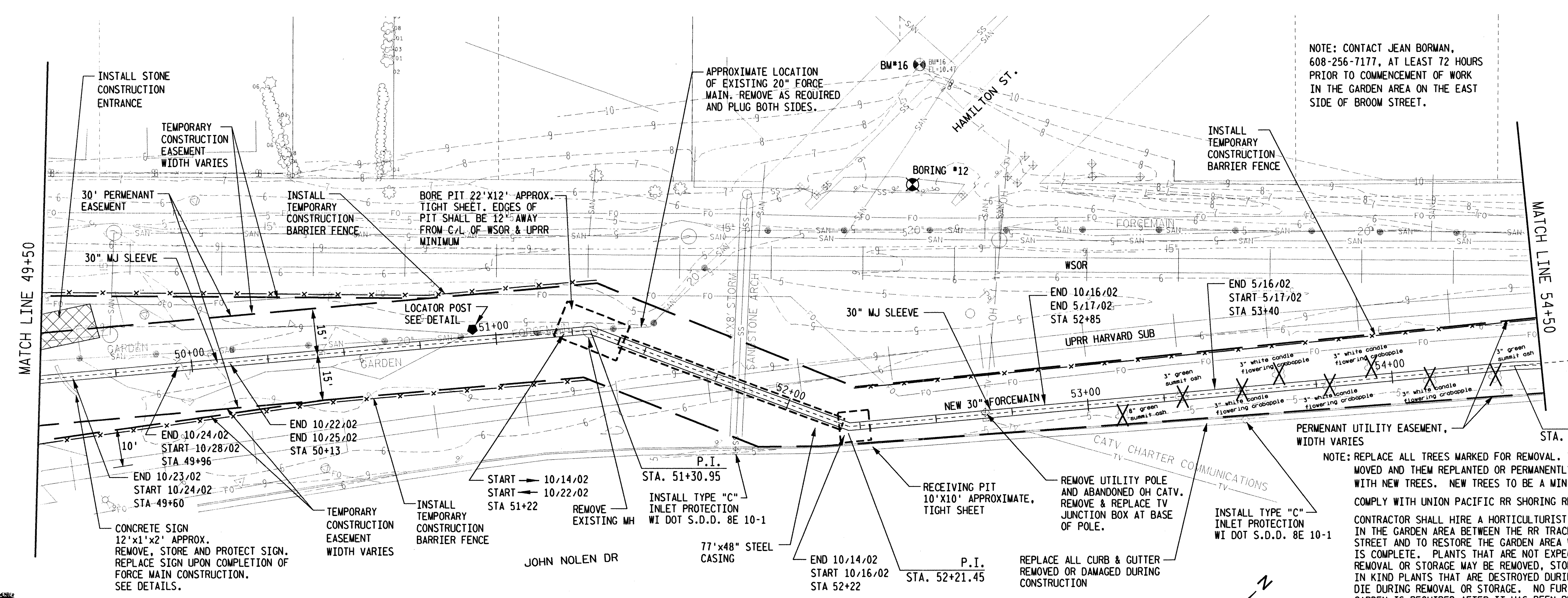
OFFICE NAME	
DRN	DBM
DES	EDH
CHK	REG
APP	

AS BUILT

CROSS TOWN FORCE MAIN REPLACEMENT

MADISON METROPOLITAN SEWERAGE DISTRICT

DATE	JANUARY, 2002
PROJECT NO	42990
FILENAME	M-12489
SHEET NO	19
DRAWING NO	42990pp9.dgn



NOTE: CONTACT JEAN BORMAN, 608-256-7177, AT LEAST 72 HOURS PRIOR TO COMMENCEMENT OF WORK IN THE GARDEN AREA ON THE EAST SIDE OF BROOM STREET.

NOTE: 19 TREES TOTAL WERE REMOVED ALONG JOHN NOLEN DRIVE. 12 WERE MOVED AND 7 WERE REPLACED.

NOTE: REPLACE ALL TREES MARKED FOR REMOVAL. TREES MAY BE TEMPORARILY MOVED AND THEM REPLANTED OR PERMANENTLY REMOVED AND REPLACED WITH NEW TREES. NEW TREES TO BE A MINIMUM 3-INCH DIAMETER.

COMPLY WITH UNION PACIFIC RR SHORING REQUIREMENTS. SEE DETAIL.

CONTRACTOR SHALL HIRE A HORTICULTURIST TO MAP AND CATALOG PLANTINGS IN THE GARDEN AREA BETWEEN THE RR TRACKS ON THE EAST SIDE OF BROOM STREET AND TO RESTORE THE GARDEN AREA WHEN FORCE MAIN CONSTRUCTION IS COMPLETE. PLANTS THAT ARE NOT EXPECTED TO DIE AS A RESULT OF REMOVAL OR STORAGE MAY BE REMOVED, STORED AND REPLANTED. REPLACE IN KIND PLANTS THAT ARE DESTROYED DURING CONSTRUCTION OR PLANTS THAT DIE DURING REMOVAL OR STORAGE. NO FURTHER MAINTENANCE OF THE GARDEN IS REQUIRED AFTER IT HAS BEEN RESTORED.

ALL DEWATERING OPERATIONS SHALL DISCHARGE TO A SEDIMENT BASIN PRIOR TO DISCHARGE TO A STORM SEWER OR SURFACE WATERS.

CALL DIGGERS HOTLINE 1-800-242-8511 TOLL FREE
FAX-A-LOCATE 1-800-338-3860
TDD (FOR HEARING IMPAIRED) 1-800-542-2289
WIS. STATUTE 182.0175 (1974) REQUIRES MIN. OF 3 WORK DAYS NOTICE BEFORE YOU EXCAVATE.

NOTE:
EXISTING UTILITIES SHOWN, IN PLAN & PROFILE, ARE INDICATED IN ACCORDANCE WITH AVAILABLE RECORDS. OTHER UTILITIES MAY ALSO BE PRESENT. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING EXACT LOCATIONS & ELEVATIONS OF ALL UTILITIES, INCLUDING SEWER AND WATER FROM THE OWNERS OF THE RESPECTIVE UTILITIES. ALL UTILITY OWNERS SHALL BE NOTIFIED BY THE CONTRACTOR, 72 HOURS PRIOR TO EXCAVATION.

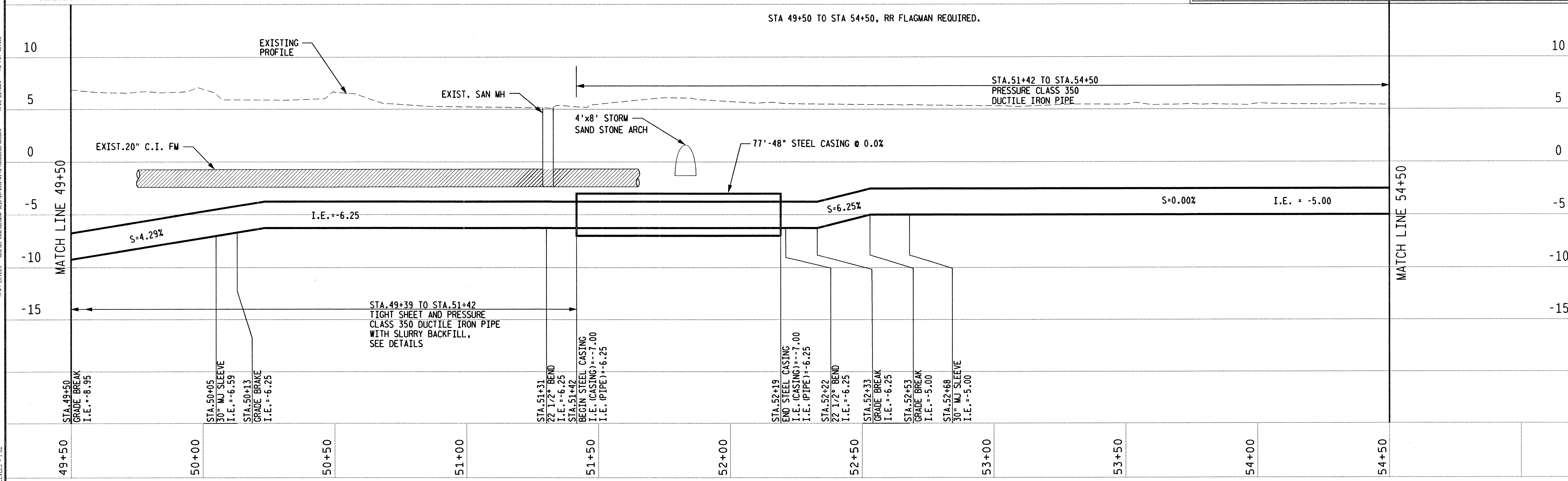
P.I. STA	NORTHING	EASTING	△ ANGLE
51+30.95	390,226.71	2,164,517.43	25.40°
52+21.45	390,263.93	2,164,599.92	25.48°
54+40.14	390,430.84	2,164,741.22	3.38°

SCALE 0' 10' 20' 40'

BENCH MARK TABLE

NO.	STATION	DESCRIPTION	ELEV.
16	52+57 118' LT.	TOP NUT HYDRANT, WEST SIDE HAMILTON STREET	10.47

STA 49+50 TO STA 54+50, RR FLAGMAN REQUIRED.



Designed by: EDH Checked by: REG Graphics by: EARTH TECH Project No.: 42990

NO	REVISIONS	DATE	DRN	CHK

OFFICE	NAME
DRN	DBM
DES	EDH
CHK	REG
APP	

AS BUILT

CROSS TOWN FORCE MAIN REPLACEMENT

MADISON METROPOLITAN SEWERAGE DISTRICT

DATE	JANUARY, 2002
PROJECT NO	42990
FILENAME	M-12488
SHEET NO	20
DRAWING NO	42990pp10.dgn

CITY OF MADISON
INTERDEPARTMENTAL
CORRESPONDENCE

TO: Ray Fisher, City Clerk

FROM: Jeff Ekola, Real Estate Agent

DATE: December 9, 2005

SUBJECT: Permanent Limited Easement
Cross Town Force Main Sanitary Sewer
Project No. 7159

Transmitted for your file is a copy of the original recorded Permanent Limited Easement from the City of Madison to the Madison Metropolitan Sewerage District pertaining to the above-stated project.

The Permanent Limited Easement is dated July 15, 2005 and was recorded with the Dane County Register of Deeds on October 24, 2005, as Document No. 4124010.

Resolution No. 59136, ID No. 31069, adopted by the Common Council of the City of Madison on February 19, 2002, authorized the above.

Attachment

c: City Assessor's Office (w/attachment)
Risk Management, Attn.: Kevin Houlihan
City Engineering Division, Attn.: Eric Pederson (w/attachment)
City Engineering Division, Attn.: Randy Wiesner (w/attachment)
City Parks, Attn.: Si Widstsrand (w/attachment)
City Transportation, Attn.: Dan McCormick (w/attachment)
Madison Metropolitan Sewerage District,
Attn.: Bruce Borelli (original already sent)

PERMANENT LIMITED EASEMENT
CROSS TOWN FORCE MAIN
SANITARY SEWER

DANE COUNTY
REGISTER OF DEEDS

DOCUMENT #
4124818

10/24/2005 10:33AM

Trans. Fee:
Exempt #:

Rec. Fee: 67.00
Pages: 29

000591

THIS SPACE RESERVED FOR RECORDING DATA

RETURN TO: City of Madison
CEDU – Real Estate Section
P.O. Box 2983
Madison, WI 53701-2983

Tax Parcel No.
Numerous. See attached Exhibit A

The **City of Madison**, a Wisconsin municipal corporation (the "City") being the owner of the property hereinafter described, in consideration of the sum of One Dollar ($1.00) and other valuable consideration, the receipt whereof is hereby acknowledged, grants and conveys to the **Madison Metropolitan Sewerage District**, a Wisconsin municipal corporation ("MMSD"), a non-exclusive, permanent, limited easement (the "Easement") for the purpose of the cross-town force main sanitary sewer replacement project, including the right of ingress and egress and the right to excavate, install, operate, maintain, repair, replace and modify an underground, sanitary sewer force main and related facilities and improvements, in the parcels of land described and depicted in the attached Exhibits A through M (the "Easement Areas"), together with a temporary easement for construction purposes hereinafter referred to as the temporary limited easement (the "TLE"), in the parcels of land described and depicted in the attached Exhibits A through M (the "TLE Areas").

The Easement is subject to the following terms and conditions:

1. The Project. By Resolution No. 59136, ID No. 31069, adopted February 19, 2002, the Common Council of the City of Madison approved granting a non-exclusive, permanent, limited easement to MMSD to improve, construct, replace and relocate a replacement underground sanitary sewer force main and related facilities and improvements, including Pumping Station No. 2, in City-owned lands (that portion of Brittingham Park located in Section 23, T07N-R09E, and the former railroad right of way acquired by the City in the quit claim deeds recorded as Document No's. 2265621 and 2265622) and City-managed lands (filled land between the original shoreline of Lake Monona and the Dock Line in Sections 23 and 24, T07N-R09E, as determined and depicted in the Plat of Survey filed with Dane County Department of Planning and Development, Land Records, as File No. 93-0350, Large Maps; said Plat of Survey is made part of this Easement and incorporated herein by reference), hereinafter collectively referred to as the "City Lands". The original force main was constructed in 1914 without any easements of record. The force main's Pumping Station 2 easement area recorded in Volume 383, Page 70, as Document No. 1059123, Dane County Registry, is redescribed in Exhibit B attached. What is authorized by the resolution is hereinafter collectively referred to as the "Project," and the equipment and improvements, including those retained and those replaced, are hereinafter referred to as the "Facilities".

2. Construction, Restoration, Repair and Maintenance.

   a. The work of construction, repair and maintenance of the Facilities shall be done by MMSD at the sole expense of MMSD. The work shall be completed in a good and professional manner. MMSD shall be responsible for following all applicable ordinances, codes, statutes, and laws, and obtaining all permits required for any construction, repair or maintenance activity.

   b. After completion of any work on the Facilities, or as soon thereafter as the weather reasonably permits, MMSD, at its expense, shall promptly restore the area affected by the work in a manner and condition satisfactory to the City of Madison Superintendent of Parks or the Superintendent's designee; said required restoration shall be reasonable.

   c. Following the installation of the Facilities and completion of the Project, no grade change shall be made to the Easement Area without the written consent of the City and MMSD.

   d. No buildings, structures or improvements unrelated to the Facilities or the Project shall be constructed in the Easement Area without the written consent of the City of Madison Superintendent of Parks and MMSD.

   e. MMSD shall not use the Easement Area for permanent open storage or parking of equipment or vehicles of any kind.

Madison

29/67

f. Initial construction of the Facilities shall not commence without the prior written approval of applicable plans and specifications by the City. Access to City Lands shall be maintained throughout the construction period.

3. Expiration of the TLE's. The TLE's shall expire after completion of construction of the Project, but not later than December 31, 2005.

4. Reservation of Use by the City. The City reserves the right to use and occupy the Easement Area in a manner consistent with the rights conveyed herein and with respect to the placement and use of the improvements authorized by the Project, provided that such use and occupancy shall not interfere with or disturb the installation, operation, maintenance, repair, replacement and/or modification of the Facilities. Such use by the City shall include, but is not limited to, paved pathways for pedestrian and bicycle use, placement of park recreational equipment, and public transportation projects.

5. Landscaping and Pavement. After completion of the Project, except for the portions of the Easement Area that are paved, the surface of the Easement Area shall have a vegetative cover approved by the City of Madison Superintendent of Parks. Plantings, landscaping, surface vegetation or topsoil within or outside the Easement Area that are destroyed or damaged by MMSD during repair, maintenance or reconstruction shall be replaced and/or restored by MMSD at MMSD's expense. Pavement and sub base destroyed or damaged by MMSD during repair, maintenance or reconstruction, shall be replaced and/or restored by MMSD at MMSD's expense. All replacement and restoration shall be done to the satisfaction and approval of the City of Madison Superintendent of Parks or the Superintendent's designee. Such approval shall not be unreasonably withheld.

6. Compliance. The City and MMSD shall comply with all applicable laws, including, but not limited to, any laws, standards, regulations, or permit requirements relating to environmental pollution or contamination or to occupational health and safety. MMSD agrees that the Easement shall not be used for purposes not related to the function and operation of the force main and the pumping station.

7. Notice of Entry. Except for emergencies, routine maintenance and repairs and normal use of the Facilities, MMSD shall give the City at least thirty (30) days written notice before entering upon the Easement Areas for construction purposes or for the purpose of performing significant alteration to or removal of the Facilities.

8. Authorized Agent. The City of Madison Superintendent of Parks, or the Superintendent's designee, is hereby designated as the official representative of the City for the enforcement of all provisions of this Easement, with authority to administer this Easement lawfully on behalf of the City.

9. Notices. All notices to be given under the terms of this Easement shall be signed by the person sending the same, and shall be sent by certified mail, return receipt requested and postage prepaid, to the address of the parties specified below:

Notices for the City

Superintendent of Parks
Parks Division, Dept. of Public Works
Madison Municipal Building, Room 120
215 Martin Luther King Jr.
P. O. Box 2987
Madison, WI 53701-2987

Notices for MMSD

Madison Metropolitan Sewerage District
Project Engineer
1610 Moorland Road
Madison, WI 53713-3398

Any party hereto may, by giving five (5) days written notice to the other party in the manner herein stated, designate any other address in substitution of the address shown above to which notices shall be given.

10. Term. This Easement shall continue for so long as the Facilities are in use. In the event and to the extent that the Facilities shall be removed or abandoned, then this Easement shall terminate and MMSD will execute and deliver to the City such document(s) as may be requested for the purpose of further evidencing the termination of the rights granted hereby.

11. Termination. In the event MMSD defaults in the performance of any term or condition of this Easement and fails to remedy such default within thirty (30) days after written notice from the City, the City shall have the right, at its sole option, to declare this Easement void and terminate the same. Notwithstanding the foregoing, if such default is not a health or safety violation and cannot, because of the nature of the default, be cured within said thirty (30) days, then MMSD shall be deemed to be complying with such notice if, promptly upon receipt of such notice, MMSD immediately takes steps to cure the default as soon as reasonably possible and proceeds thereafter continuously with due diligence to cure the default within a period of time which, under all prevailing circumstances, shall be reasonable.

Madison

12. Indemnification. MMSD shall be liable to and hereby agrees to indemnify, defend and hold harmless the City, and its officers, officials, agents, and employees, against all loss or expense (including liability costs and attorney's fees) by reason of any claim or suit, or of liability imposed by law upon the City or its officials, officers, agents or employees for damages because of bodily injury, including death at any time resulting therefrom, sustained by any person or persons, or on account of damages to property, including loss of use thereof, arising from, in connection with, caused by or resulting from the acts or omissions of MMSD and/or its officials, officers, agents, employees, assigns, guests, invitees, or subcontractors, in the performance of this Easement, whether caused by or contributed to by the negligent acts of the City, its officers, officials, agents, and employees.

13. Amendment. This Easement may not be amended, modified, terminated, or released without the written consent of all the parties hereto, or their respective successors-in-interest.

14. Applicable Law. This Easement shall be construed in accordance with the laws of the State of Wisconsin.

15. Severability. If any term or provision of this Easement is held to be invalid or unenforceable by a court of competent jurisdiction, then such holding shall not affect any of the remaining terms and provisions of this Easement and the same shall continue to be effective to the fullest extent permitted by law.

16. Public Record. This Easement shall be recorded at the office of the Dane County Register of Deeds.

17. Binding Effect. The rights and easement granted herein shall be deemed to be covenants running with the land and shall inure to the benefit of and shall be binding upon the parties hereto and their respective successors and assigns.

Dated this 15th day of July, 2005.

CITY OF MADISON

By: [signature]
David J. Cieslewicz, Mayor

By: [signature]
Ray Fisher, City Clerk

State of Wisconsin)
)ss.
County of Dane)

Personally came before me this 15th day of July, 2005, the above-named David J. Cieslewicz, Mayor of the City of Madison, acting in said capacity and known by me to be the person who executed the foregoing instrument and acknowledged the same.

Linda L. Lewis
Linda L. Lewis
Print or type name
Notary Public, State of Wisconsin
My Commission: exp. 8/24/08

State of Wisconsin)
)ss.
County of Dane)

Personally came before me this 15th day of July, 2005, the above-named Ray Fisher, City Clerk of the City of Madison, acting in said capacity and known by me to be the person who executed the foregoing instrument and acknowledged the same.

Nancy L. Kowalewsky
Nancy L. Kowalewsky
Print or type name
Notary Public, State of Wisconsin
My Commission: 1/11/09

Madison

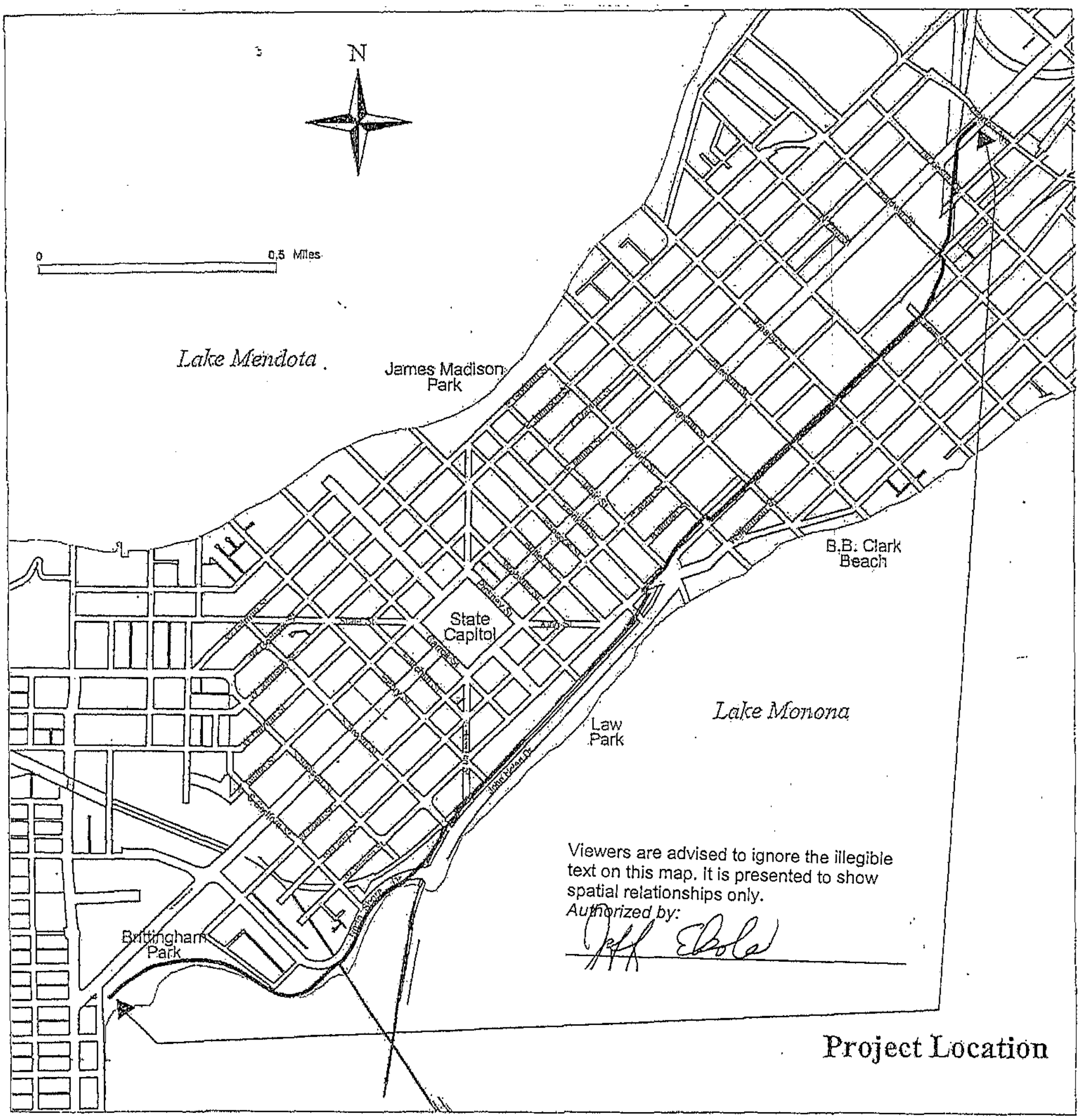
Drafted by the City of Madison Real Estate Section — Real Estate Project No. 7159
Execution of this easement by the City of Madison is authorized by Resolution No. 59136, ID No. 31069, adopted February 19, 2002.

EXHIBIT "A"

000594

PROJECT LOCATION MAP

Madison Metropolitan Sewerage District
Crosstown Forcemain Replacement



The Project is located in Brittingham Park along the north shore of Monona Bay, in Brittingham Park along the east side of North Shore Drive, along the north side of John Nolen Drive, in the east rail corridor bike path (East Wilson Street ROW), in former Soo Line Railroad properties now owned by the City of Madison, and in East Washington Avenue (State Hwy 151) all in the City of Madison. The Project lies within the S ½ and the NE ¼ of Section 23, the NW ¼ of Section 24, and the S ½ and the NE ¼ of Section 13, T7N, R9E; and within the NW ¼ of Section 7, T7N, R10E. City of Madison, Dane County, Wisconsin.

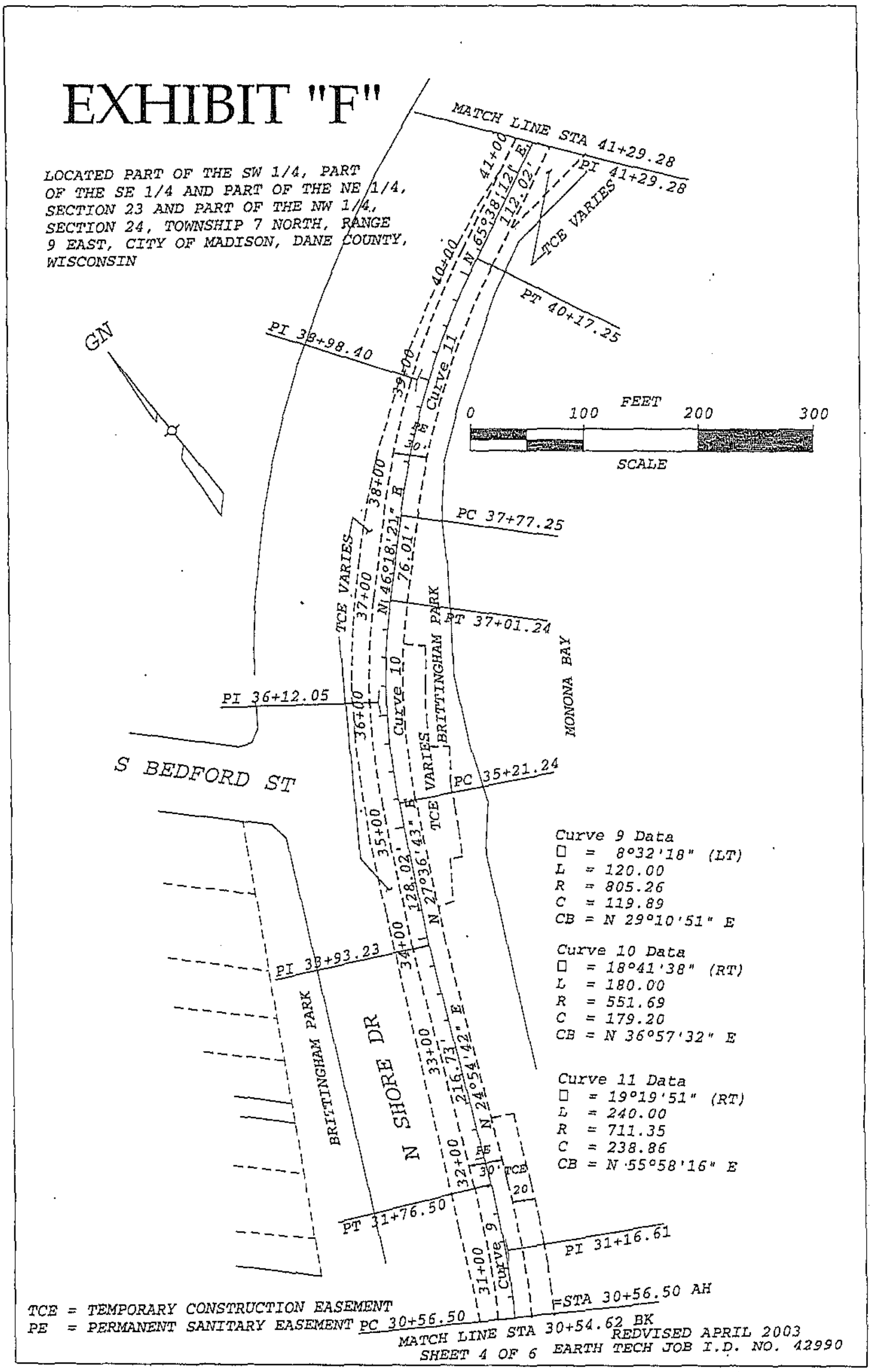
Tax Parcel Numbers

251-0709-131-0103-9	251-0709-234-0101-5
251-0709-131-2304-1	251-0709-242-1301-3
251-0709-131-2309-1	251-0710-072-1104-9
251-0709-133-3802-0	251-0710-072-2604-8
251-0709-231-2901-3	251-0710-072-2705-4
251-0709-233-1105-8	

Note: The Temporary Construction Easements, or Temporary Limited Easements, (TCE or TLE) have a varying width where the legal descriptions of the Permanent Easements are centerline descriptions. Therefore refer to the Exhibit Maps "C" – "H" to see the depictions of the TCE of TLE Areas.

Viewers are advised to ignore the illegible text on this map. It is presented to show spatial relationships only. Authorized by: ______________________________

000599

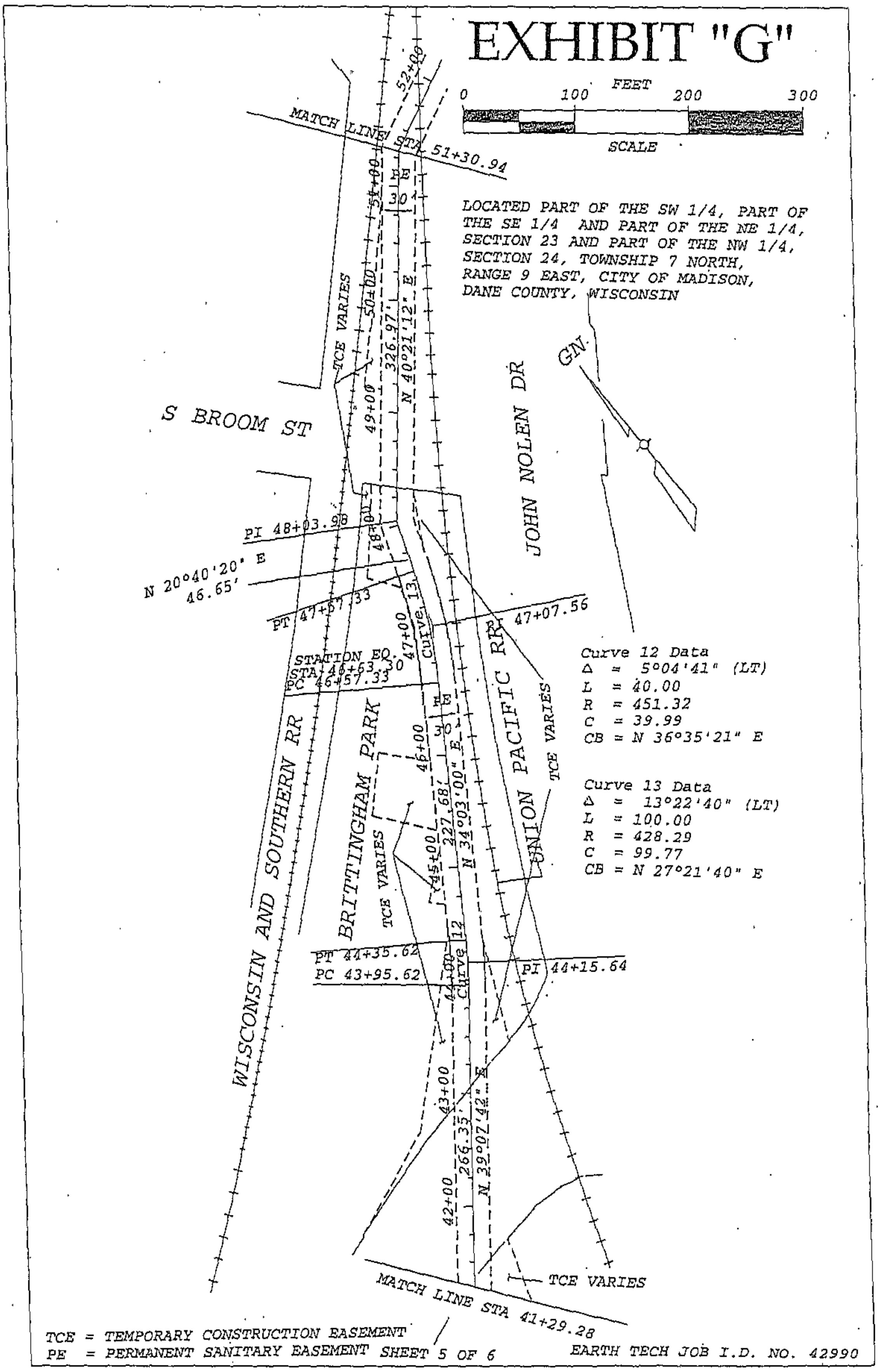


Viewers are advised to ignore the illegible text on this map. It is presented to show spatial relationships only.

Authorized by:

[signature]

000600



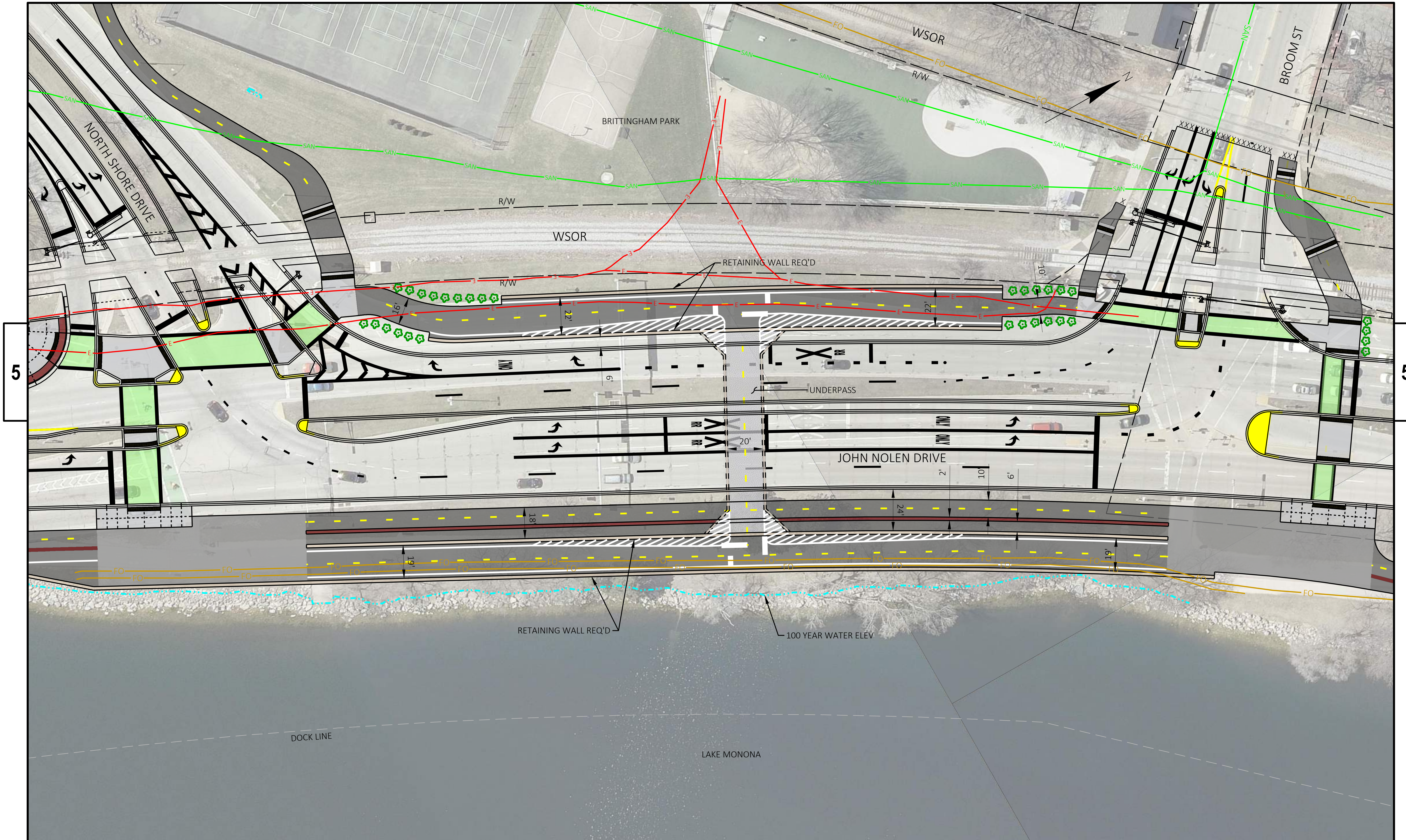
Viewers are advised to ignore the illegible text on this map. It is presented to show spatial relationships only.

Authorized by:

Jeff Ekola

APPENDIX G

Alternative 1A (H Concept)



PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ALTERNATIVE 1A (H CONCEPT)	SHEET	E

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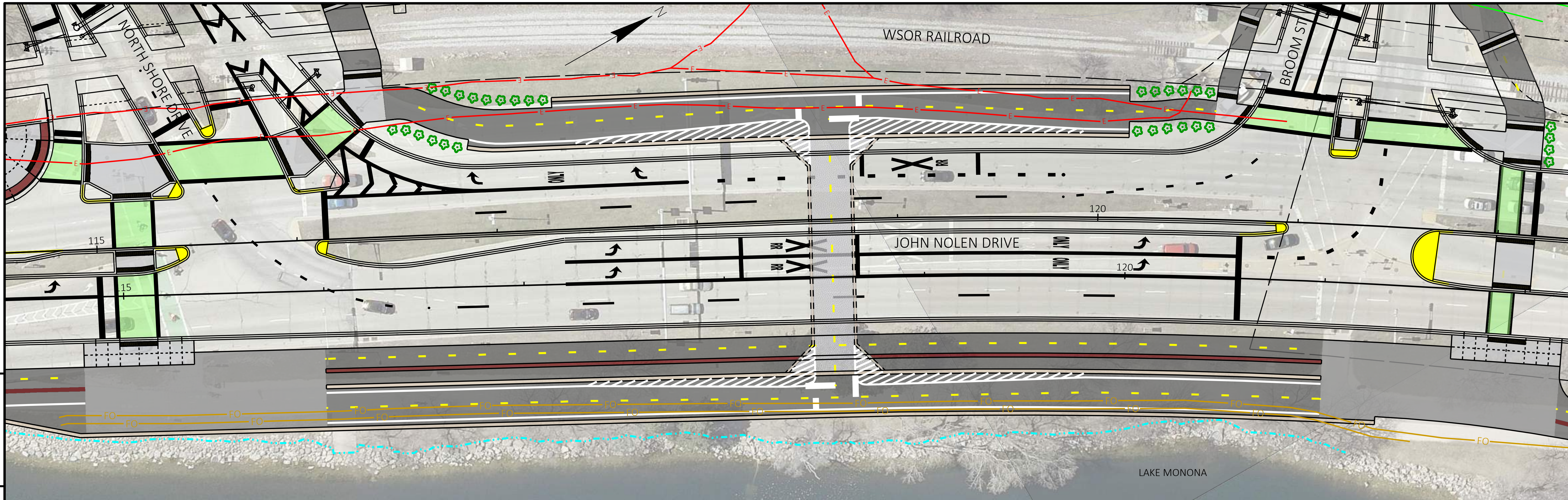
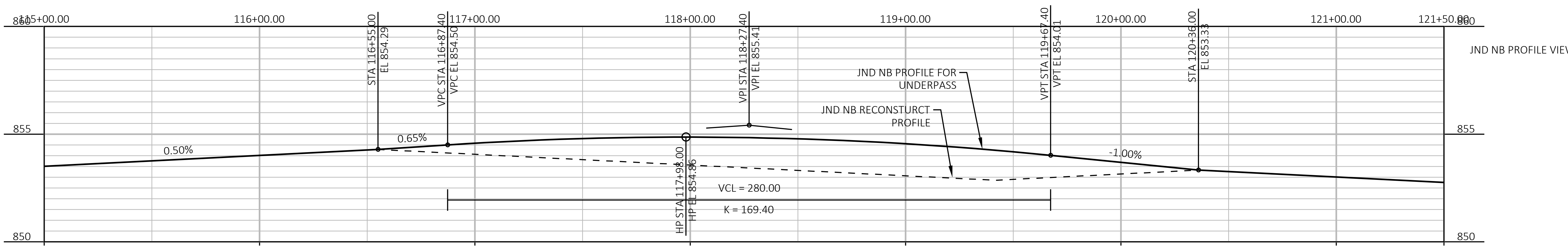
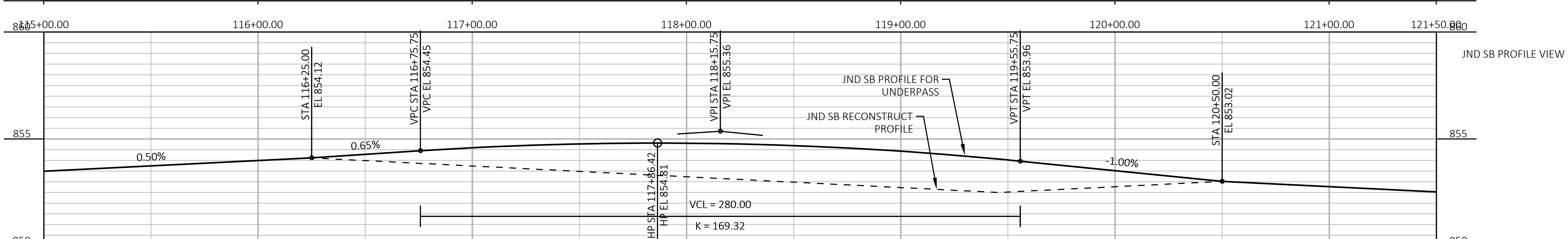
LAYOUT NAME - OVERVIEW
PLOT DATE : 4/24/2024 9:09 AM
PLOT BY : DAN RYAN
PLOT NAME :
PLOT SCALE : ##########
WISDOT/CADDS SHEET 44

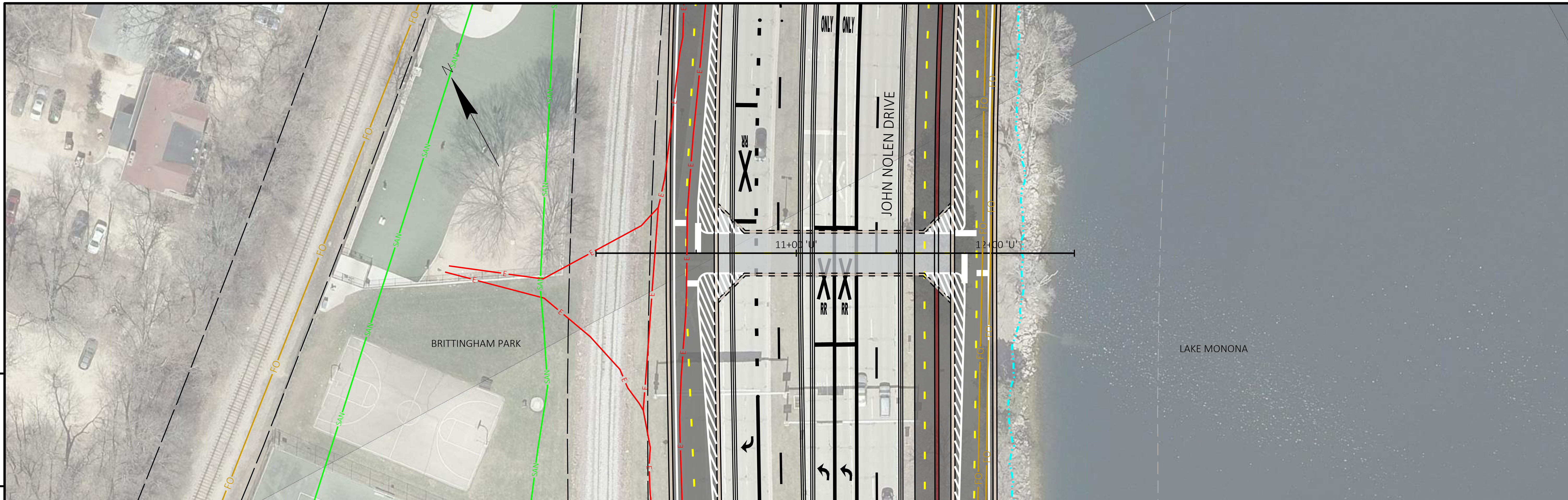


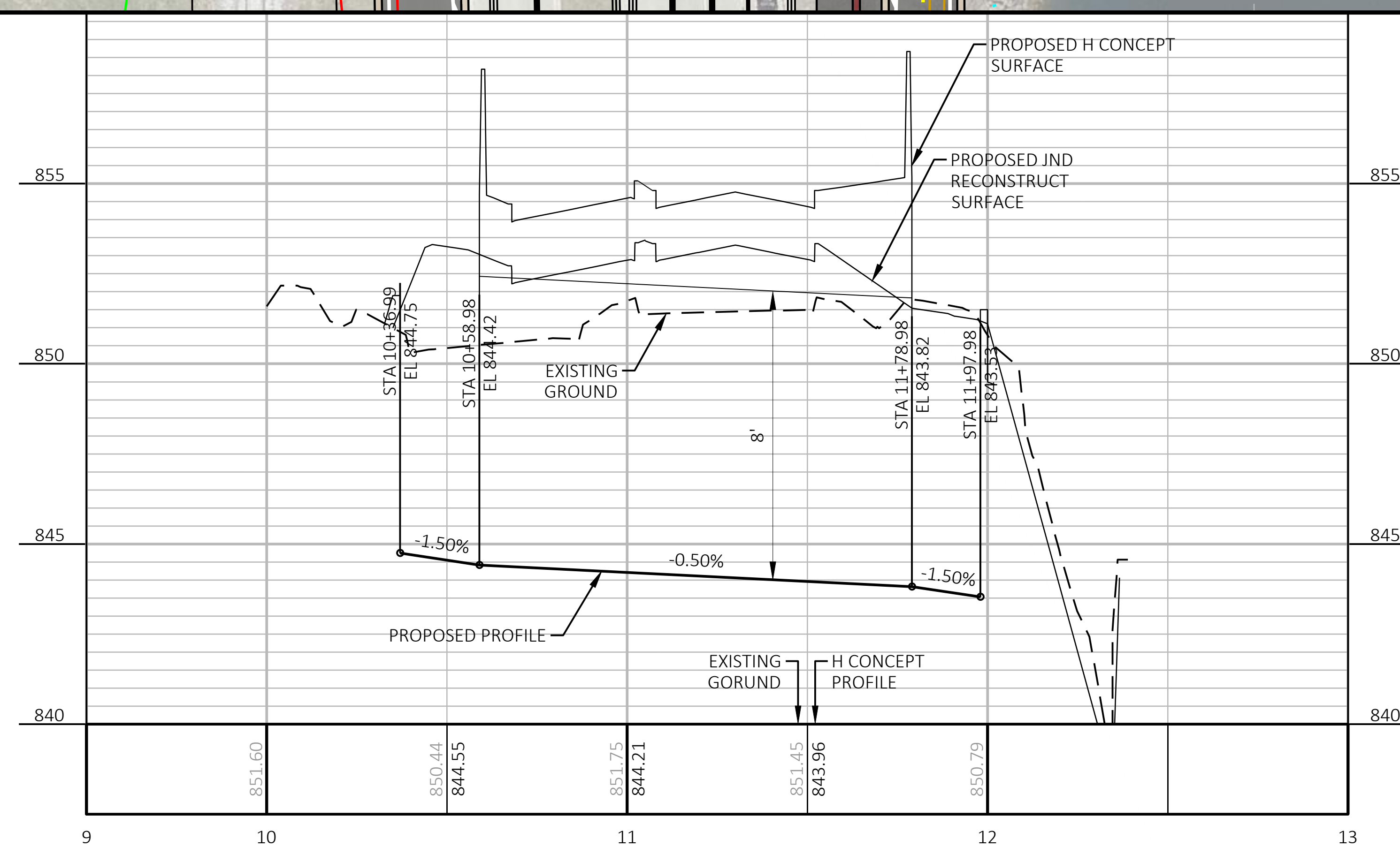




PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ALTERNATIVE 1A (H CONCEPT)	SHEET E

FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\ALIPROFS\KL_ALI_UNDERPASS-COLOR COPY.DWG PLOT DATE : 4/25/2024 9:13 AM PLOT BY : DAN RYAN PLOT NAME : PLOT SCALE : 1 IN:50 FT
LAYOUT NAME - JND

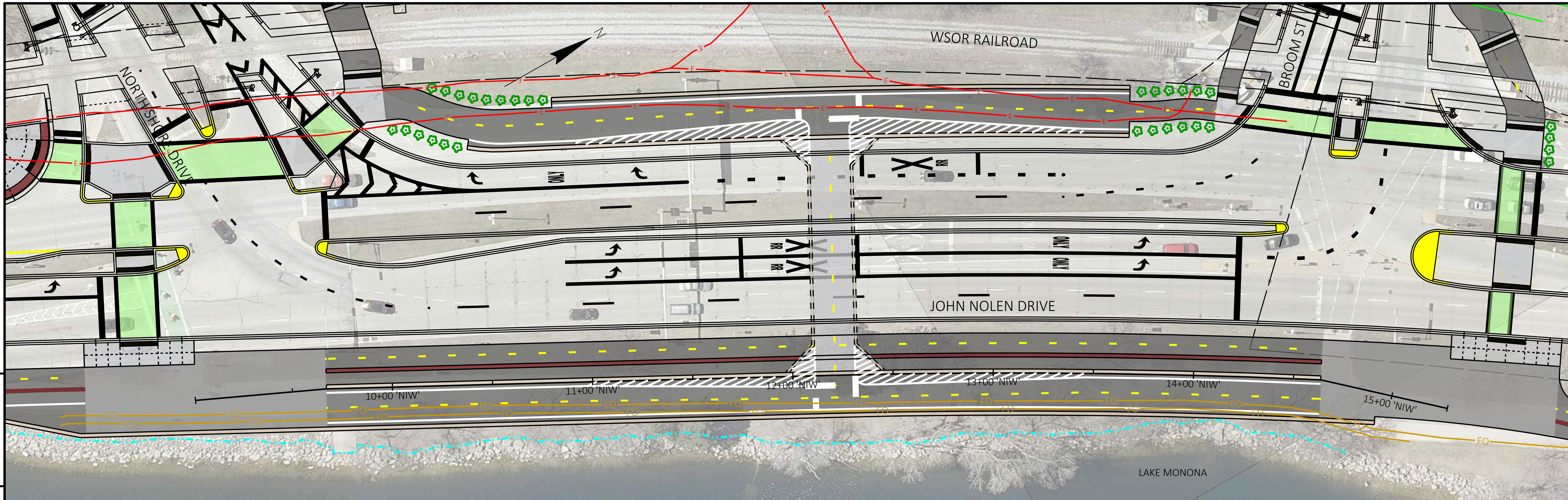




PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ALTERNATIVE 1A (H CONCEPT)	SHEET	E

FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\ALIPROFS\KL_ALI_UNDERPASS-COLOR COPY.DWG
LAYOUT NAME - UNDERPASS
PLOT DATE : 4/25/2024 9:38 AM
PLOT BY : DAN RYAN
PLOT NAME :
PLOT SCALE : 1 IN:50 FT
WISDOT/CADDS SHEET 44

5



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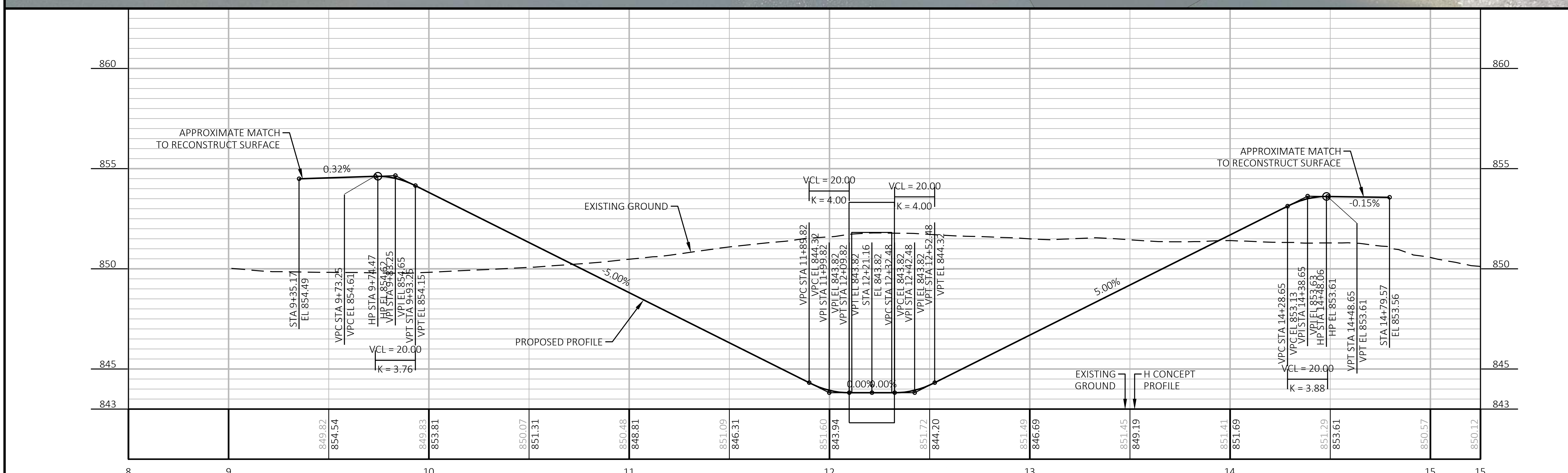
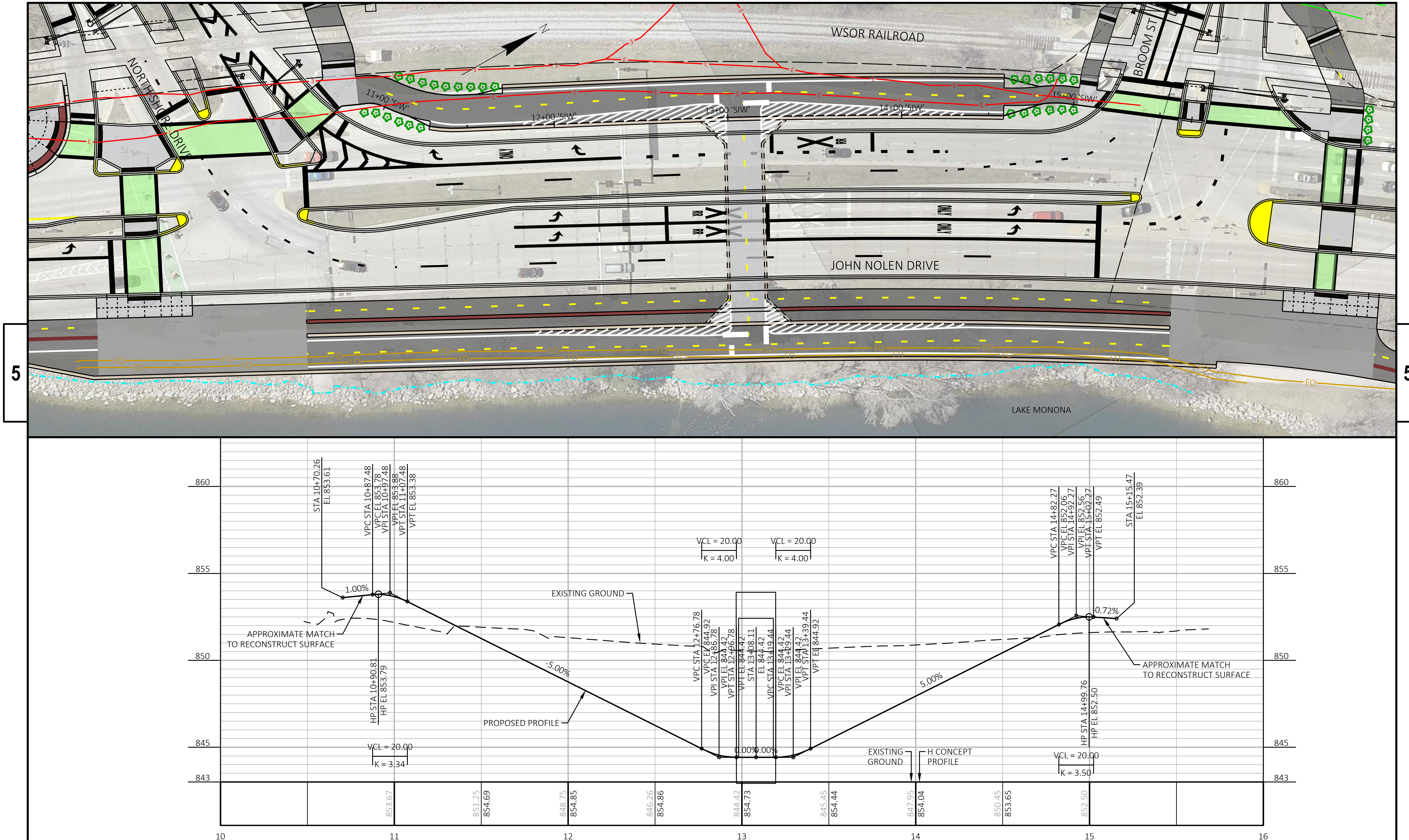


PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ALTERNATIVE 1A (H CONCEPT) - NB SIDE APPROACH	SHEET	E



PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ALTERNATIVE 1A (H CONCEPT) - SB SIDE APPROACH	SHEET	E

FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\ALIPROFS\KL_ALI_UNDERPASS-COLOR COPY.DWG
LAYOUT NAME - SB
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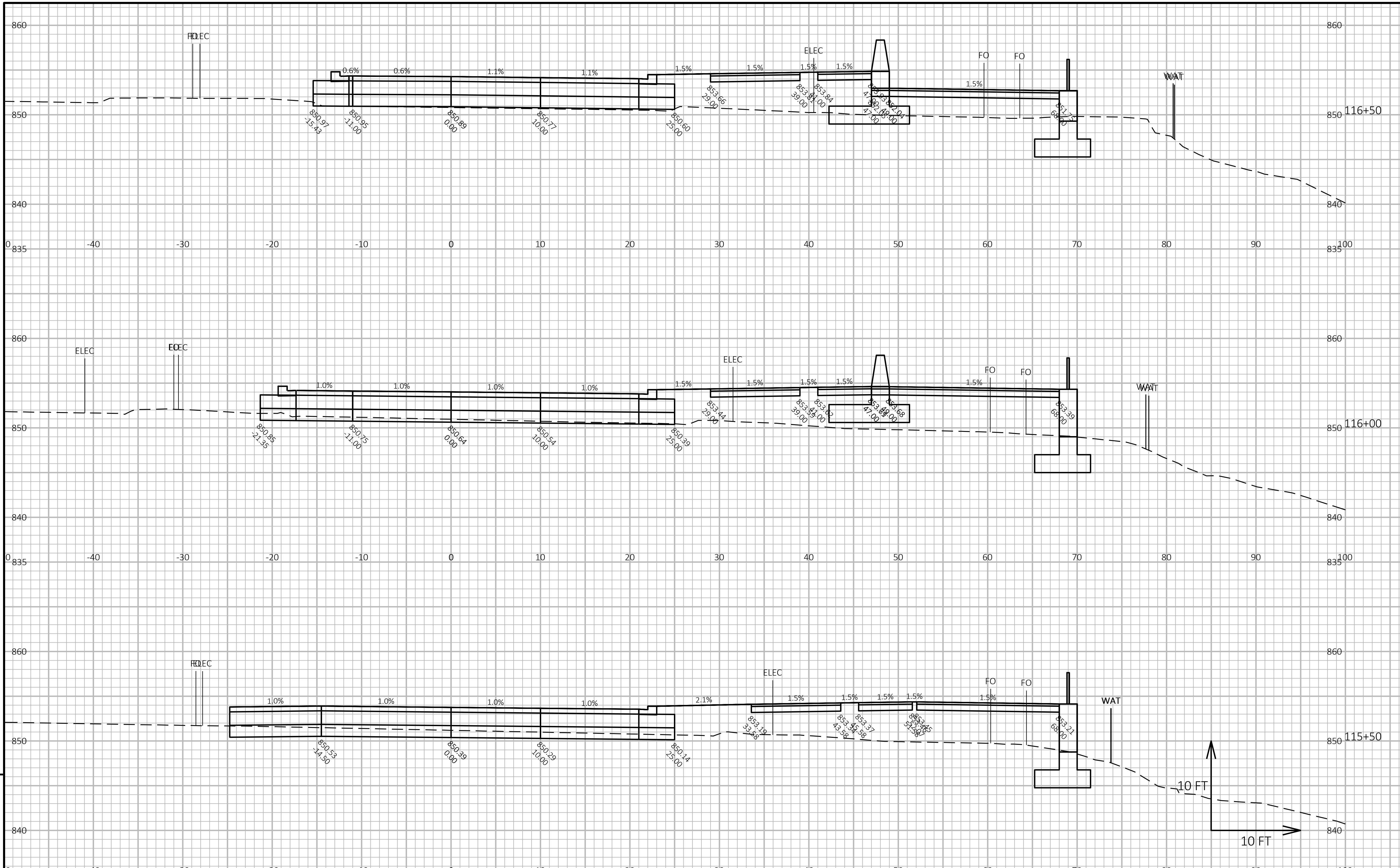
PLOT NAME :
PLOT SCALE : 1 IN:50 FT
WISDOT/CADDS SHEET 44



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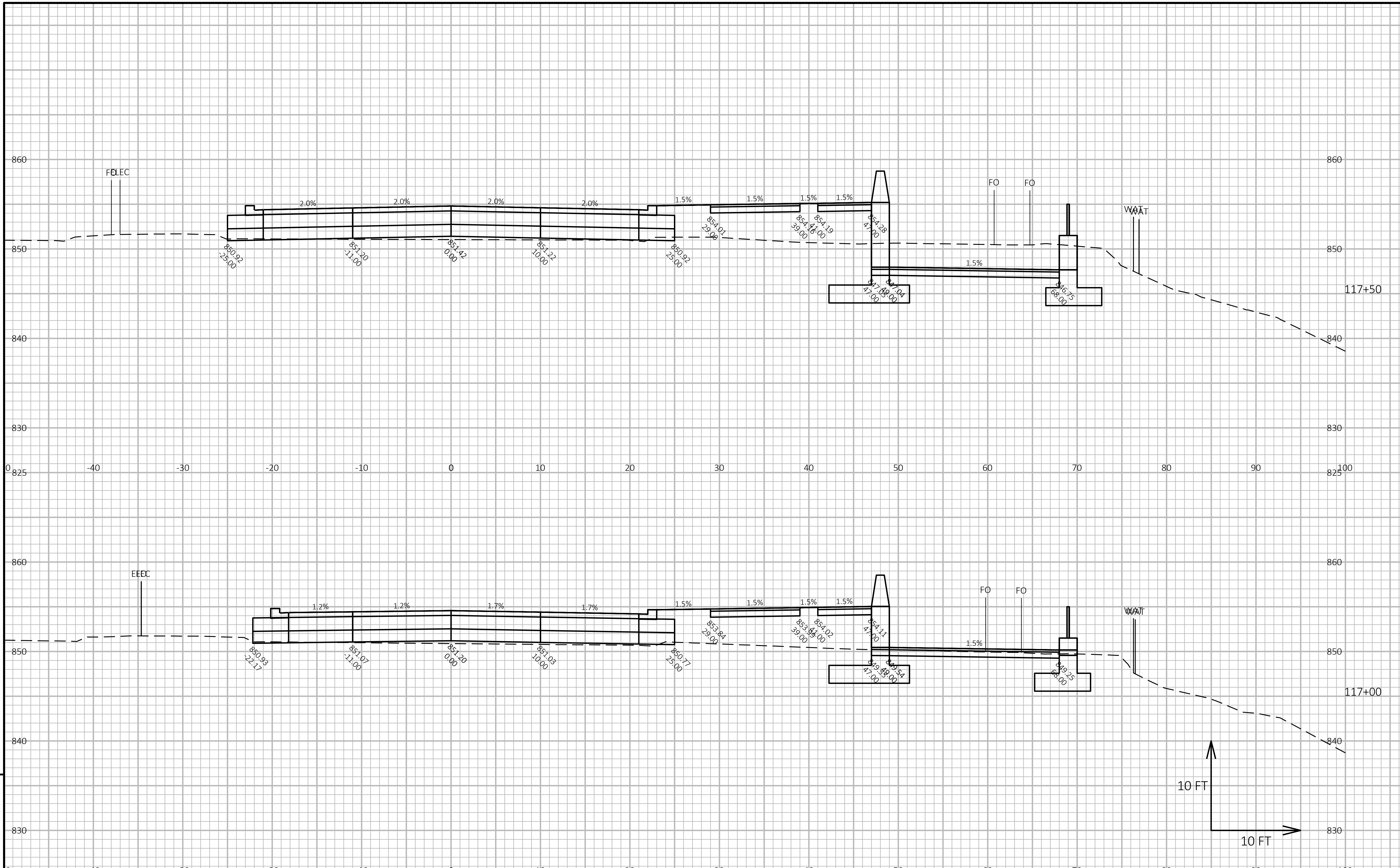
PROJECT NO: 5992-11-21	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: UNDERPASS OPTION JOHN NOLEN DRIVE NB	SHEET	E



PROJECT NO: 5992-11-21	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: UNDERPASS OPTION JOHN NOLEN DRIVE NB	SHEET	E

9

FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\CORRIDORS\PAVEMENTCORRIDORS\CRDR-JND_UNDERPASS.DWG
LAYOUT NAME - 02
PLOT DATE : 3/25/2024 8:33 AM
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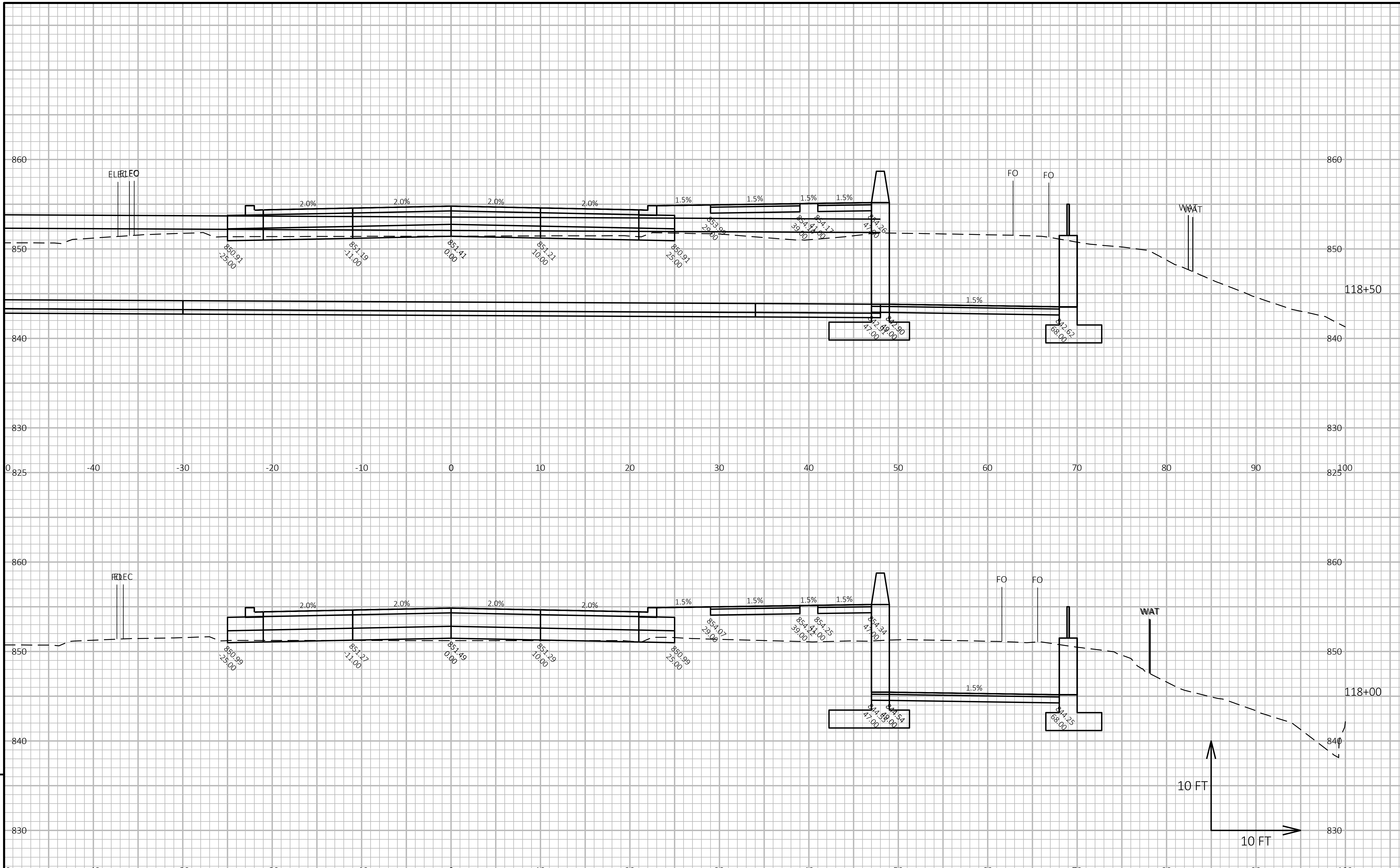
PLOT NAME :
PLOT SCALE : 1 IN:10 FT HORZ. / 1 IN:10 FT VERT.
WISDOT/CADDS SHEET 49



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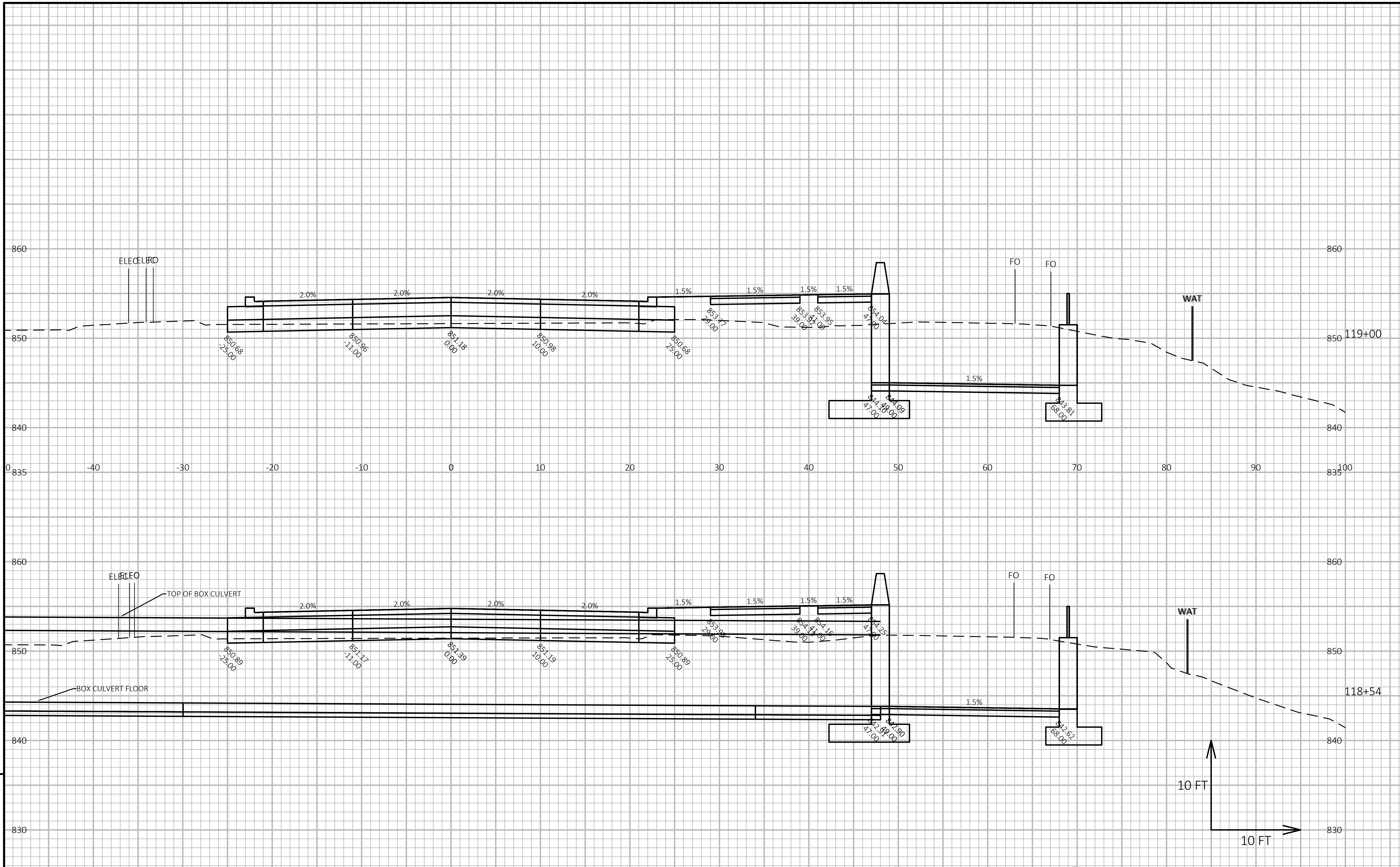
9

PROJECT NO: 5992-11-21	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: UNDERPASS OPTION JOHN NOLEN DRIVE NB	SHEET	E

FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\CORRIDORS\PAVEMENTCORRIDORS\CRDR-JND_UNDERPASS.DWG
LAYOUT NAME - 03
PLOT DATE : 3/25/2024 8:33 AM
PLOT BY : BRIAN ST. VINCENT
PLOT NAME :
PLOT SCALE : 1 IN:10 FT HORZ. / 1 IN:10 FT VERT.
WISDOT/CADDS SHEET 49



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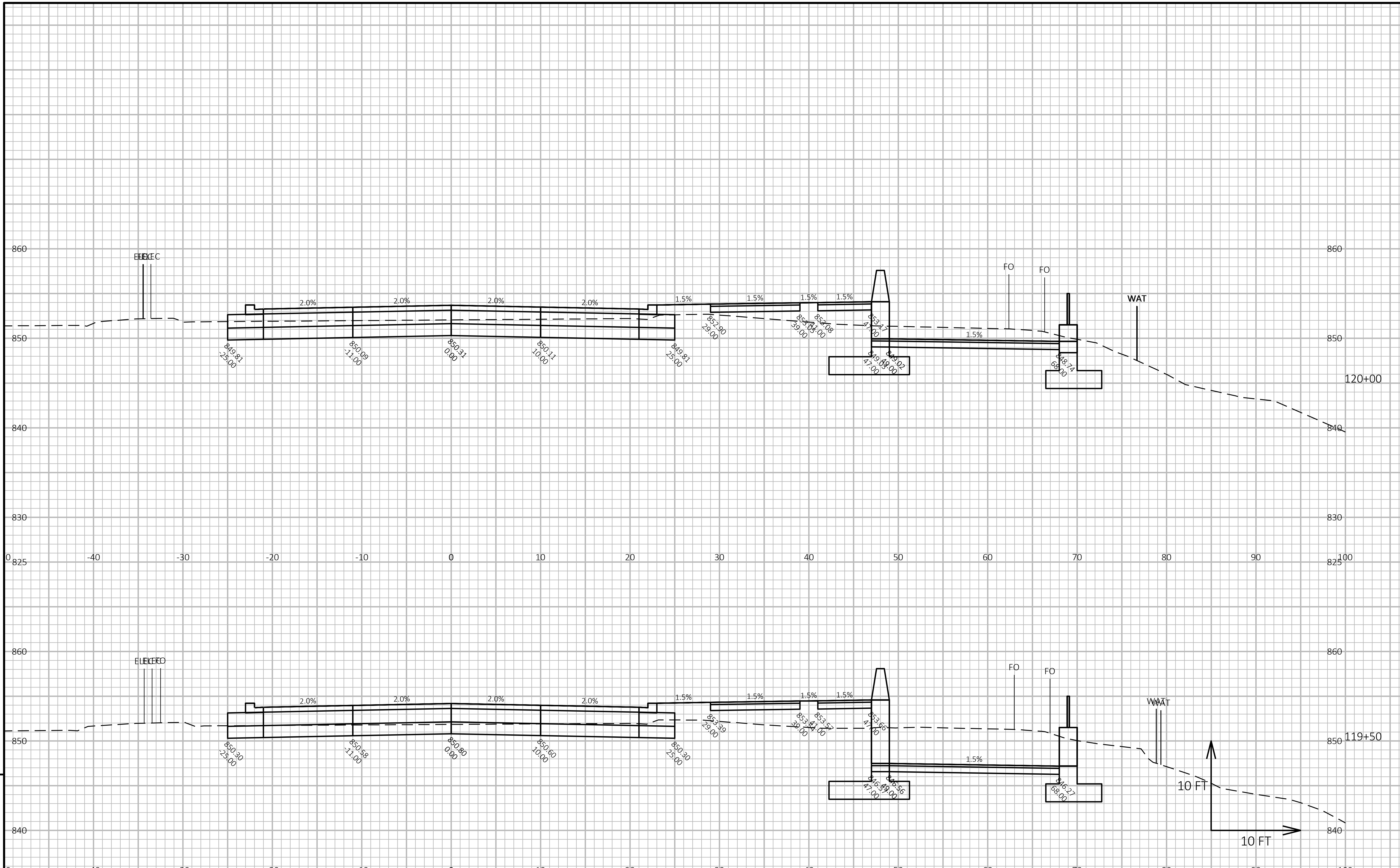
PROJECT NO: 5992-11-21	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: UNDERPASS OPTION JOHN NOLEN DRIVE NB	SHEET	E



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9

PROJECT NO: 5992-11-XX	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: UNDERPASS OPTION JOHN NOLEN DRIVE NB	SHEET	E

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LAYOUT NAME - 04 (2)
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PLOT NAME :
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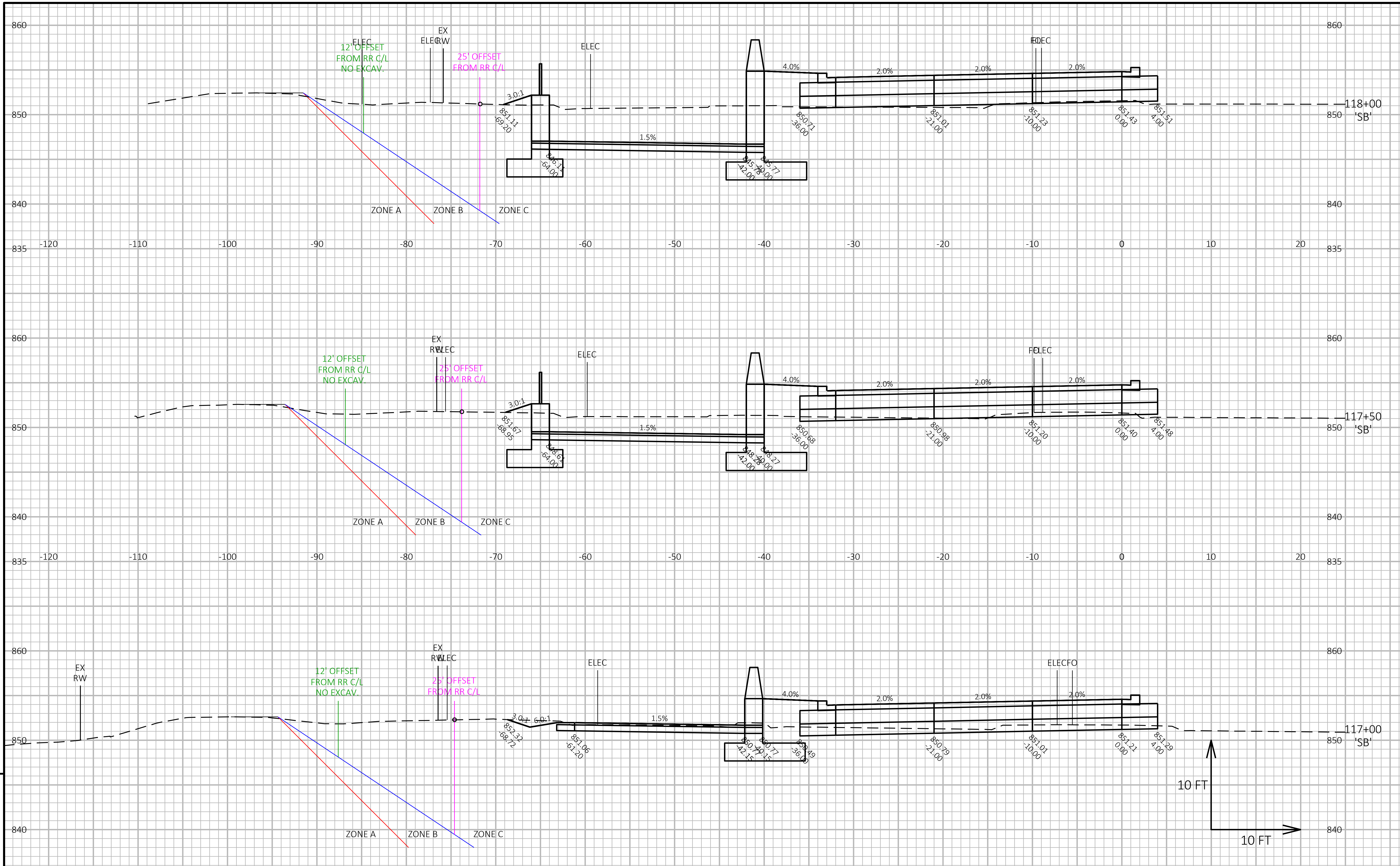

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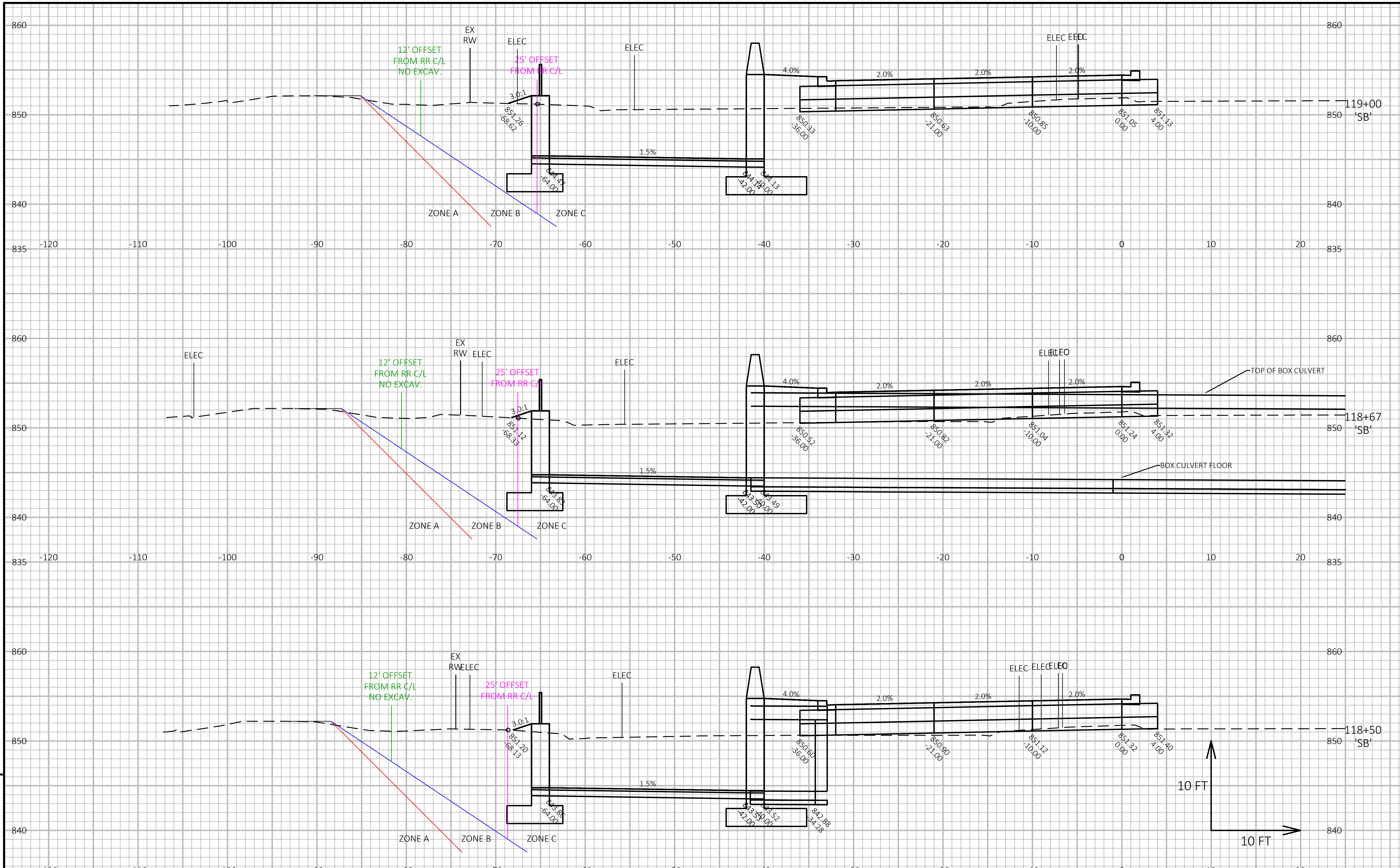
PROJECT NO: 5992-11-21	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: UNDERPASS OPTION JOHN NOLEN DRIVE SB	SHEET	E



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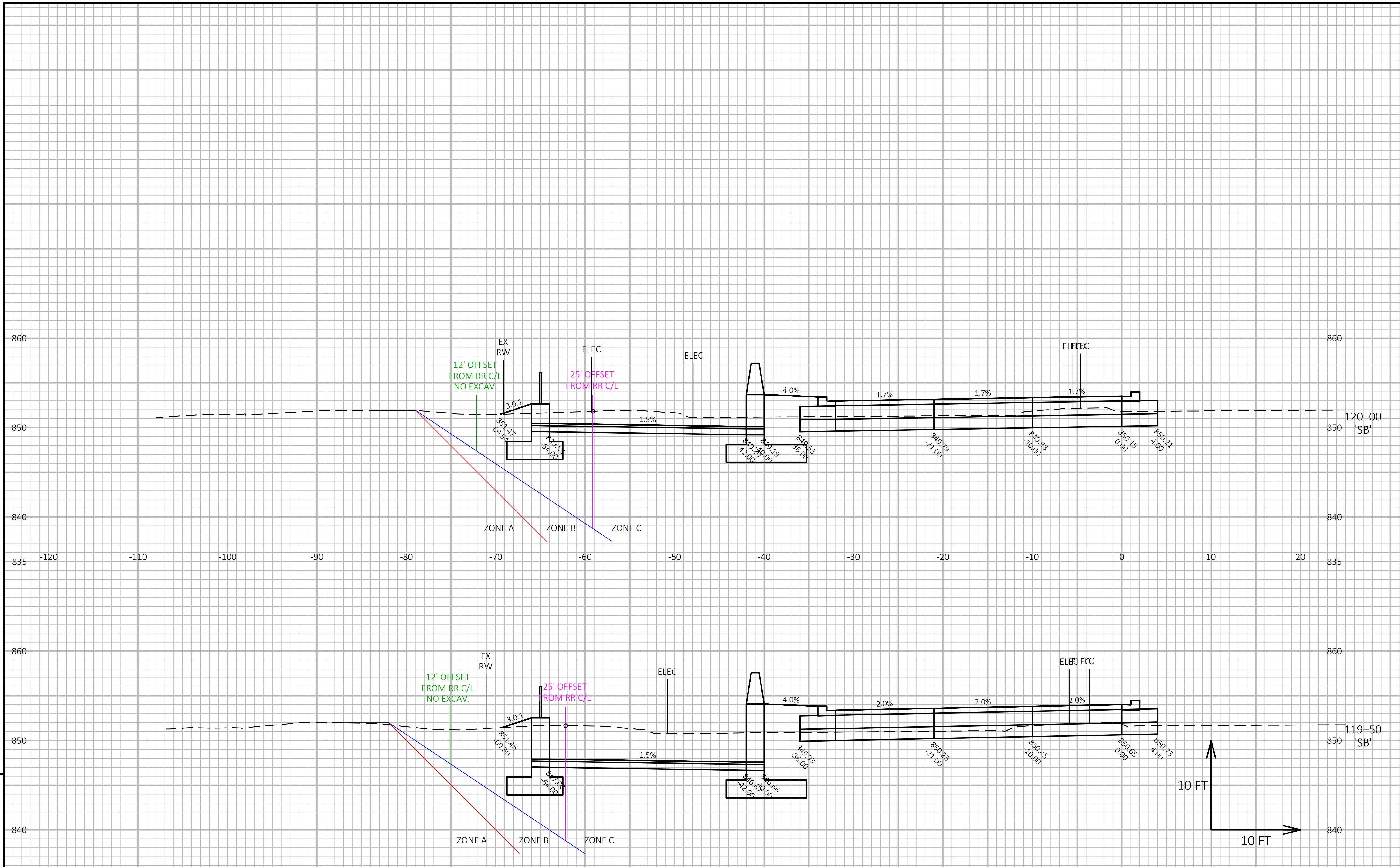
PROJECT NO: 5992-11-21	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: UNDERPASS OPTION JOHN NOLEN DRIVE SB	SHEET	E

FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\CORRIDORS\PAVEMENTCORRIDORS\CRDR-JND_UNDERPASS.DWG
LAYOUT NAME - 06
PLOT DATE : 3/25/2024 8:33 AM
PLOT BY : BRIAN ST. VINCENT
PLOT NAME :
PLOT SCALE : 1 IN:10 FT HORZ. / 1 IN:10 FT VERT.
WISDOT/CADDS SHEET 49

9



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PROJECT NO: 5992-11-21	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: UNDERPASS OPTION JOHN NOLEN DRIVE SB	SHEET	E

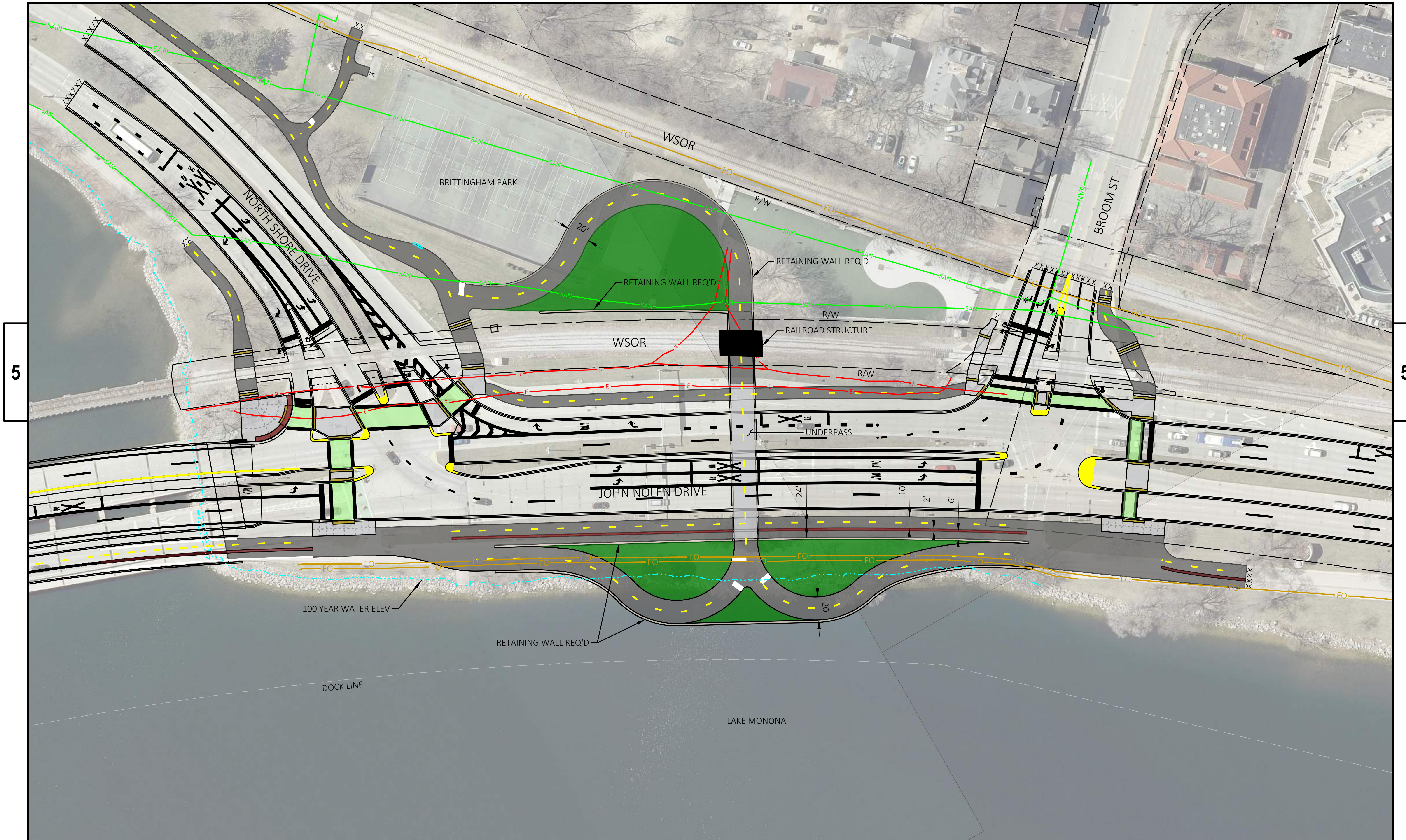
FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\CORRIDORS\PAVEMENTCORRIDORS\CRDR-JND_UNDERPASS.DWG
LAYOUT NAME - 07
PLOT DATE : 3/25/2024 8:34 AM PLOT BY : BRIAN ST. VINCENT PLOT NAME : PLOT SCALE : 1 IN:10 FT HORZ. / 1 IN:10 FT VERT.

WISDOT/CADDS SHEET 49

Alternative 1A (H-Concept) Renderings

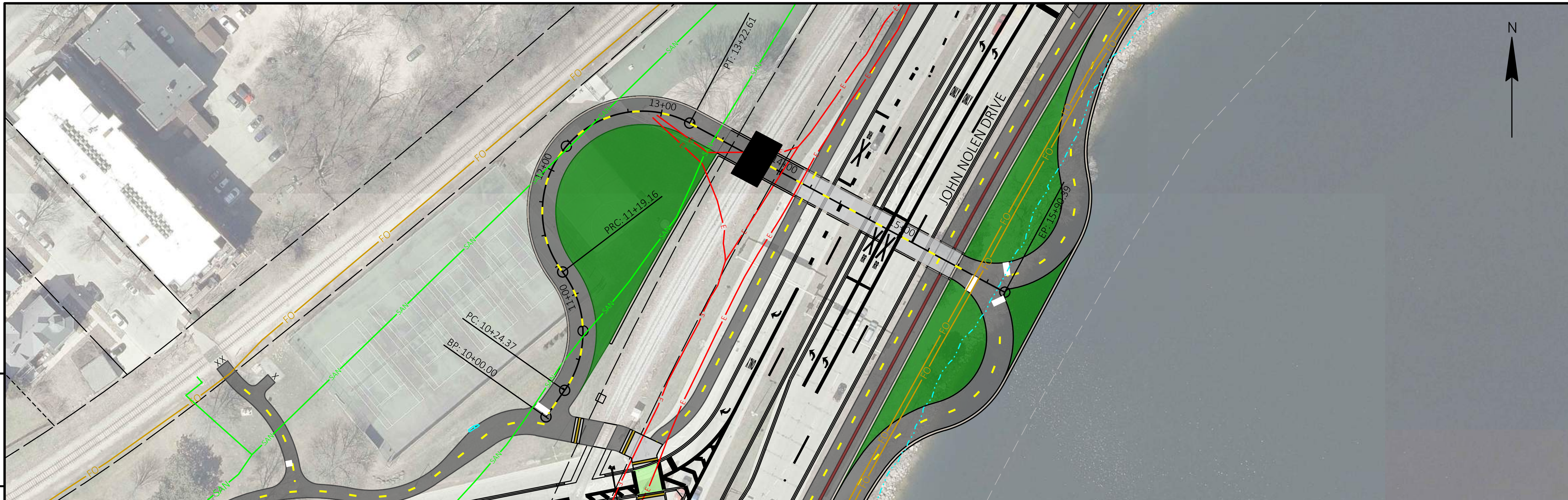
APPENDIX H

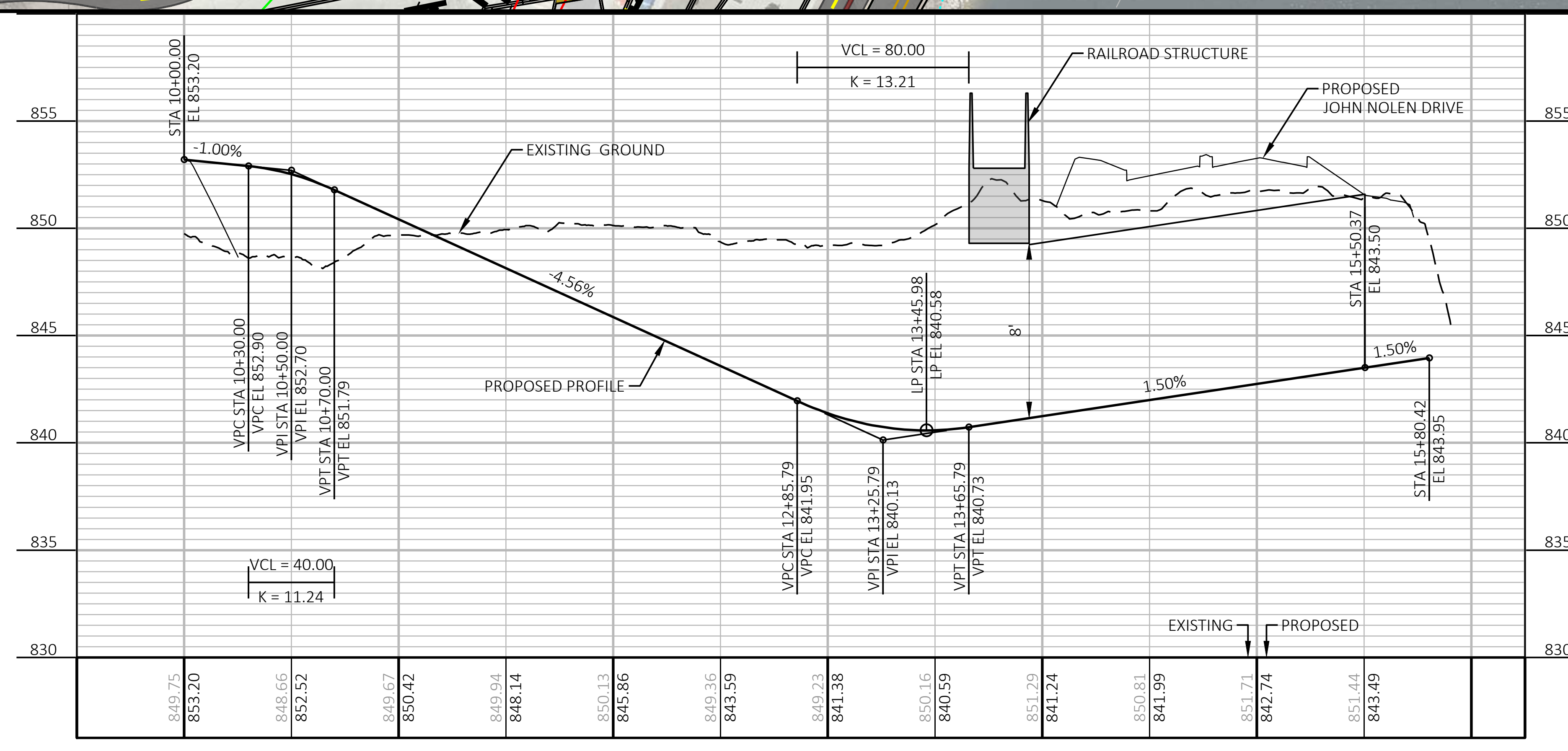
Alternative 2A (J Concept)



PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ALTERNATIVE 2A (J CONCEPT)	SHEET E

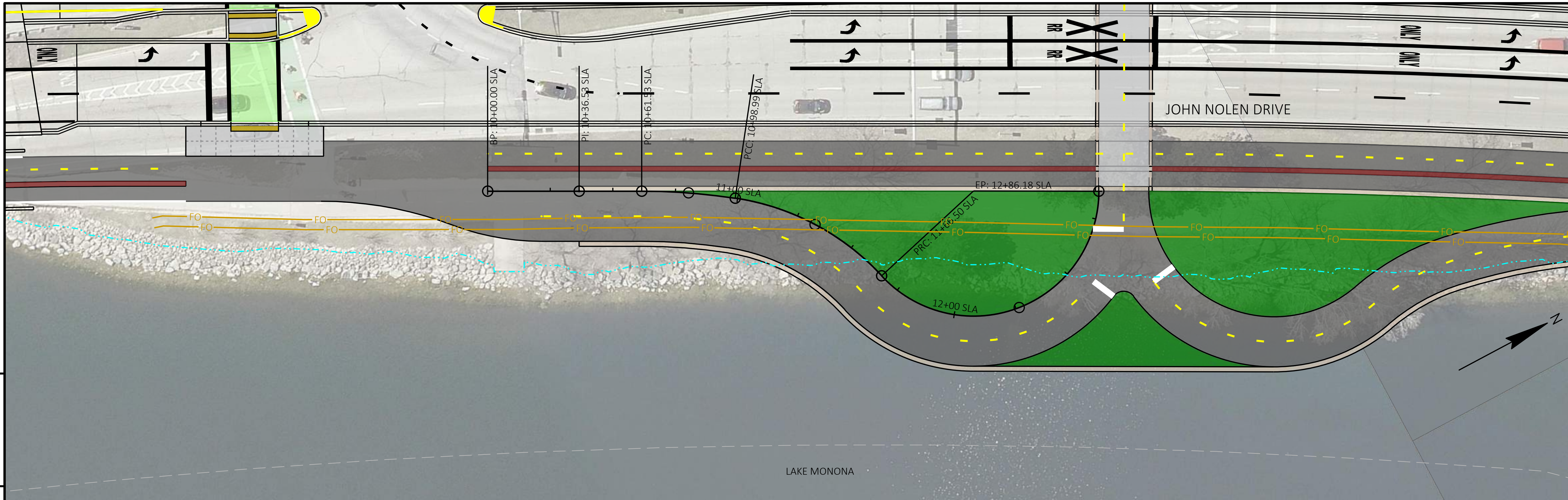
FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\EDGELINES\UNDERPASS\PAVT_UNDERPASS_J CONCEPT_PREFERRED_PATH ALT.DWG
LAYOUT NAME - OVERVIEW
PLOT DATE : 4/24/2024 9:10 AM PLOT BY : DAN RYAN PLOT NAME : PLOT SCALE : ##########
WISDOT/CADDS SHEET 44

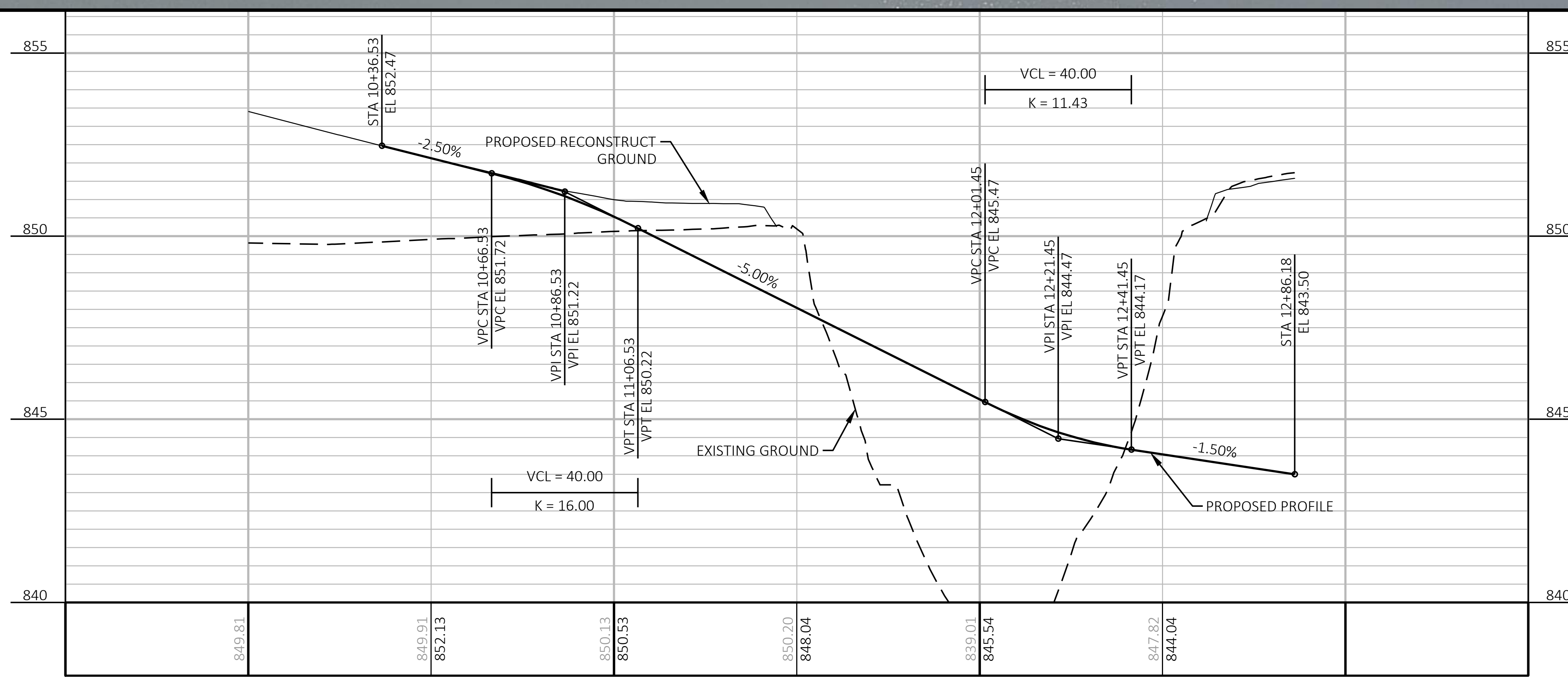




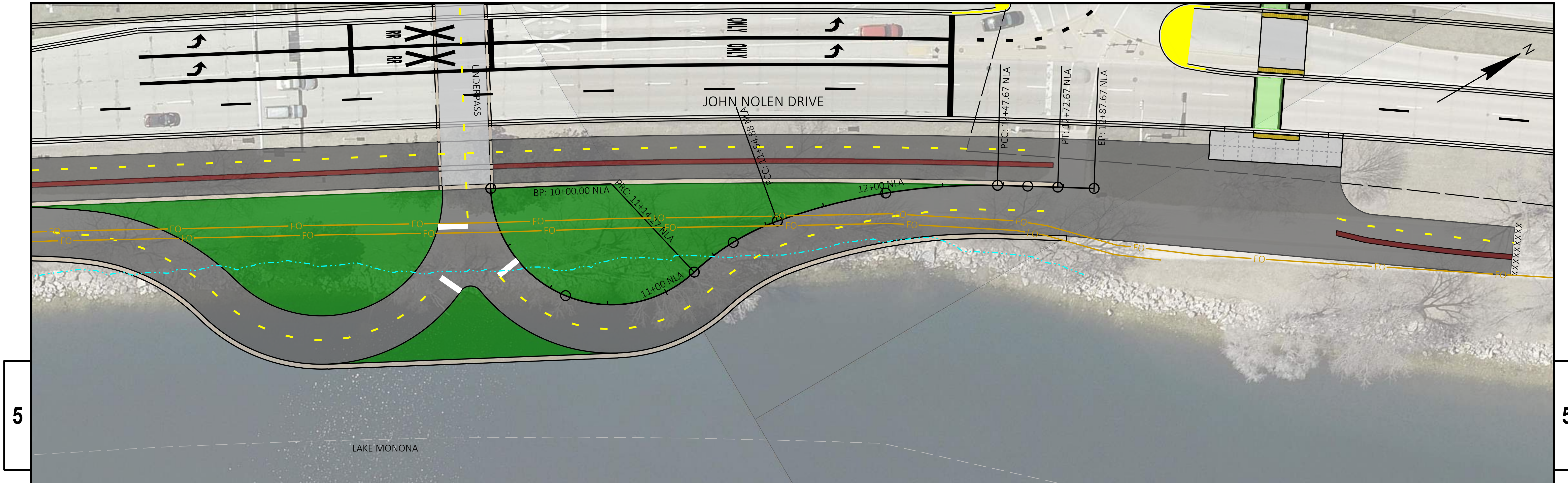
PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ALTERNATIVE 2A (J CONCEPT)	SHEET	E

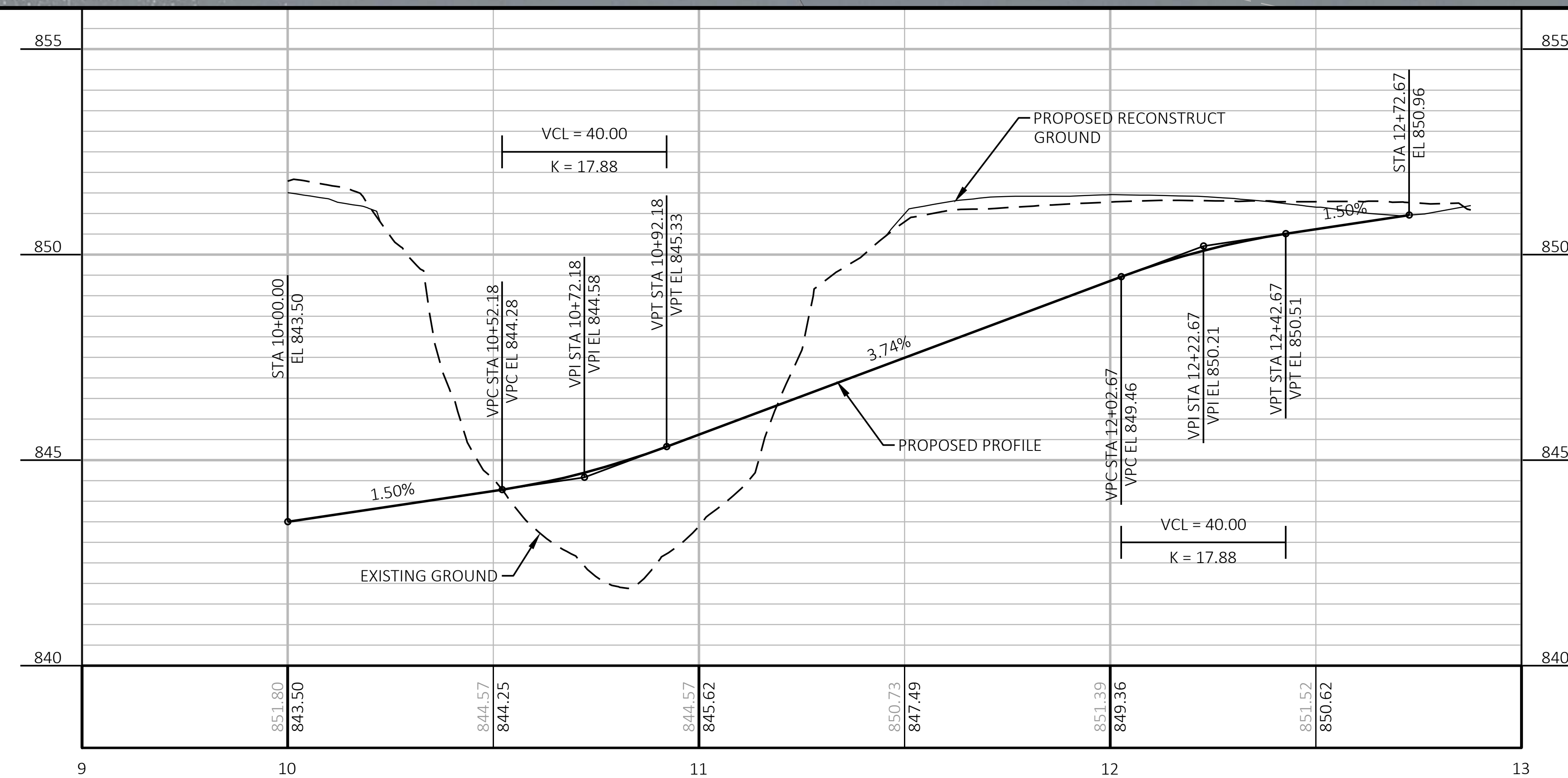
FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\EDGELINES\UNDERPASS\PAVT_UNDERPASS_J CONCEPT_PREFERRED_PATH ALT.DWG
LAYOUT NAME - J Concept - Tunnel
PLOT DATE : 4/24/2024 9:31 AM PLOT BY : DAN RYAN PLOT NAME : PLOT SCALE : 1 IN:75 FT WISDOT/CADDS SHEET 44





PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ALTERNATIVE 2A (J CONCEPT)	SHEET E

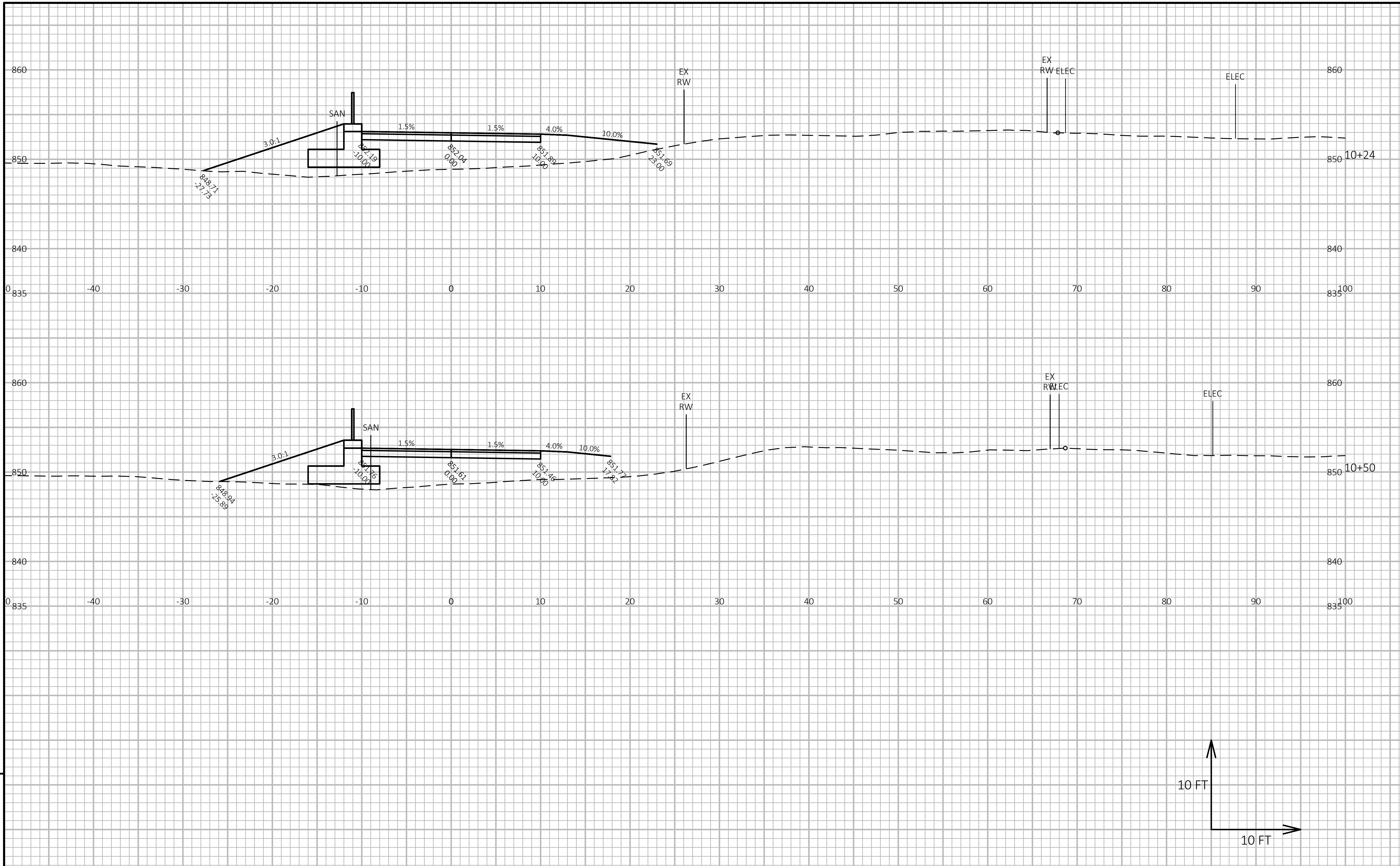




PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	PLAN AND PROFILE: ALTERNATIVE 2A (J CONCEPT)	SHEET	E

FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\EDGELINES\UNDERPASS\PAVT_UNDERPASS_J CONCEPT_PREFERRED_PATH ALT.DWG
LAYOUT NAME - J Concept North Lakeside Approach
PLOT DATE : 4/24/2024 10:32 AM PLOT BY : DAN RYAN PLOT NAME : PLOT SCALE : 1 IN:40 FT

9



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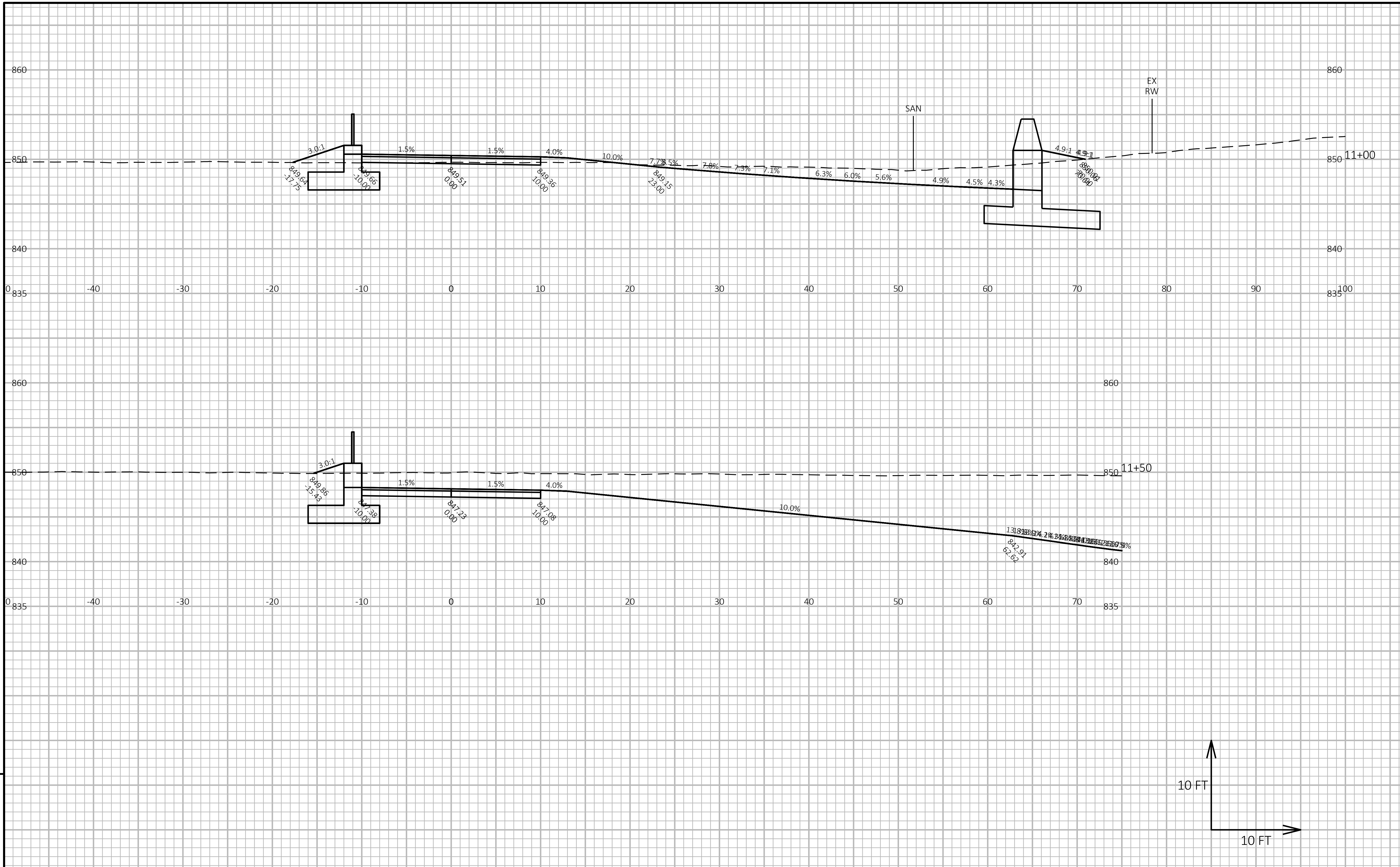
PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: ALTERNATIVE 2A (J CONCEPT)	SHEET	E

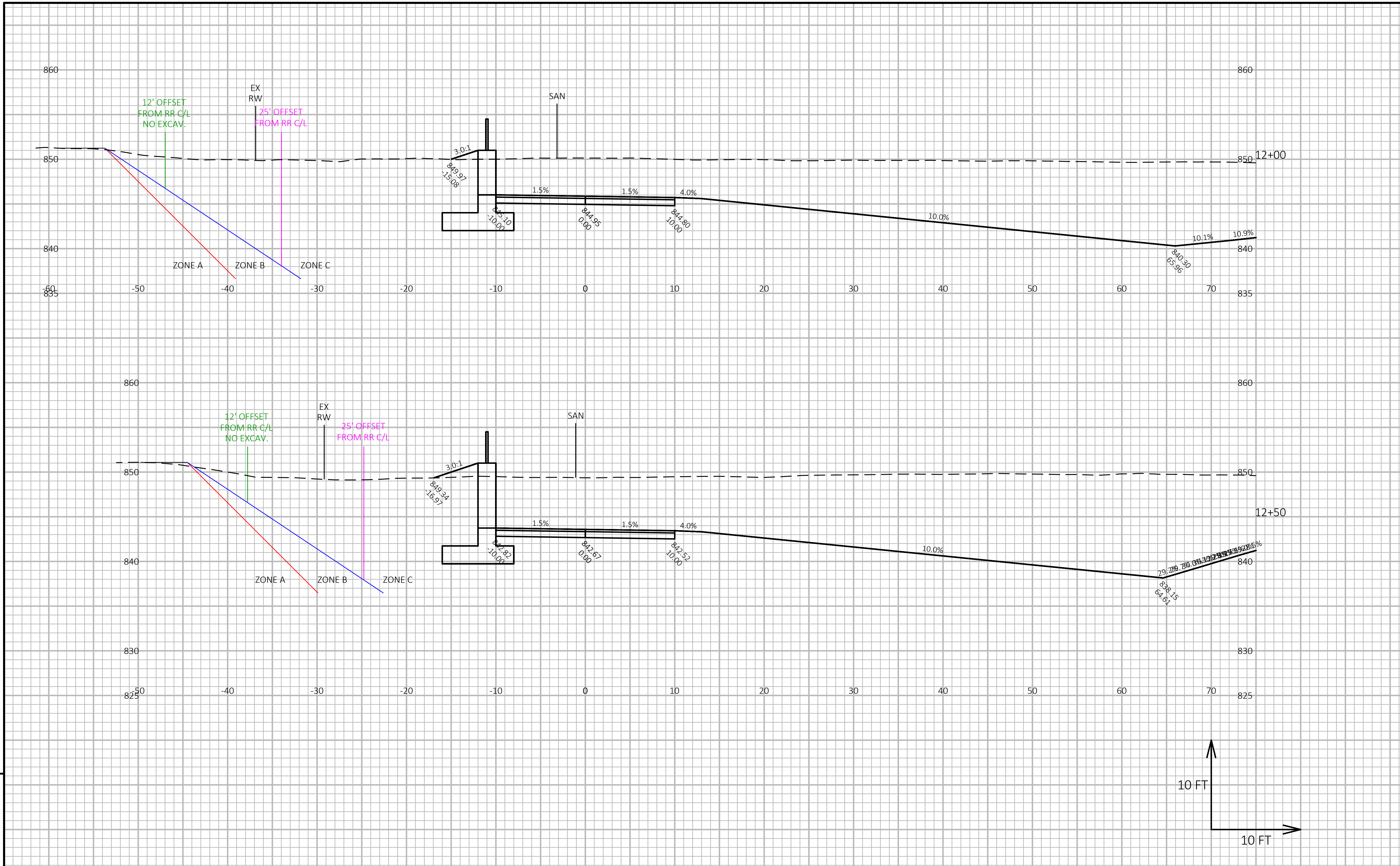


9

9

PROJECT NO: UNDERPASS FEASIBILITY STUDY | HWY: JOHN NOLEN DRIVE | COUNTY: DANE | CROSS SECTIONS: ALTERNATIVE 2A (J CONCEPT) | SHEET | E

FILE NAME : G:\MADISON\21012-000 JND (OA - NSD)\CIVIL 3D\DESIGN\CORRIDORS\PAVEMENTCORRIDORS\CRDR-JND_UNDERPASS_ULT.DWG
LAYOUT NAME - J CONCEPT 02
PLOT DATE : 4/24/2024 11:32 AM
PLOT BY : JACK HAFEMANN
PLOT NAME :
PLOT SCALE : 1 IN:10 FT HORZ. / 1 IN:10 FT VERT.
WISDOT/CADDS SHEET 49



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PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: ALTERNATIVE 2A (J CONCEPT)	SHEET	E

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LAYOUT NAME - J CONCEPT 03
PLOT DATE : 4/24/2024 11:32 AM PLOT BY : JACK HAFEMANN PLOT NAME : PLOT SCALE : 1 IN:10 FT HORZ. / 1 IN:10 FT VERT. WISDOT/CADDS SHEET 49

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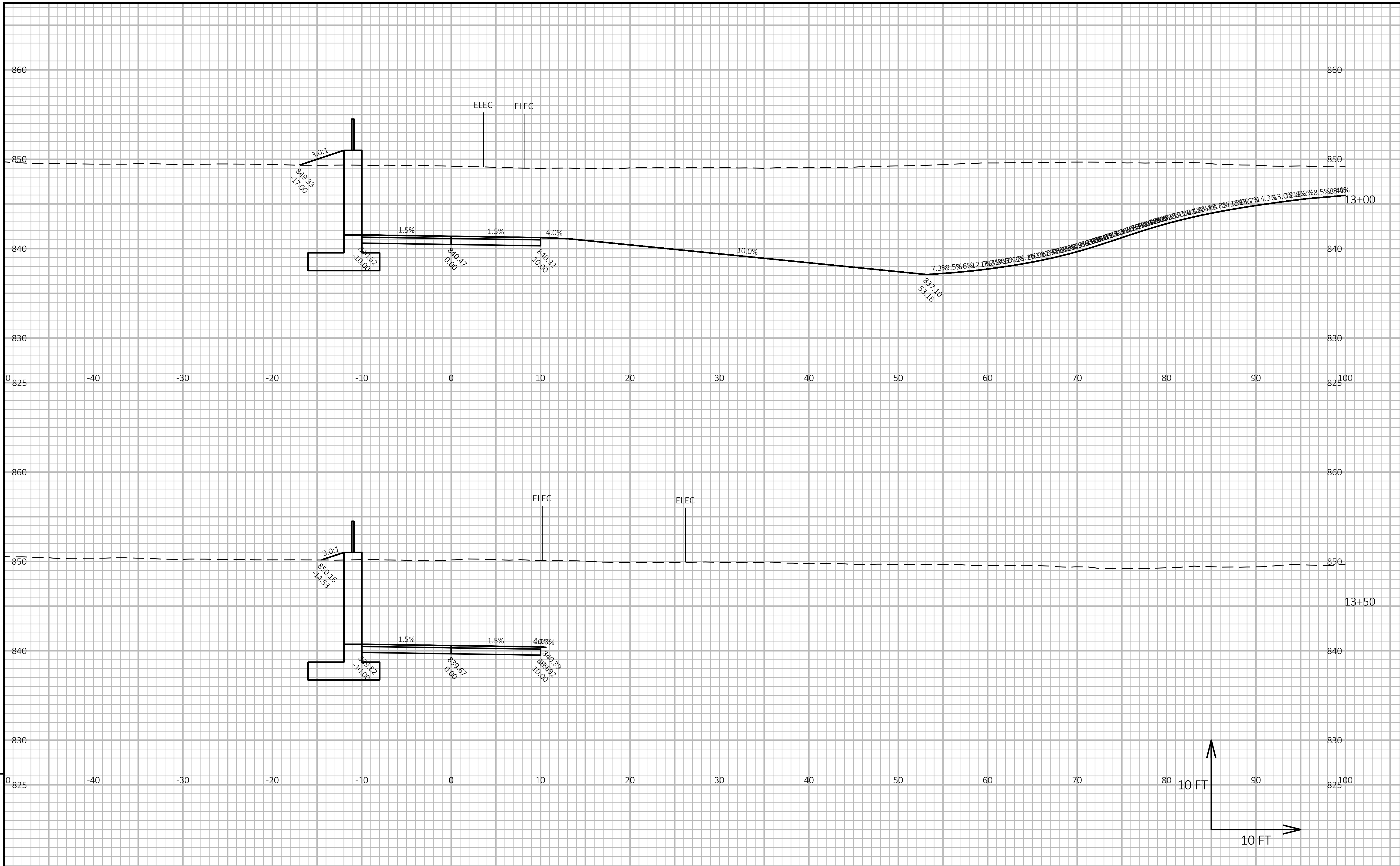

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PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: ALTERNATIVE 2A (J CONCEPT)	SHEET	E

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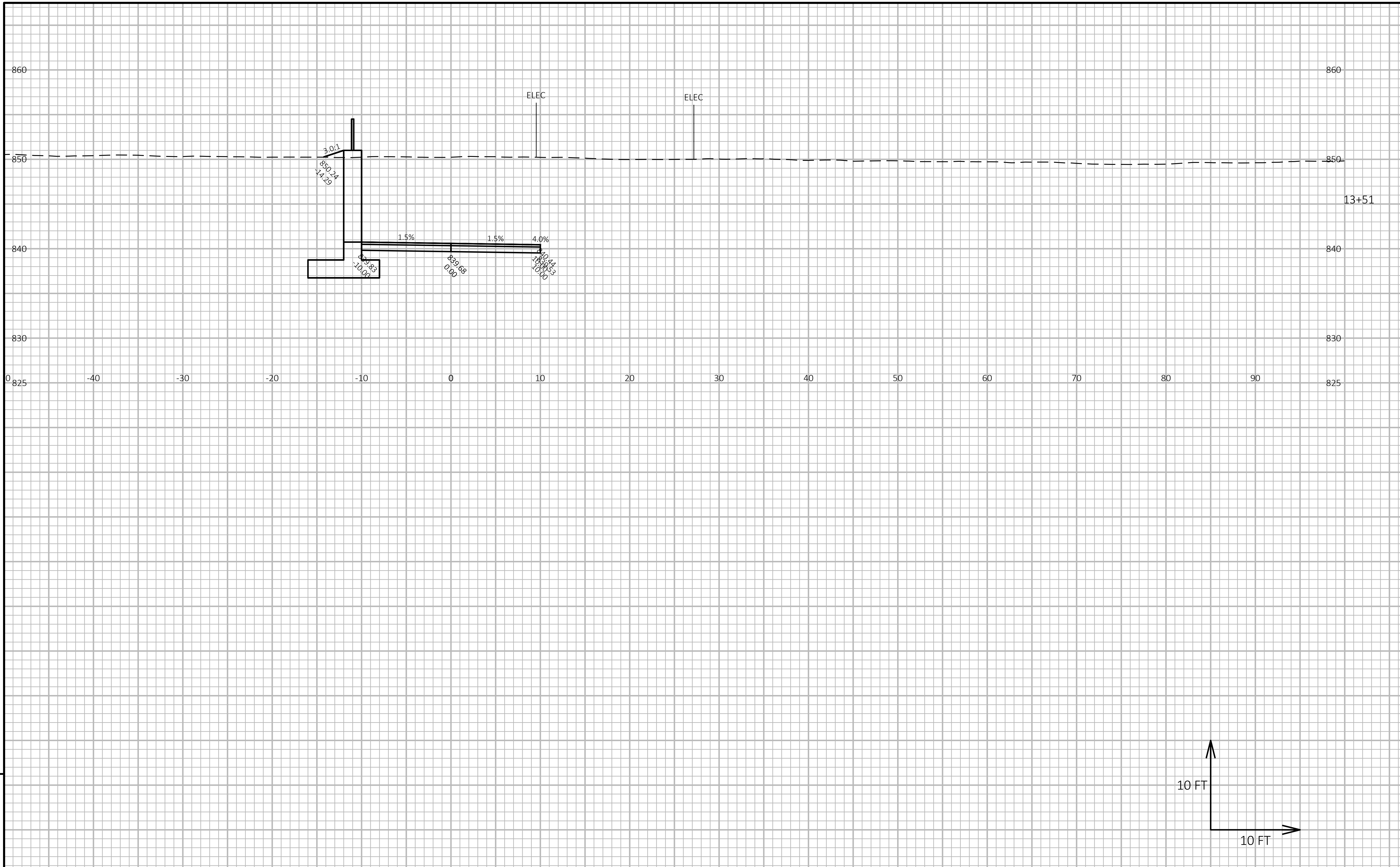
PLOT NAME :
PLOT SCALE : 1 IN:10 FT HORZ. / 1 IN:10 FT VERT.
WISDOT/CADDS SHEET 49



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PROJECT NO: UNDERPASS FEASIBILITY STUDY	HWY: JOHN NOLEN DRIVE	COUNTY: DANE	CROSS SECTIONS: ALTERNATIVE 2A (J CONCEPT)	SHEET	E

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LAYOUT NAME - J CONCEPT 05
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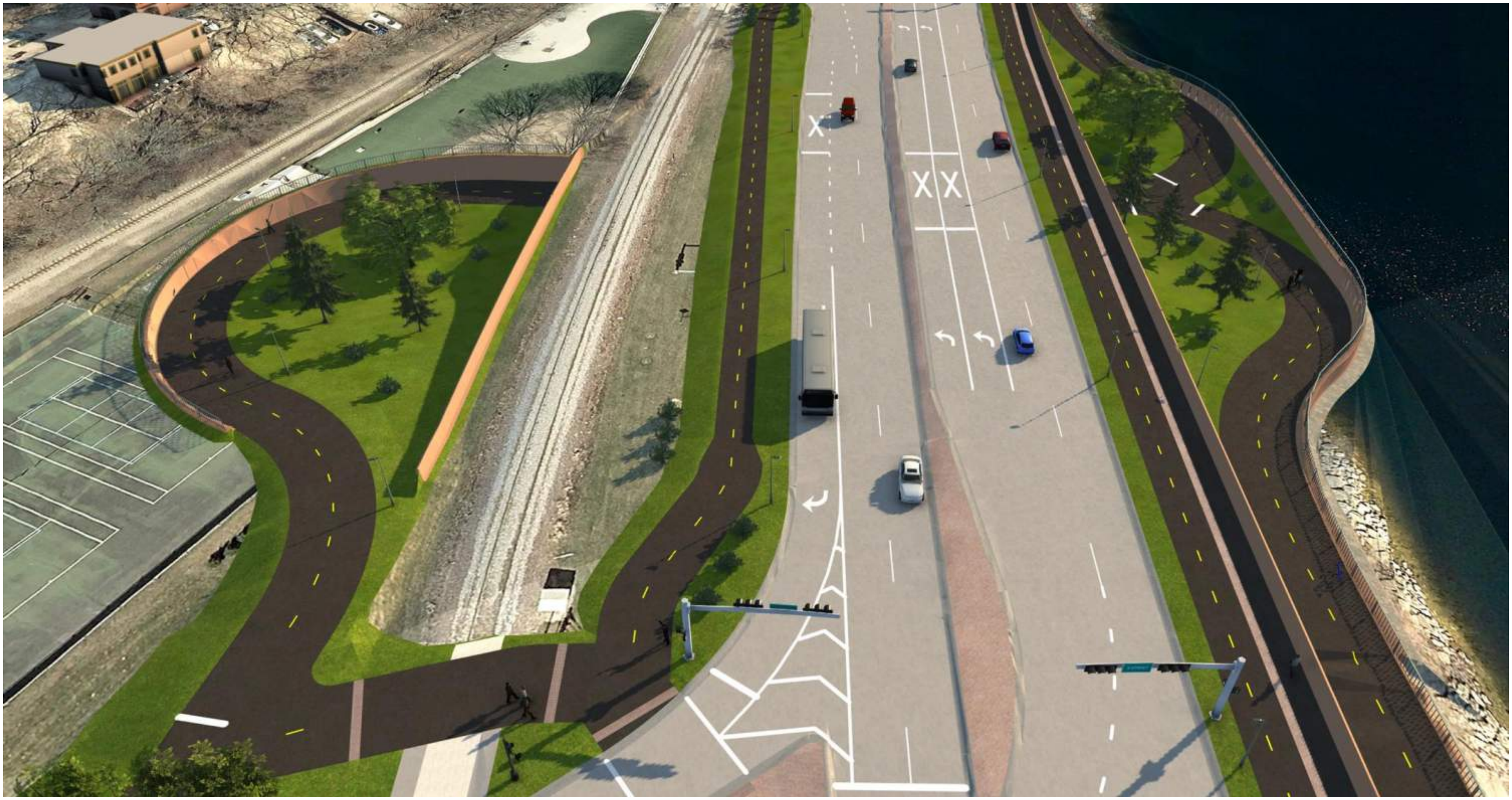
PLOT BY : JACK HAFEMANN
PLOT NAME :
PLOT SCALE : 1 IN:10 FT HORZ. / 1 IN:10 FT VERT.
WISDOT/CADDS SHEET 49

Alternative 2A (J-Concept) Renderings



APPENDIX I

Alternative Cost Estimates

Line No.	Item Description	Unit	Quantity	Unit Price	Total
	City of Madison, John Nolen Drive Underpass North Shore Drive - Broom Street Alternative 1A (H-Concept) September 29, 2024 - Concept Level Estimate				
	Roadway and Path				
	Removing Curb & Gutter	LF	1,400	$6.00	$8,400.00
	Borrow	CY	1,800	$30.00	$54,000.00
	Base Aggregate Dense 1 1/4-Inch	TON	3,000	$23.00	$69,000.00
	Select Crushed Material	TON	3,000	$20.00	$60,000.00
	HMA Pavement	TON	500	$98.00	$49,000.00
	Concrete Pavement 9 1/2-Inch	SY	2,800	$95.00	$266,000.00
	Colored Concrete Sidewalk 7-Inch	SF	5,200	$19.00	$98,800.00
	Concrete Curb and Gutter 24-inch Type A	LF	1,400	$30.00	$42,000.00
	Stamping Colored Concrete (Median)	CY	22	$200.00	$4,360.00
	Light Weight Foamed Concrete	CY	740	$200.00	$148,000.00
	Construction Staking	EACH	1	$20,000.00	$20,000.00
	Lighting	LS	1	$250,000.00	$250,000.00
	Storm Sewer	LS	1	$160,000.00	$160,000.00
	Railroad Flagging Reimbursement	DOL	100,000	$1.00	$100,000.00
1				Roadway Subtotal Cost	$1,329,560.00
	Structure - West Side Approaches				
	Excavation Common	CY	2,200	$30.00	$66,000.00
	Excavation Contaminated Soil	CY	2,200	$65.00	$143,000.00
	Geotextile Fabric	SY	700	$5.00	$3,500.00
	Cast in Place Retaining Walls	SF	6,900	$510.00	$3,519,000.00
	Architectural Surface Treatment (Includes Multi Color Staining)	SF	6,900	$30.00	$207,000.00
	Concrete Masonry (Structural Foundation)	CY	300	$850.00	$255,000.00
	Bar Steel (Structural Foundation)	LS	1	$77,000.00	$77,000.00
	Base Aggregate Open Graded (Clear Stone)	TON	820	$35.00	$28,700.00
	Retaining Wall Parapet	LF	280	$200.00	$56,000.00
	Railing Pedestrian Steel Type C2	LF	280	$300.00	$84,000.00
	Temporary Shoring Left in Place	SF	7,200	$75.00	$540,000.00
2				Structure Subtotal Cost	$4,913,200.00
	Structure - East Side Approaches				
	Excavation Common	CY	1,900	$30.00	$57,000.00
	Excavation Contaminated Soil	CY	1,900	$65.00	$123,500.00
	Geotextile Fabric	SY	700	$5.00	$3,500.00
	Cast in Place Retaining Walls	SF	10,200	$510.00	$5,202,000.00
	Architectural Surface Treatment (Includes Multi Color Staining)	SF	10,200	$30.00	$306,000.00
	Concrete Masonry (Structural Foundation)	CY	300	$850.00	$255,000.00
	Bar Steel (Structural Foundation)	LS	1	$77,000.00	$77,000.00
	Base Aggregate Open Graded (Clear Stone)	TON	800	$35.00	$28,000.00
	Retaining Wall Parapet	LF	250	$200.00	$50,000.00
	Railing Pedestrian Steel Type C2	LF	250	$300.00	$75,000.00
	Temporary Shoring Left in Place	SF	10,300	$75.00	$772,500.00
3				Structure Subtotal Cost	$6,949,500.00
	Structure - Underpass				
	Excavation Common	CY	1,400	$30.00	$42,000.00
	Excavation Contaminated Soil	CY	1,400	$65.00	$91,000.00
	Geotextile Fabric	SY	600	$5.00	$3,000.00
	8' X 20' Rectangular Structure	LF	120	$5,000.00	$600,000.00
	Architectural Surface Treatment (Includes Multi Color Staining)	SF	6,720	$30.00	$201,600.00
	Base Aggregate Open Graded (Clear Stone)	TON	700	$35.00	$24,500.00
	Temporary Shoring Left in Place	SF	3,100	$75.00	$232,500.00
4				Structure Subtotal Cost	$1,194,600.00
	Pumping System				
	Pumps, Generator, Cabinet, and Piping	LS	1	$2,700,000.00	$2,700,000.00
5				Pumping System Subtotal Cost	$2,700,000.00
	Shoreline Revetment				
	Riprap Extra-Heavy	CY	2,100	$90.00	$189,000.00
	Riprap Medium	CY	1,100	$85.00	$93,500.00
	Geotextile Type ES	SY	1,600	$5.00	$8,000.00
	Turbidity Barrier	SY	500	$50.00	$25,000.00
6				Shoreline Revetment Subtotal Cost	$315,500.00
	Roadway Incidentals				
	Erosion Control	LS	1	$20,000.00	$20,000.00
	Signing and Marking	LS	1	$20,000.00	$20,000.00

Line No.	Item Description	Unit	Quantity	Unit Price	Total
	Traffic Control	LS	1	$150,000.00	$150,000.00
7	Roadway Incidentals Subtotal Cost				$190,000.00
8	**Major Items Subtotal Cost (Sum of Lines 1 through 7)**				**$17,592,360.00**
	Mobilization & Design Contingency				
	Mobilization	LS	10.0	% of Line 7	$1,759,236.00
	Design Contingency	LS	30.0	% of Line 7	$5,277,708.00
9	Mobilization & Design Contingency Subtotal Cost				$7,036,944.00
10	**Total Project Let Cost (Lines 8+9)**				**$24,629,304.00**
	Utility Relocations (Compensability To Be Determined)				
	ATC Underground 69kv Service	LS	1	$16,000,000.00	$16,000,000.00
	MG&E Electrical Service	LF	500	$170.00	$85,000.00
	AT&T Fiber Optic	LF	1,000	$150.00	$150,000.00
	Charter Fiber Optic	LF	1,000	$150.00	$150,000.00
11	**Utility Relocation Subtotal Cost**				$16,385,000.00
	Total Estimated Rounded Project Cost				**$41,100,000**

Note 1: Costs are shown in year 2024 dollars.

Note 2: Annual operational costs are estimated at $25,000 to $40,000.

Line No.	Item Description	Unit	Quantity	Unit Price	Total
	City of Madison, John Nolen Drive Underpass **North Shore Drive - Broom Street** **Alternative 2A (J-Concept)** **September 30, 2024 - Concept Level Estimate**				
	Roadway and Path				
	Removing Curb & Gutter	LF	1,400	$6.00	$8,400.00
	Base Aggregate Dense 1 1/4-Inch	TON	3,300	$23.00	$75,900.00
	Select Crushed Material	TON	3,000	$20.00	$60,000.00
	HMA Pavement	TON	500	$98.00	$49,000.00
	Concrete Pavement 9 1/2-Inch	SY	2,800	$95.00	$266,000.00
	Colored Concrete Sidewalk 7-Inch	SF	7,600	$19.00	$144,400.00
	Concrete Curb and Gutter 24-inch Type A	LF	1,400	$30.00	$42,000.00
	Stamping Colored Concrete (Median)	CY	22	$200.00	$4,360.00
	Construction Staking	EACH	1	$25,000.00	$25,000.00
	Lighting	LS	1	$325,000.00	$325,000.00
	Storm Sewer	LS	1	$270,000.00	$270,000.00
	Railroad Flagging Reimbursement	DOL	100,000	$1.00	$100,000.00
1				Roadway Subtotal Cost	$1,370,060.00
	Structure - West Side Approach				
	Excavation Common	CY	6,300	$30.00	$189,000.00
	Excavation Contaminated Soil	CY	3,200	$65.00	$208,000.00
	Geotextile Fabric	SY	3,300	$5.00	$16,500.00
	Cast in Place Retaining Walls	SF	7,700	$510.00	$3,927,000.00
	Architectural Surface Treatment (Includes Multi Color Staining)	SF	7,700	$30.00	$231,000.00
	Concrete Masonry (Structural Foundation)	CY	1,100	$850.00	$935,000.00
	Bar Steel (Structural Foundation)	LS	1	$281,000.00	$281,000.00
	Base Aggregate Open Graded (Clear Stone)	TON	4,400	$35.00	$154,000.00
	Engineered Soil For Greenspace	CY	1,600	$55.00	$88,000.00
	Railing Pedestrian Steel Type C2	LF	500	$300.00	$150,000.00
	Temporary Shoring Left in Place	SF	9,600	$75.00	$720,000.00
2				Structure Subtotal Cost	$6,899,500.00
	Structure - East Side Approaches				
	Excavation Common	CY	3,000	$30.00	$90,000.00
	Excavation Contaminated Soil	CY	3,000	$65.00	$195,000.00
	Excavation Marsh (Lake Monona)	CY	14,000	$35.00	$490,000.00
	Geotextile Fabric	SY	3,900	$5.00	$19,500.00
	Granular Backfill	TON	28,000	$30.00	$840,000.00
	Cast in Place Retaining Walls	SF	10,600	$510.00	$5,406,000.00
	Architectural Surface Treatment (Includes Multi Color Staining)	SF	10,600	$30.00	$318,000.00
	Concrete Masonry (Structural Foundation)	CY	1,300	$850.00	$1,105,000.00
	Bar Steel (Structural Foundation)	LS	1	$332,000.00	$332,000.00
	Base Aggregate Open Graded (Clear Stone)	TON	5,200	$35.00	$182,000.00
	Engineered Soil For Greenspace	CY	1,500	$55.00	$82,500.00
	Retaining Wall Parapet	LF	460	$200.00	$92,000.00
	Railing Pedestrian Steel Type C2	LF	300	$300.00	$90,000.00
	Temporary Shoring Left in Place	SF	13,200	$75.00	$990,000.00
3				Structure Subtotal Cost	$10,232,000.00
	Structure - Underpass				
	Excavation Common	CY	2,300	$30.00	$69,000.00
	Excavation Contaminated Soil	CY	2,300	$65.00	$149,500.00
	Geotextile Fabric	SY	900	$5.00	$4,500.00
	8' X 20' Rectangular Structure	LF	140	$5,000.00	$700,000.00
	Architectural Surface Treatment (Includes Multi Color Staining)	SF	11,200	$30.00	$336,000.00
	Base Aggregate Open Graded (Clear Stone)	TON	1,100	$35.00	$38,500.00
	Temporary Shoring Left in Place	SF	4,600	$75.00	$345,000.00
4				Structure Subtotal Cost	$1,642,500.00
	Structure - Railroad Bridge				
	Steel Railroad Bridge	SF	500	$6,000.00	$3,000,000.00
5				Structure Subtotal Cost	$3,000,000.00
	Pumping System				
	Pumps, Generator, Cabinet, and Piping	LS	1	$3,200,000.00	$3,200,000.00
6				Pumping System Subtotal Cost	$3,200,000.00
	Sanitary Sewer				
	Remove Sanitary Pipe	LF	120	$150.00	$18,000.00
	Sanitary Sewer Pipe, 30-Inch	LF	130	$300.00	$39,000.00

Line No.	Item Description	Unit	Quantity	Unit Price	Total
	Sanitary Manhole with Cover	EACH	4	$15,000.00	$60,000.00
7				Sanitary Sewer Subtotal	$117,000.00
	Shoreline Revetment				
	Riprap Extra-Heavy	CY	500	$90.00	$45,000.00
	Riprap Medium	CY	300	$85.00	$25,500.00
	Geotextile Type ES	SY	400	$5.00	$2,000.00
	Turbidity Barrier	SY	700	$50.00	$35,000.00
8				Shoreline Revetment Subtotal Cost	$107,500.00
	Roadway Incidentals				
	Erosion Control	LS	1	$50,000.00	$50,000.00
	Signing and Marking	LS	1	$30,000.00	$30,000.00
	Traffic Control	LS	1	$150,000.00	$150,000.00
9				Roadway Incidentals Subtotal Cost	$230,000.00
10				**Major Items Subtotal Cost (Sum of Lines 1 through 9)**	**$26,798,560.00**
	Mobilization & Design Contingency				
	Mobilization	LS	10.0	% of Line 10	$2,679,856.00
	Design Contingency	LS	30.0	% of Line 10	$8,039,568.00
11				Mobilization & Design Contingency Subtotal Cost	$10,719,424.00
12				**Total Project Let Cost (Lines 10+11)**	**$37,517,984.00**
	Utility Relocations (Compensability to Be Determined)				
	ATC Underground 69kv Service	LS	1	$16,000,000.00	$16,000,000.00
	MG&E Electrical Service	LF	500	$170.00	$85,000.00
	AT&T Fiber Optic	LF	1,000	$150.00	$150,000.00
	Charter Fiber Optic	LF	1,000	$150.00	$150,000.00
	MMSD 36" Sanitary Force Main	LS	1	$1,000,000.00	$1,000,000.00
13				**Utility Relocation Subtotal Cost**	$17,385,000.00
				Total Estimated Rounded Project Cost	**$55,000,000**

Note 1: Costs are shown in year 2024 dollars.

Note 2: Annual operational costs are estimated at $25,000 to $40,000.

Note3: The use of uplift anchors may be used in lieu of a of a reinforced concrete slab foundation.