ENGINEERING REPORT

STRUCTURAL STABILITY ANALYSIS

FLOODWALLS

HOUSATONIC RIVER and NAUGATUCK RIVER

FLOOD PROTECTION PROJECTS

SECTION 1

ANSONIA and DERBY, CONNECTICUT

December 2010

MMI #1560-119 and #3118-03

Prepared for:

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1.0 INTRODUCTION

In June 2010, Ansonia and Derby retained Milone & MacBroom, Inc. (MMI) of Cheshire, Connecticut to perform the investigative and engineering services required to pursue accreditation of Section 1 of the Housatonic River and Naugatuck River Flood Control Systems. In order to establish and/or maintain accreditation of a levee system, the levee owners [Ansonia and Derby] are required to demonstrate compliance with Section 65.10 under Title 44, Chapter 1, Subchapter B, Part 65 of the Code of Federal Regulations.

For the purposes of this report, the observations, analyses, conclusions, and recommendations provided herein pertain to Section 1 only as described below:

- Section 1 – The left (east) bank of the Housatonic River in Derby from Bridge Street to the confluence with the Naugatuck River/Route 8 embankment and the right (west) bank of the Naugatuck River from the Main Street (Route 34) bridge north through Derby to the embankment supporting Pershing Drive in Ansonia.

In particular, this report provides the structural analysis of the elements of the flood protection systems needed to satisfy Section 65.10(b)(2), (b)(4), and (b)(5) summarized under Section 2 below. This report is also prepared in conjunction with the following reports, which specifically address the conditions of the closure device and geotechnical analyses for the levee embankments and subsurface soil conditions.

- Engineering Report – Analysis of Closures, prepared by Milone & MacBroom, Inc., dated December, 2010

- Geotechnical Evaluation Report – Embankment and Foundation Stability and Settlement, prepared by PS&S, dated December, 2010

2.0 FEDERAL REGULATORY CRITERIA

44 CFR Section 65.10(b)(2) *Closures*.

All openings must be provided with closure devices that are structural parts of the system during operation and designed according to sound engineering practice.

44 CFR Section 65.10(b)(4) *Embankment and foundation stability.*

Engineering analyses that evaluate levee embankment stability must be submitted. The analyses provided shall evaluate expected seepage during loading conditions associated with the base flood and shall demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability. An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case IV as defined in the U.S. Army Corps of Engineers (COE) manual, "Design and Construction of Levees" (EM 1110–2–1913, Chapter 6, Section II), may be used. The factors that shall be addressed in the analyses include: Depth of flooding, duration of flooding, embankment geometry and length of seepage path at critical locations, embankment and foundation materials, embankment compaction, penetrations, other design factors affecting seepage (such as drainage layers), and other design factors affecting embankment and foundation stability (such as berms).

44 CFR Section 65.10(b)(5) *Settlement.*

Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum standards set forth in

paragraph (b)(1) of this section. This analysis must address embankment loads, compressibility of embankment soils, compressibility of foundation soils, age of the levee system, and construction compaction methods. In addition, detailed settlement analysis using procedures such as those described in the COE manual, "Soil Mechanics Design—Settlement Analysis" (EM 1100–2–1904) must be submitted.

3.0 DESCRIPTION OF STRUCTURAL COMPONENTS

The flood control systems within the city of Ansonia and the city of Derby consist of earth embankments and concrete walls as well as railroad gate structures, gated conduits, and pumping stations. The structural assessment of the concrete structures included a field inspection of the exposed concrete walls and railroad gate structures, review of as-built drawings and a verification of the walls' stability under the 100-year flood condition.

The types of wall structures and their locations are as follows:

Location	Length	Type	Avg. Height
"T Walls"			
Bridge Street	300'	Reinforced Concrete	18.0'
Railroad Structure No. 2	85'	Reinforced Concrete	13.0'
"I Walls"			
South End of Sloping "T" Wall	47'	Reinforced Concrete and Steel Sheet Piling	Concrete Section <10'
Railroad Structure No. 1	140'	Reinforced Concrete and Steel Sheet Piling	Concrete Section <10'
Railroad Structure No. 2	166'	Reinforced Concrete and Steel Sheet Piling	Concrete Section <10'

Railroad Structure No. 3	162'	Reinforced Concrete and Steel Sheet Piling	Concrete Section <10'

Railroad gate structures location are as follows:

Location	Type	Size Opening
Railroad Gate No. 1	Reinforced Concrete Abutments with Steel Swing Gates/Leaves	28'-0" x 10'-9"
Railroad Gate No. 2A	Reinforced Concrete Abutments with Steel Swing Gates/Leaves	26'-0" x 11'-8"
Railroad Gate No. 2B	Reinforced Concrete Abutments with Steel Swing Gates/Leaves	39'-6" x 9'-1"
Railroad Gate No. 3	Reinforced Concrete Abutments with Steel Swing Gates/Leaves	28'-0" x 10'-9"
Railroad Gate No. 4	Reinforced Concrete Abutments with Steel Swing Gates/Leaves	30'-0" x 13'-2"

At the “T” wall adjacent to Bridge Street, the Army Corps of Engineers “as-built” drawings indicate that a steel sheet pile was installed on the landside of the wall to facilitate wall construction and to protect the 18-inch diameter sanitary sewer. The "as-built" drawings also indicate that the retained soil (landside) consists of loose to dense granular fill with some miscellaneous debris such as wood, asphalt, etc.

4.0 STRUCTURAL FIELD INSPECTIONS

On September 1, 2010, an MMI structural engineer performed a field inspection of the exposed portions of the reinforced concrete "T walls," "I Walls," and railroad gate structures.

In general, the concrete walls were in good condition. The following areas of deterioration were noted:

T-wall Near Bridge Street Bridge – Vertical crack at base of wall with a length of approximately eight feet on the river side of wall stem. The crack shows some minor efflorescence. This crack does not affect the structural integrity of the wall. The crack should be repaired by removing all deteriorated concrete and placing repair mortar up to the original surface.



Top of I-Wall at Railroad Gate Structure No. 1 – There is a spall on the top of the eastern wall approximately 1'-6" wide x 2' long x 5" deep. This spall does affect the structural integrity of the wall. The spall should be repaired by removing all deteriorated concrete and timber and placing repair mortar up to the original surface.



Water stops were confirmed to be in place through expansion joints as required by the design plans. However, numerous vertical expansion joints had damaged or missing joint seals (caulking). This condition does not affect the integrity of the walls but should be repaired to keep debris and water out of the joints. The repair would be to remove cracked or damaged seals, clean the surface, and install new seal (caulk).



As indicated in the Army Corps of Engineers report based upon inspections performed on 4/23/2009 areas of spalling concrete and deterioration were also observed at Derby's Railroad Gate Structure No. 3. As shown in the adjacent photo, the city has performed repairs to the sill of this structure. The municipality should continue to monitor these locations in order to address any continued deterioration that may occur.



5.0 STABILITY ANALYSIS

Subsurface Soil Conditions Below Footings

In support of the analyses provided in this report, reference is also made to Appendix D the Geotechnical Evaluation Report prepared by Paulus, Sokolowski and Sartor (PS&S), dated December 2010 which is provided as Appendix D in the certification package compiled for this section of the levee and flood control system. As indicated in that report, PS&S reviewed both historic test borings (FD-4, FD-8, DF-49, and FD-50) and recent test boring PSS-7 under this project which indicate that the footing is underlain by dense to very dense natural sand and gravel deposits with SPT blow counts varying from 23 to 38.

Analysis

The first location is located just south of the Bridge Street bridge, which runs approximately 110 feet downstream along the north side of the Housatonic River. The wall was analyzed with

additional fill placed on the landward side of the wall due to the placement of a walking trail. The analysis shows that the wall is stable under this normal loading condition. This loading condition produced a maximum bearing pressure of 1.932 tons per square foot. Based upon the information obtained by PS&S, the bearing capacity of the foundation soils will adequately support this bearing pressure. During the base flood condition, the water pressure acting on the face of the wall will reduce the maximum bearing pressure.

The second location is the T-wall that connects Railroad Gates 2A and 2B (see Figure STR-2). This wall was analyzed using the 100-year water surface elevation of 22.00. This analysis shows that the wall is stable under this loading condition.

One section of "I-Wall" located at Railroad Gate No. 1 was also analyzed (see Figure STR-3). The wall was analyzed using a 100-year water surface of 22.00 and an existing ground elevation of 18.00. The tip elevation of the sheeting is -15.00. The analysis shows that the wall is stable under this loading condition.

Two computer programs were used in the stability analysis. The T-wall sections were analyzed with REST (Retaining Structure) version 2.0 software developed by NECO. The I-Wall section was analyzed with SPW911, V2.00 software developed by Pile Buck, Inc.

6.0 PENETRATIONS

Within the flood control systems for Section I several penetrations were incorporated into the design and construction performed by the Army Corps of Engineers including:

- Sanitary sewers gravity conduit – Ansonia & Derby
- Sanitary sewer force mains/siphons - Ansonia
- Storm drainage gravity conduit and force main – Ansonia & Derby

The locations of these penetrations are depicted on the USACE as-built drawings.

Since the original construction, Williams Communication constructed a new penetration through the levee embankment at Railroad Flood Gate No. 3. The design details and construction were approved by the Army Corps of Engineers.

Detailed analyses and investigation of the penetrations through the levee have not been performed as part of this certification effort. However, based upon the accuracy of the USACE as-built drawings in relation to other levee components that MMI and the project team were able to confirm, it is assumed that the penetrations and associated anti-seep collars were installed as depicted on the USACE provided as-built drawings. With no current evidence or historical data indicating seepage, settlement or structural problems at these locations, it is anticipated that these components will not diminish the overall ability of the flood control system to provide protection from the base flood and obtain FEMA accreditation. It is our recommendation that in addition to the observations and procedures outlined in the updated O&M manual, specific observations around each penetration shall be incorporated during elevated river conditions to determine if seepage is occurring and if further investigation and possible remedy is required.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Following the field inspections, review of the U.S. Army Corps of Engineers "as-built" drawings, structural analysis, and comparison of the structural flood control elements associated in relation to the anticipated depth of flooding, Section I of the Ansonia and Derby Flood Control System is expected to continue to provide protection during the base flood.

As indicated herein, there are some recommendations for maintenance associated with the structural elements which are offered below in addition to on-going requirements outlined in the adopted Operations and Maintenance Manuals for each municipality:

- T-wall Near Bridge Street Bridge – Repair vertical crack at base of wall.

- Top of I-Wall at Railroad Gate Structure No. 1 – Repair spalling on top of wall.

- Inspect all expansion joints and repair as necessary.

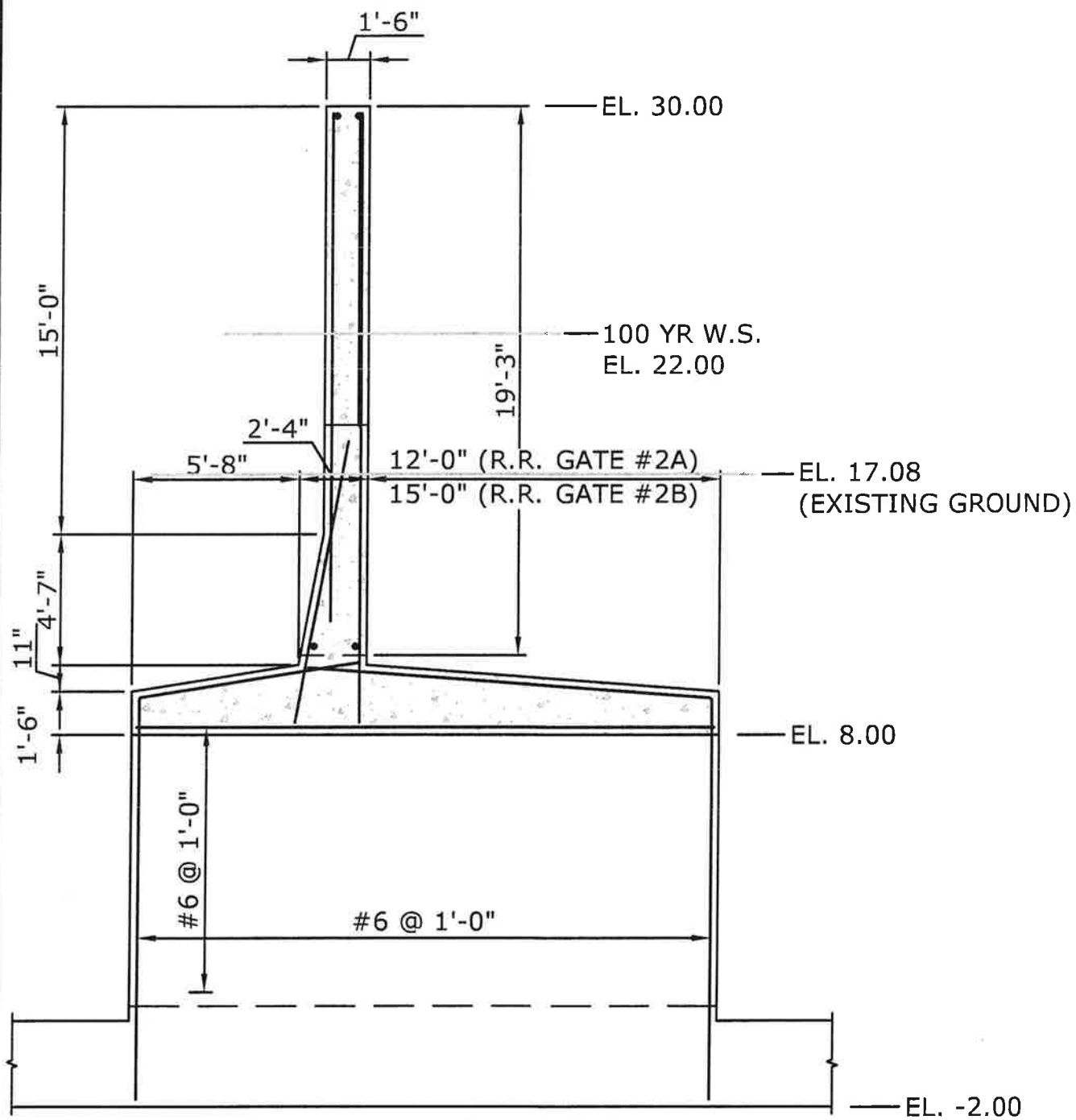
- Remove remaining vegetation immediately adjacent to and in the vicinity of the retaining walls.

- Monitor integrity of the sill at Railroad Gate No. 3 and all flood gates and repair as needed.

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SUPPORTING DOCUMENTATION

Results of Structural Analyses



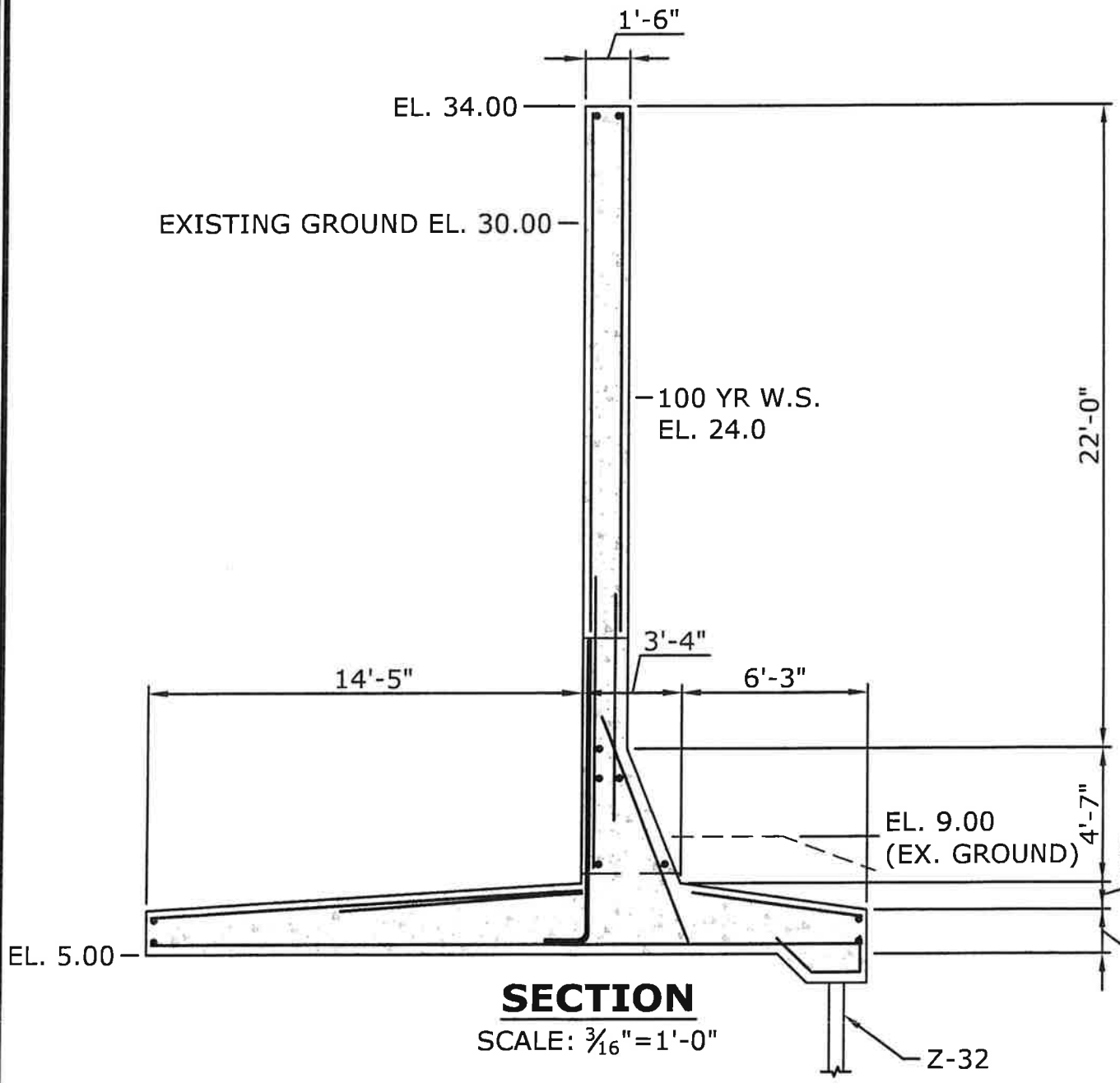
SECTION

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FEMA LEVEE CERTIFICATION		LOCATION: HOUSATONIC/NAUGATUCK RIVERS DERBY, CONNECTICUT	
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SECTION

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FEMA LEVEE CERTIFICATION

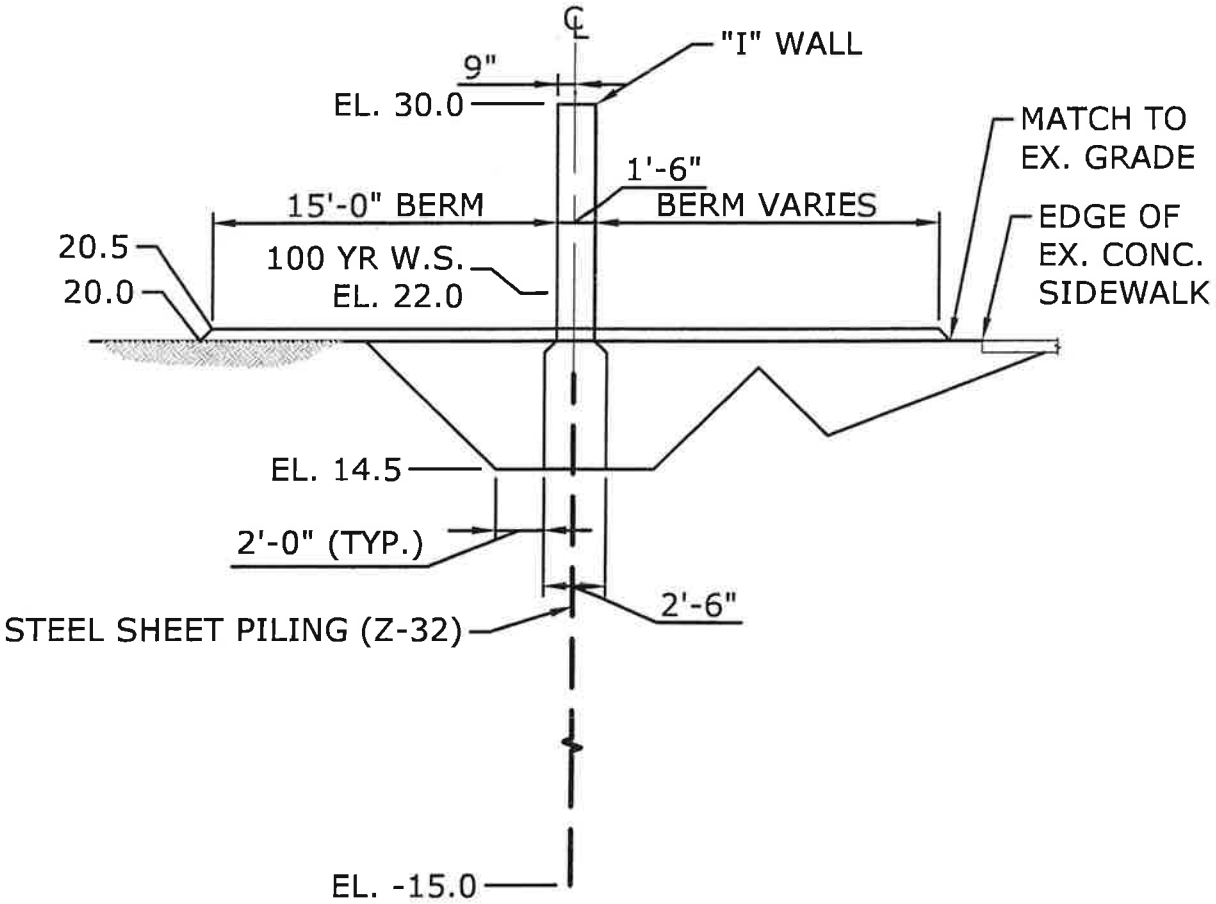
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HOUSATONIC RIVER FLOOD WALL

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SECTION D-D

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FEMA LEVEE CERTIFICATION		LOCATION: HOUSATONIC/NAUGATUCK RIVERS DERBY, CONNECTICUT	
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