ENGINEERING EVALUATION

OLD TROLLEY BRIDGE OVER BRANCH BROOK
WATERTOWN/THOMASTON, CONNECTICUT

March 20, 2017

Prepared by:

Lenard Engineering, Inc.
2210 Main Street
Glastonbury, Connecticut

TABLE OF CONTENTS

ATTACHMENTS

1. INTRODUCTON

Lenard Engineering, Inc. (LEI) was retained on January 23, 2017 by the Town of Watertown to conduct a general engineering evaluation of the old trolley bridge spanning Branch Brook on the Watertown/Thomaston town line, approximately 300 feet upstream from the confluence of Branch Brook with the Naugatuck River. The *Location Plan* of the bridge is included in Attachment A.

The evaluation was requested because the Towns of Watertown and Thomaston are contemplating to utilize the structure in the future for pedestrian traffic, as part of a recreational trail project between the two municipalities. The evaluation entailed the assessment of the existing condition of the structure and the establishment of the scope of the necessary improvements with the estimated construction cost.

LEI visited the site on March 2, 2017, inspected and surveyed, then evaluated the structure for structural integrity, hydraulic performance, functionality. The cost of the necessary improvements was also calculated. *Photographs of the existing structure* are included in Attachment E.

The conclusion of the investigation is that the structure can be fitted for the intended use but only at the cost of significant improvements. The following report is a summary of LEI's findings and conclusions as well as the recommended improvements with the associated estimated construction cost.

2. DESCRIPTION OF THE STRUCTURE

The structure is a concrete arch of 50 foot span oriented in the north-south direction. The curb-to-curb width of the dirt roadway on the structure is 11 feet with parapets on either side. The northwest and the southeast wingwalls are angled at 160 degrees and are 25 feet and 45 feet long respectively. The northeast and southwest wingwalls are 12 feet and 7 feet long respectively and are perpendicular to the parapets. The parapets and all wingwalls are 2 feet thick. There is no railing on the parapets *(see Pictures 1 & 2).*

The concrete arch is skewed at 39 degrees for improved channel hydraulics. The height of the arch is approximately 15 feet above the deepest point of the channel. The roadway on the bridge is on earth fill over the concrete arch. Assuming that the concrete arch is also 2 feet thick, the thickness of the earth fill varies between approximately 3 feet and 10 feet.

The structure is of either reinforced or unreinforced concrete; the presence of reinforcement in the concrete could not be verified. The geometry of the structure is pictured in *Drawings 1 through 4* in Attachment B.

The year of construction of the bridge is uncertain. Based on its general configuration and the fact that it was built as a trolley bridge, it was likely constructed in the 1920's.

3. **STRUCTURAL COMPUTATIONS**

The configuration of many structure components remain unknown (foundations, concrete reinforcement, etc.), therefore our structural computations focused on the concrete arch, the principal load bearing component of the structure. The load included the existing and proposed dead loads and the future live loads associated with the proposed use.

The dead loads included the concrete parapets and the arch, as well as earth overburden on the arch. We calculated the live loads based on the latest AASHTO LRFD Bridge Design Specification. The live loads are alternatively either pedestrian loads of 90 PSF applied over the entire bridge, or H10 vehicular load with the dynamic factor of 1.33 to represent a light service truck or an ambulance. The controlling load combination was calculated with the load factors of 1.25 and 1.75 for the dead and live loads respectively. We calculated the compression stresses in the arch at the shoulders and at the peak of the arch. We found that the controlling compression force in the arch is generated at the shoulder of the arch by the H10 vehicular live load

The compression (cylinder) strength of the concrete is not exactly know, but based on the general condition of the structure we assumed it as 1,500 PSI. The calculated compression stress in the concrete arch at the shoulder from the controlling loading case is approximately 178 PSI, which is safely below the assumed cylinder strength of the concrete. The *Structural Computations* are included in Attachment C.

4. **HYDROLOGY, HYDRAULICS, AND SCOUR**

No full-scale hydrology/hydraulic investigation was done for the structure, but the FEMA FIS and the FEMA FIRM documents indicate that the structure does not overtop in the 100 year repeat frequency storm. The *FEMA documents* are included in Attachment D.

We examined the channel for stability and scour. The brook takes a left turn just upstream from the bridge (see the *Location Plan* and the *Structure Layout Plan* in Attachments A and B respectively), and accordingly the right embankment at that location and the south abutment of the bridge are under attack by the flow. The right embankment and the downstream channel appear stable (see Pictures 14, 15, and 16). The south abutment is prone to scour damage. There is no deep scour hole in front of the south abutment, but much of its footing is exposed doe to channel erosion (see Picture 8). The brook is depositing sediment on the opposite embankment, and the north abutment is safe from scour (see Picture 9).

5. GENERAL CONDITION OF THE STRUCTURE

The structural concrete is severely deteriorated, and the rate of deterioration seems accelerating. The concrete is disintegrating due to frost/thaw action (see Pictures 5 and 6), and efflorescence can be seen over the entire underside of the arch (see Picture 8). Evidently the structure is not protected against water damage. Vegetation grows over and damaging the wingwalls (see Pictures 3, 4, 5, and 6). Scour related erosion can be observed along the southwest and southeast wingwalls and the south abutment.

6. RECOMMENDED ACTION AND ASSOCIATED CONSTRUCTION ESTIMATE

The bridge can be converted to carry pedestrian traffic but the following significant improvements are necessary and strongly recommended to stop the further deterioration of the structure:

a) Clear vegetation from the face of and around the wingwalls

b) Excavate the earth overburden on the concrete arch, repair the top of the arch and the inside of the parapets, place membrane waterproofing over the entire inside of the structure

c) Install weep holes at the low point of the arch

d) Remove the top 2 feet of the parapets and wingwalls. Pour new reinforced concrete caps over the parapets and wingwalls

e) Install pedestrian and/or bicycle railing on the new parapet concrete tops

f) Place new overburden of pervious structure backfill over the arch

g) Place subbase and build bituminous roadway over the bridge

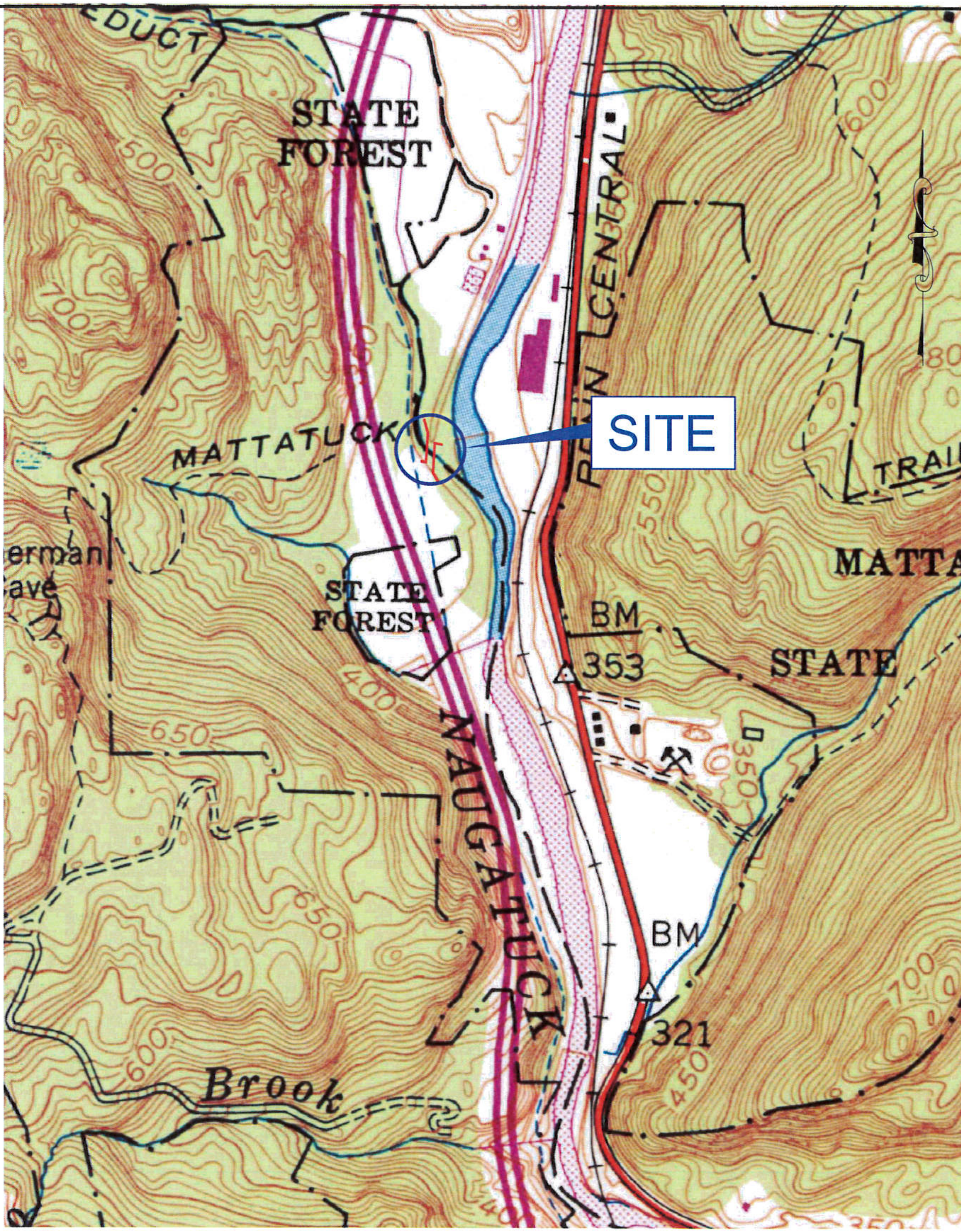
h) Excavate channel in front of the north abutment. Move channel to the middle of the span. Place standard riprap protection in front of the abutments and wingwalls at the south side

i) Repair (patch and coat) the entire surface of the structure with polymer modified concrete compound

The estimated construction cost of the listed improvements is $356,000. The *Construction Cost Estimate* is included in Attachment F.

ATTACHMENTS

Attachment A
LOCATION PLAN



GRAPHIC SCALE

0 750 1500

(IN FEET)

LOCATION PLAN

SCALE: 1"= 750'

Drawing date: MARCH 20, 2017

Drawing Scale: 1"=750'

Rev.	Date	Revision	By

Designed By: PM

Drawn By: KLD

Checked By: PM

CAD File: Basemap

LOCATION PLAN

PREPARED FOR

OLD TROLLEY BRIDGE

OVER BRSNCH BROOK

WATERTOWN-THOMASTON, CONNECTICUT

Lenard Engineering, Inc.

Civil, Environmental and Hydrogeological Consultants

2210 MAIN STREET
GLASTONBURY, CT.
(860) 659-3100

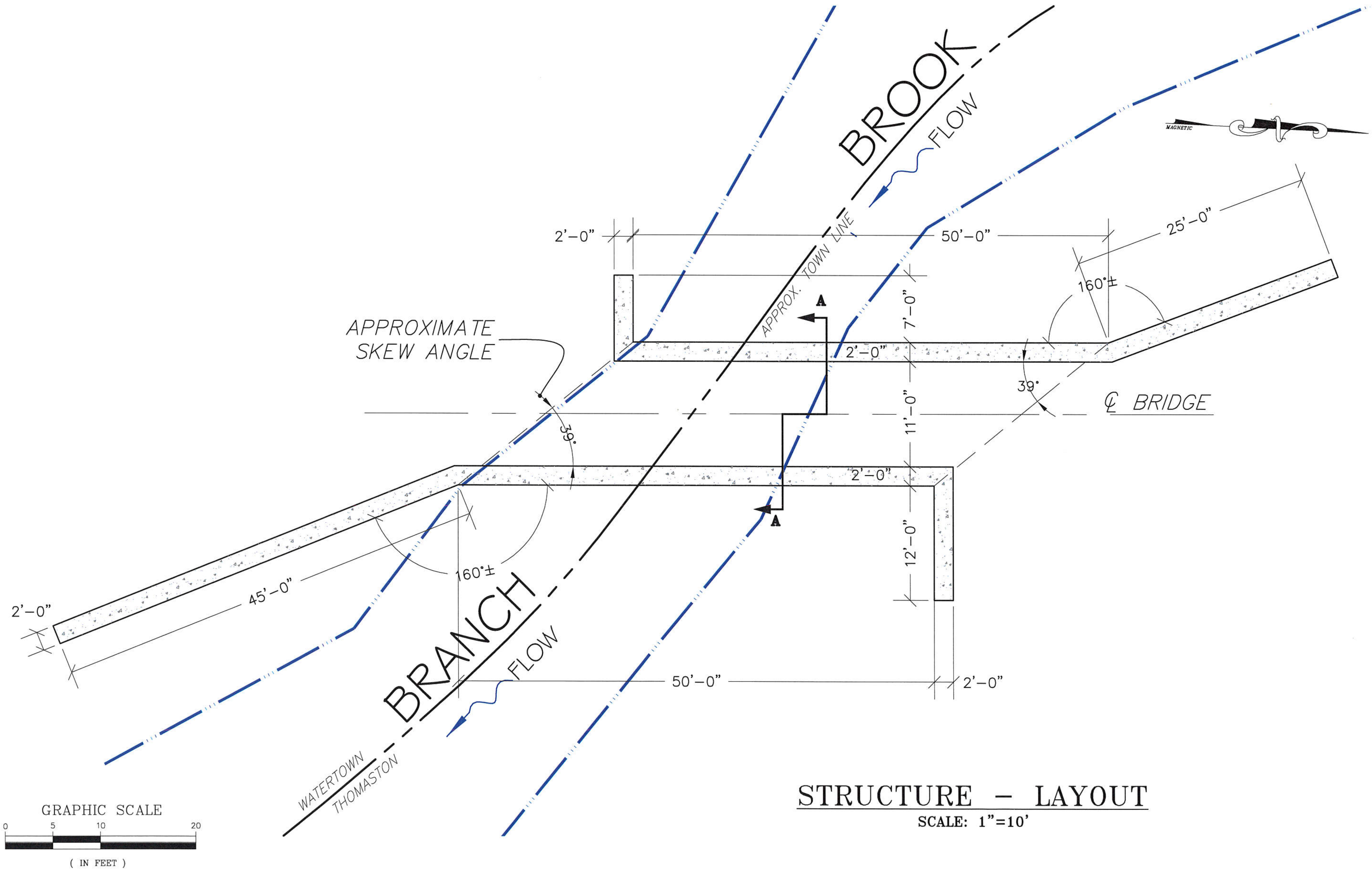
140 WILLOW STREET
WINSTED, CT.
(860) 379-6669

19 MIDSTATE DRIVE
AUBURN, MA.
(508) 721-7600

Drawing #: 1

Job #: 17-312

Attachment B
STRUCTURE PLANS 1 THROUGH 4 OF 4



STRUCTURE - LAYOUT

SCALE: 1"=10'

Designed By:	PM
Drawn By:	KLD
Checked By:	PM
CAD File:	Basemap
Drawing Scale:	1"=10'
Drawing date:	MARCH 20, 2017

Rev.	Date	Revision	By

STRUCTURE LAYOUT

PREPARED FOR

OLD TROLLEY BRIDGE

OVER BRANCH BROOK

WATERTOWN–THOMASTON, CONNECTICUT

Lenard Engineering, Inc.
Civil, Environmental and Hydrogeological Consultants

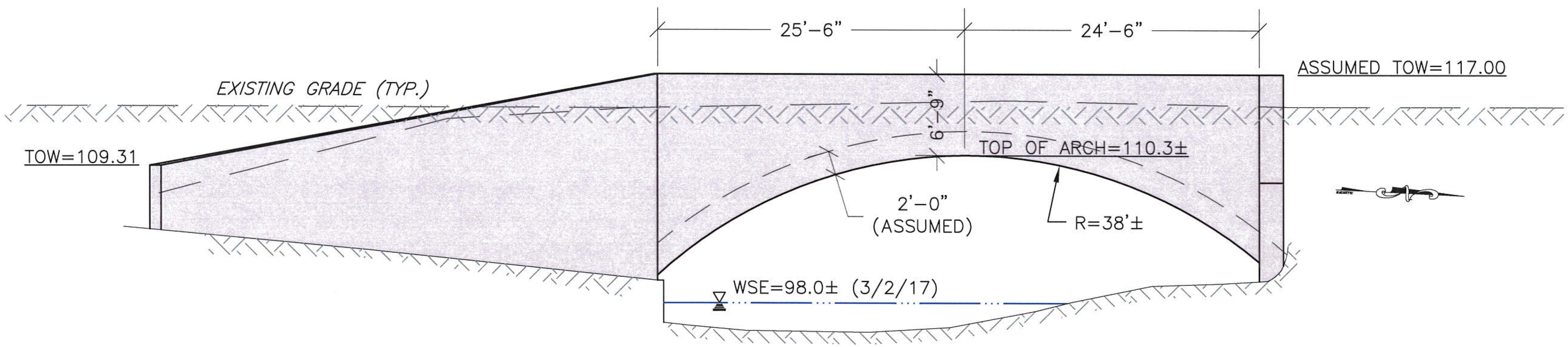
2210 Main Street
GLASTONBURY, CT
(860) 659-3100

140 Willow Street
WINSTED, CT
(860) 379-6669

19 Midstate Drive
AUBURN, MA
(508) 721-7600

Figure #: 1 OF 4

Job #: 17-312



GRAPHIC SCALE

0 5 10 20

(IN FEET)

DOWNSTREAM ELEVATION – LOOKING WEST

SCALE: 1"=10'

Designed By: PM
Drawn By: KLD
Checked By: PM
CAD File: Basemap

Drawing Scale: 1"=10'

Drawing date: MARCH 20, 2017

Rev.	Date	Revision	By

DOWNSTREAM ELEVATION

PREPARED FOR

OLD TROLLEY BRIDGE
OVER BRANCH BROOK
WATERTOWN–THOMASTON, CONNECTICUT

Lenard Engineering, Inc.
Civil, Environmental and Hydrogeological Consultants

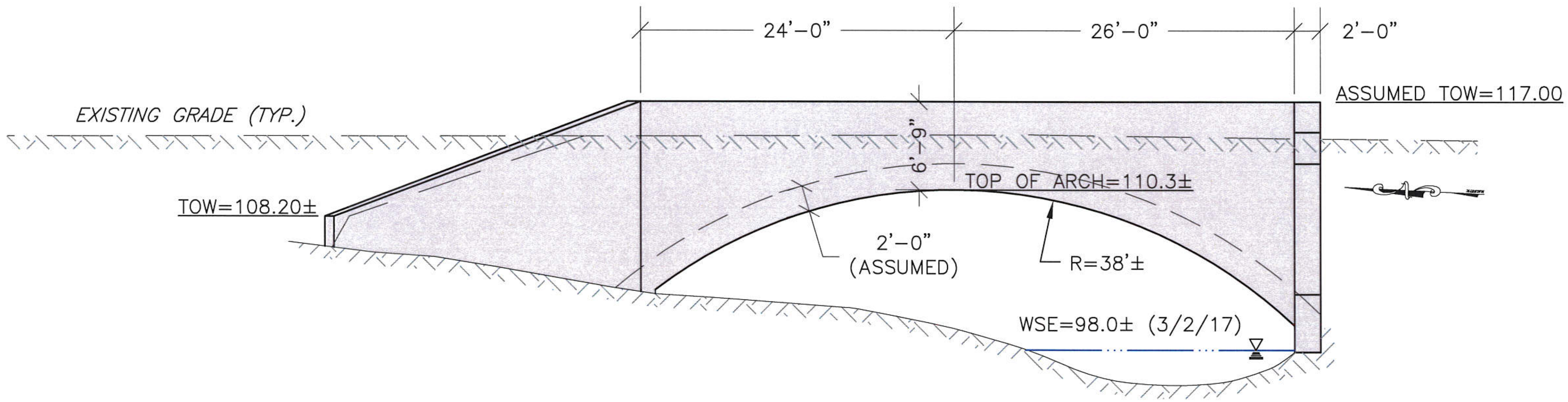
2210 Main Street
GLASTONBURY, CT
(860) 659-3100

140 Willow Street
WINSTED, CT
(860) 379-6669

19 Midstate Drive
AUBURN, MA
(508) 721-7600

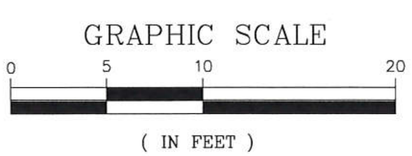
Figure #: 2 OF 4

Job #: 17-312



UPSTREAM ELEVATION – LOOKING EAST

SCALE: 1"=10'



Designed By: PM

Drawn By: KLD

Checked By: PM

CAD File: Basemap

Drawing Scale: 1"=10'

Drawing date: MARCH 17, 2017

Rev.	Date	Revision	By

UPSTREAM ELEVATION

PREPARED FOR

OLD TROLLEY BRIDGE

OVER BRANCH BROOK

WATERTOWN–THOMASTON, CONNECTICUT

Lenard Engineering, Inc.

Civil, Environmental and Hydrogeological Consultants

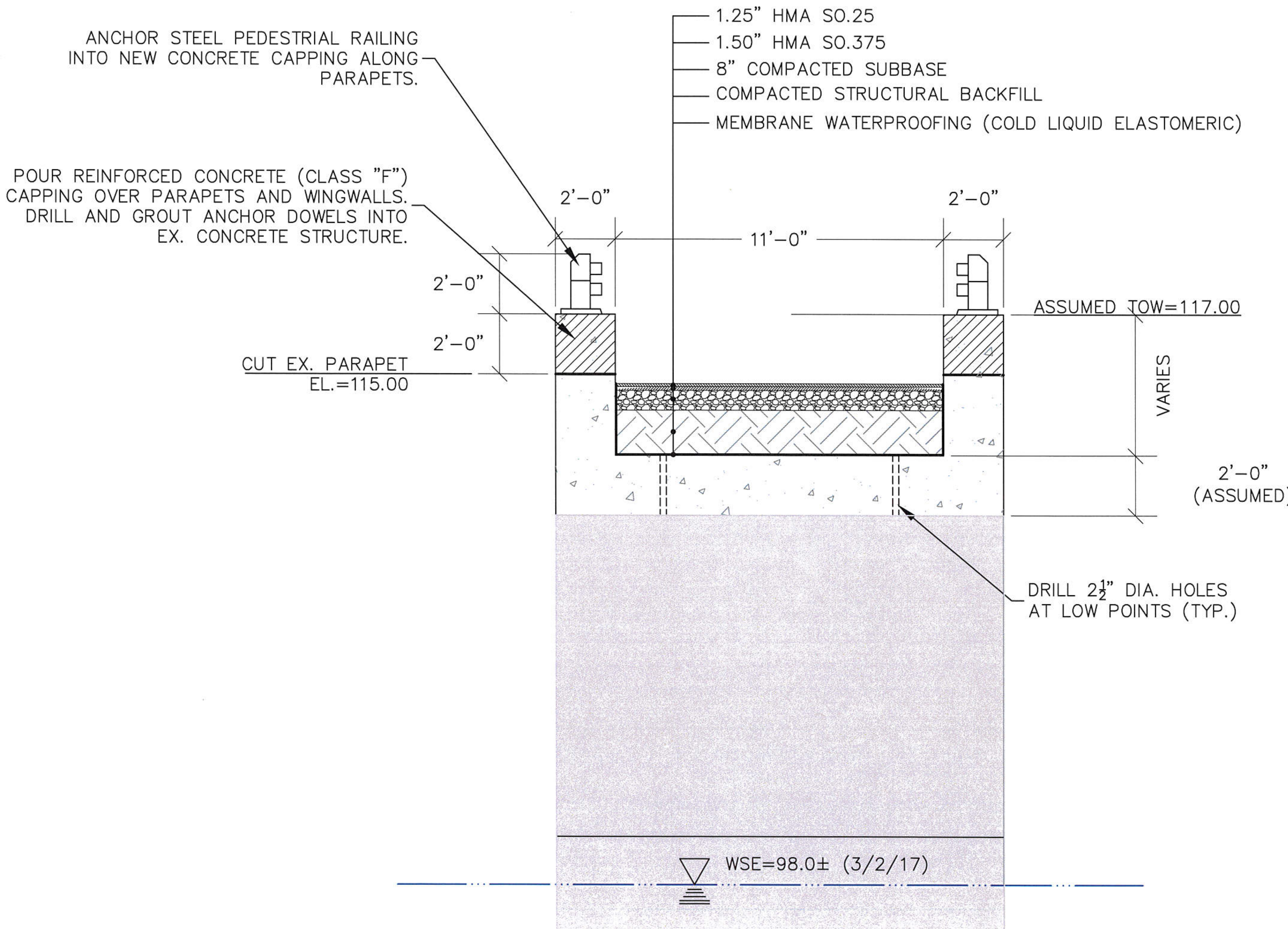
2210 Main Street GLASTONBURY, CT (860) 659-3100

140 Willow Street WINSTED, CT (860) 379-6669

19 Midstate Drive AUBURN, MA (508) 721-7600

Figure #: 3 OF 4

Job #: 17–312



SECTION A-A

SCALE: 1"=4'

GRAPHIC SCALE

0 2 4 8

(IN FEET)

Designed By: PM

Drawn By: KLD

Checked By: PM

CAD File: Basemap

Drawing Scale: 1"=10'

Drawing date: MARCH 20, 2017

Rev.	Date	Revision	By

TYPICAL SECTION

PREPARED FOR

OLD TROLLEY BRIDGE

OVER BRANCH BROOK

WATERTOWN-THOMASTON, CONNECTICUT

Lenard Engineering, Inc.
Civil, Environmental and Hydrogeological Consultants

2210 Main Street
GLASTONBURY, CT
(860) 659-3100

140 Willow Street
WINSTED, CT
(860) 379-6669

19 Midstate Drive
AUBURN, MA
(508) 721-7600

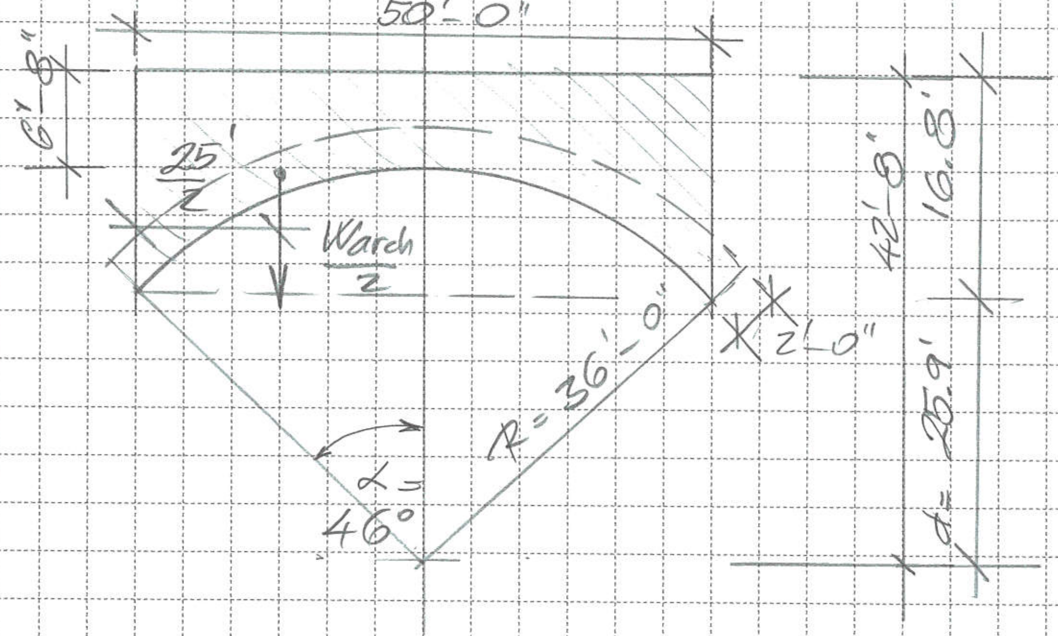
Figure #: 4 OF 4

Job #: 17-312

Attachment C
STRUCTURAL COMPUTATIONS

DEAD LOADS

WEIGHT OF THE ARCH



$d = \sqrt{36^2 - 25^2} = 25.9'$

$\alpha = \text{Arctg}\left(\frac{25.9'}{25.0'}\right) = 46°$

LENGTH OF THE ARCH = $2R\pi\left(\frac{2\times46°}{360°}\right) = \underline{L = 57.8'}$

WEIGHT OF THE ARCH:

$W_{arch} = (57.8')(11.0')(2.0')(150\,PCF) = \underline{190,740\ LBS}$

WEIGHT OF PARAPETS

AREA OF THE CIRCULAR SEGMENTS:

$$A_{CS} = \underset{\uparrow\, 36'}{R^2}\pi\left(\frac{92^\circ}{360^\circ}\right) - \frac{50.0' \times 25.9'}{2} = 393.0\ SF$$

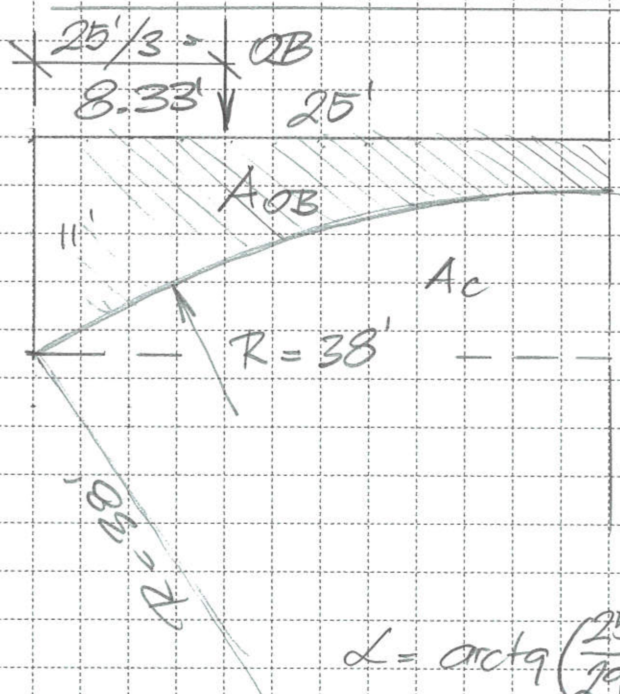
ELEVATION AREA OF PARAPET:

$$A_P = 50.0' \times 16.8' - 393.0\ SF = 447.0\ SF$$

WEIGHT OF THE TWO PARAPETS:

$$W_P = (2)(2')(447.0\ SF)(150\ PCF) = \underline{268{,}200\ LBS}$$

WEIGHT OF EARTH OVERBURDEN (APPROXIMATE)



$$= \underset{38'}{R^2}\pi\left(\frac{40.76^\circ}{360^\circ}\right) - \frac{(25')(29')}{2} = $$

$$= 151\ SF$$

$$A_{OB} = (25')(11') - 151\ SF = 124\ SF$$

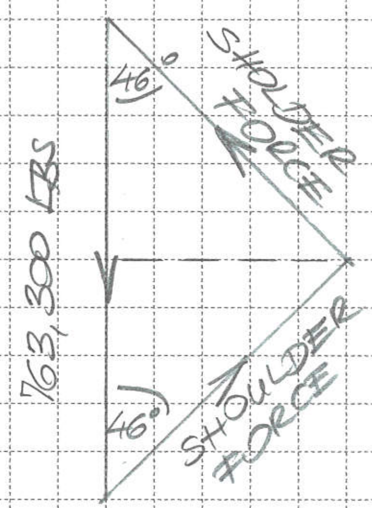
$$OB = (124\ SF)(11')(120\ PCF)$$

$$= \underline{163{,}680\ LBS}$$

$$\alpha = \arctan\left(\frac{25}{29}\right) = 40.76^\circ$$

DEAD LOAD REACTIONS AT THE SHOULDERS

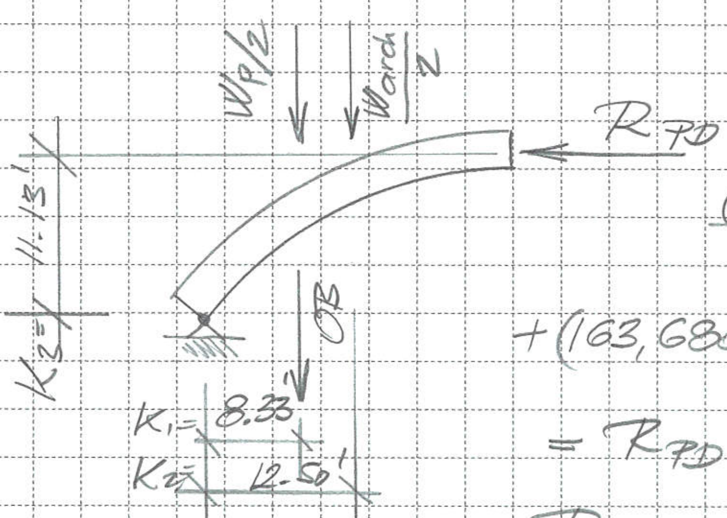
WEIGH OF ARCH =	190,740 LBS
WEIGHT OF PARAPETS	268,200 LBS
WEIGHT OF OVERBURDEN (2)(163,680 LBS) =	327,360 LBS
	768,300 LBS



SHOULDER FORCE =

$$R_{SD} = \frac{763{,}300 \text{ LBS}}{(2)\cos(46°)} = \underline{565{,}962 \text{ LBS}}$$

DEAD LOAD INTERNAL REACTION AT THE PEAK OF THE ARCH



$$\frac{W_p K_1}{2} + OB\,K_1 + \frac{W_{arch} K_2}{2} = R_{PD} K_3$$

$$\frac{(268{,}200 \text{ LBS})(8.33')}{2} +$$

$$+ (163{,}680 \text{ LBS})(8.33') + \frac{(190{,}740 \text{ LBS})(12.50')}{2}$$

$$= R_{PD}\,(11.13')$$

$$R_{PD} = \underline{329{,}976 \text{ LBS}}$$

LIVE LOADS

PEDESTRIAN LOAD = 90 PSF

ON FULL DECK = 11' × 50' × 90 PSF = 49,500 LBS

ON HALF DECK = 11' × 25' × 90 PSF = 24,750 LBS

ARCH SHOULDER REACTIONS:

$$R_{SL} = \frac{49{,}500 \text{ LBS}}{(2)(\cos(46^\circ))} = \underline{35{,}629 \text{ LBS}}$$

(VEHICULAR LOAD CONTROLS)

INTERNAL REACTION AT THE PEAK OF THE ARCH:

$$(R_{PL})(11.15') = (24{,}750 \text{ LBS})(12.50')$$

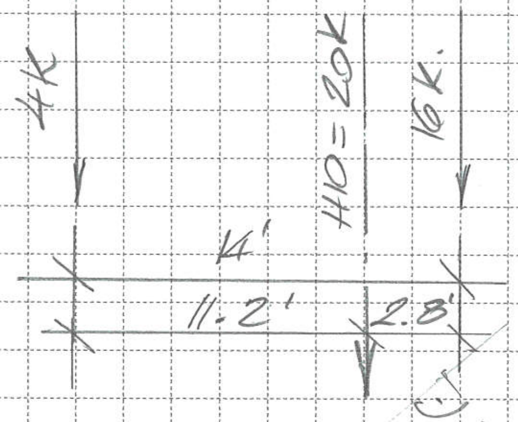
$$R_{PL} = \underline{27{,}747 \text{ LBS.}}$$

(VEHICULAR LOAD CONTROLS)

Lenard Engineering, Inc.
Civil, Environmental and Hydrogeological Consultants

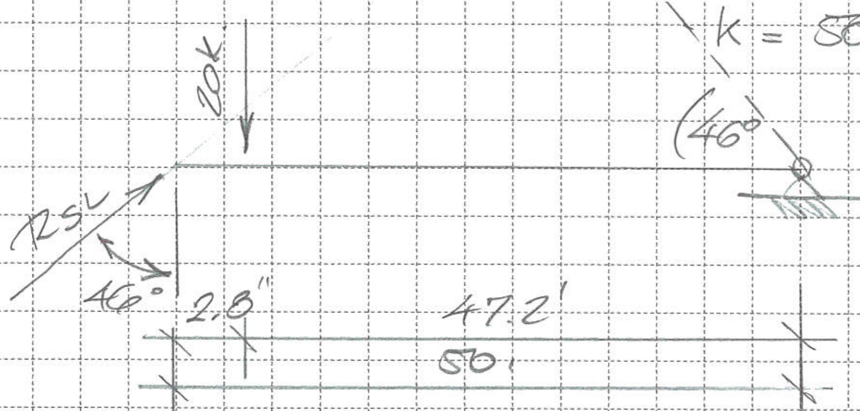
Job: WATERTOWN, CT TROLLEY BR.
Sheet No. 5 Of 6
Calculated By: PM Date: 3/17/17
Checked By: Date:
Scale

H10 VEHICULAR BRIDGE WITH DYNAMIC FACTOR



D = DYNAMIC FACTOR = 1.33

ARCH SHOULDER REACTION:



$k = 50' \cos(46°) = 34.73'$

$(20K)(47.2') = R_{SL}(34.73')$

$R_{SL} = 27.18\ K$

$(R_{SL})(D) = (27.18K)(1.33)$

$R_{SL} = 36,150\ LBS$

CONTROLS

INTERNAL REACTION AT THE PEAK OF THE ARCH:

$(R_{PL})(11.5') = 20,000\ LBS\ (25' - 2.8')$

$R_{PL} = 38,609\ LBS$

$(R_{PL})(D) = (38,609\ LBS)(1.33) = 51,350\ LBS$

CONTROLS

Rev. 9/24/09

Lenard Engineering, Inc.
Civil, Environmental and Hydrogeological Consultants

Job WATERTOWN, CT TROLLEY BR.
Sheet No. 6 Of 6
Calculated By: PM Date: 3/17/17
Checked By: Date:
Scale

LOAD COMBINATIONS

$\gamma_{DL} = 1.25$
$\gamma_{LL} = 1.75$

TABLES 3.4.1—1 &
3.4.1—2
AASHTO — LRFD

SHOULDER REACTION: (R_S)

$R_{SD}\,\gamma_{DL} + R_{SL}\,\gamma_{LL} =$

$= (565,962 \text{ LBS})(1.25) + (36,150 \text{ LBS})(1.75) = 770,715 \text{ LBS}$

CONTROLS

INTERNAL REACTION AT THE PEAK OF THE ARCH: (R_P)

$R_{PD}\,\gamma_{DL} + R_{PL}\,\gamma_{LL} =$

$= (329,976 \text{ LBS})(1.25) + (51,350 \text{ LBS})(1.75) = 502,333 \text{ LBS}$

CONCRETE COMPRESSION IN ARCH AT THE SHOULDER =

$$f_c = \frac{R_S}{A}$$

$$A = (15' \times 2')(144 \text{ IN}^2/\text{SF}) = 4,320 \text{ IN}^2$$

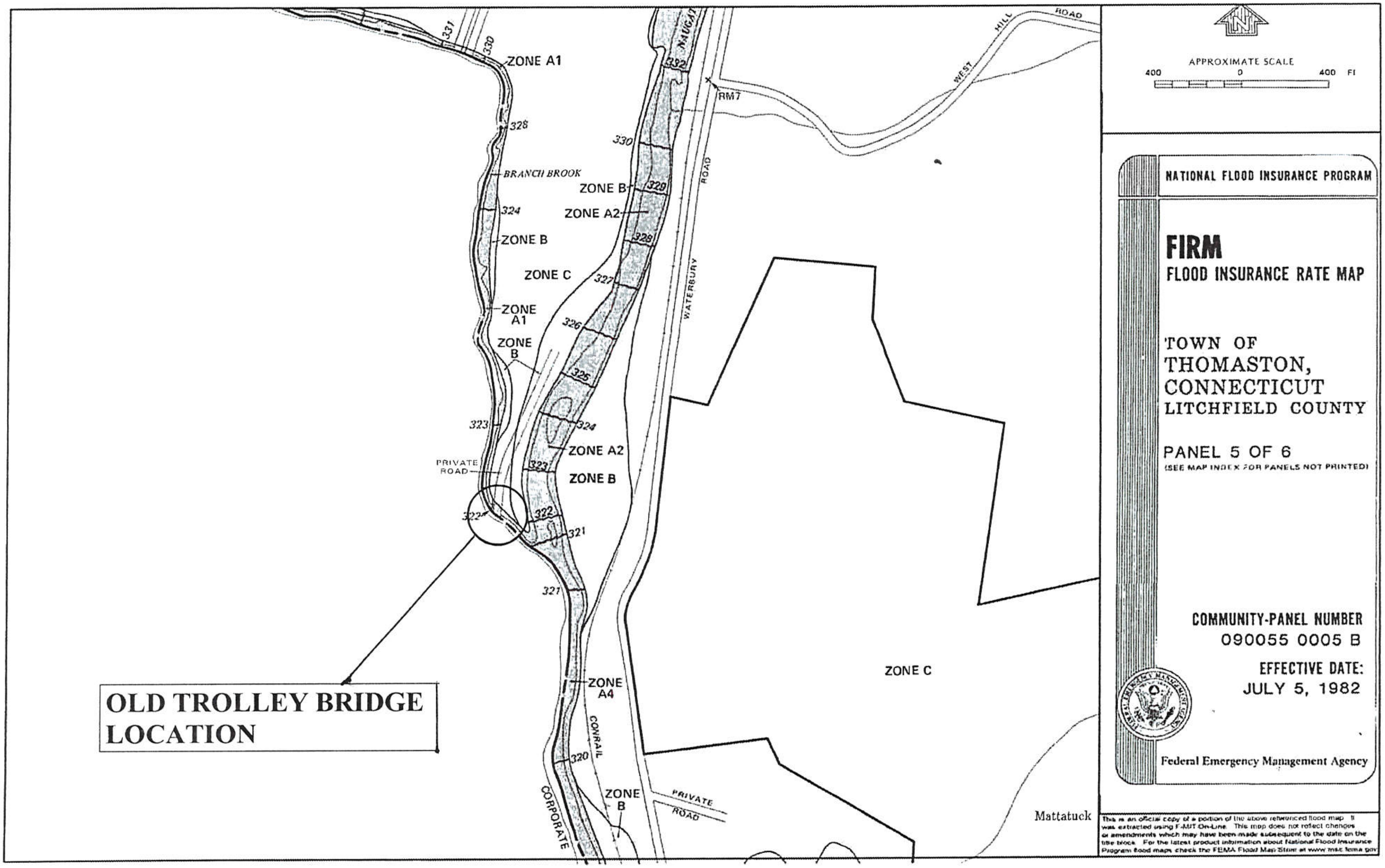
$$f_c = \frac{770,715 \text{ LBS}}{4,320 \text{ IN}^2} = 178 \text{ PSI} < f_c' \approx 1,500 \text{ PSI}$$

(ASSUMED)

Rev. 9/24/09

Z:\Forms\LEI GRAPH PAPER - PROTOTYPE.doc

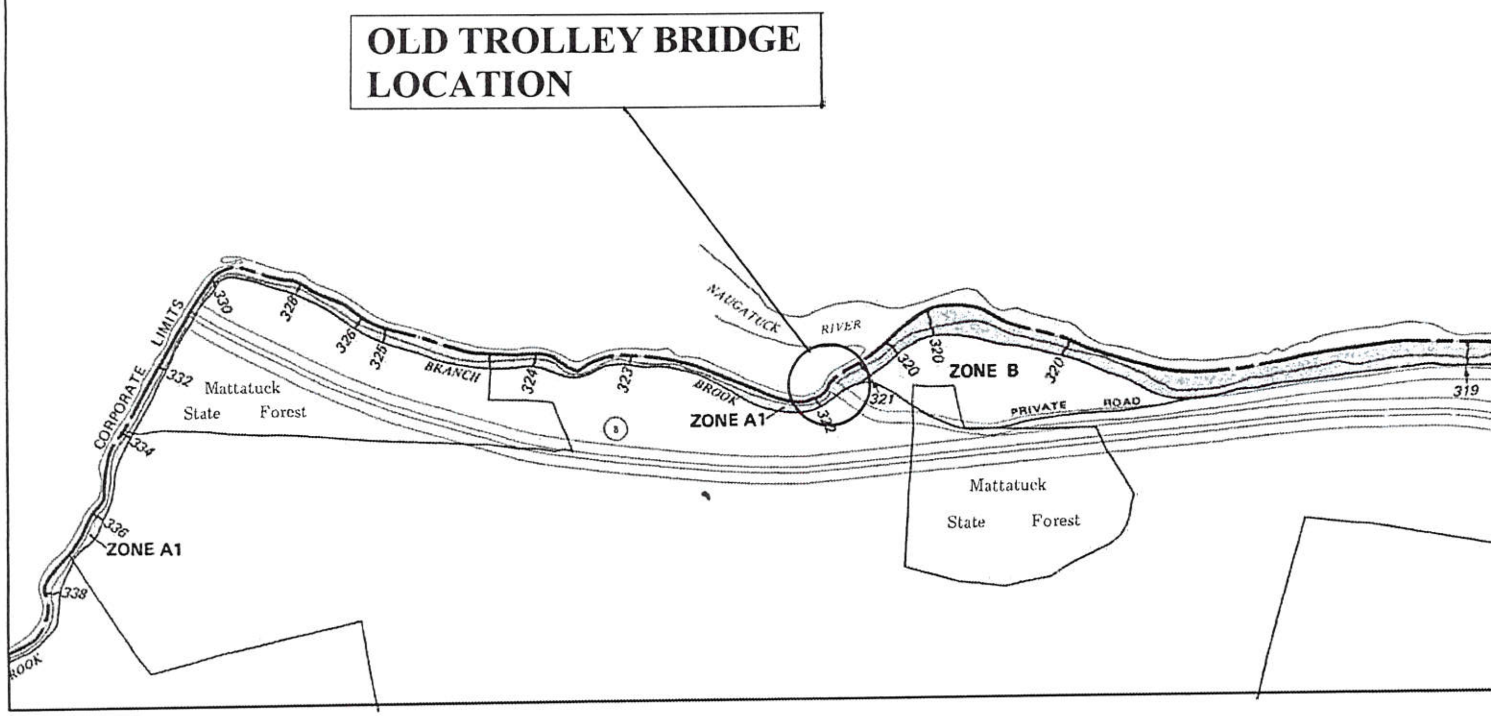
Attachment D
FEMA MAPS


NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
TOWN OF
THOMASTON,
CONNECTICUT
LITCHFIELD COUNTY
PANEL 5 OF 6
(SEE MAP INDEX FOR PANELS NOT PRINTED)
COMMUNITY-PANEL NUMBER
090055 0005 B
EFFECTIVE DATE:
JULY 5, 1982
Federal Emergency Management Agency
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov
APPROXIMATE SCALE
400
0
400 FT
OLD TROLLEY BRIDGE
LOCATION
ZONE A1
ZONE B
ZONE A2
ZONE C
ZONE A4
BRANCH BROOK
WATERBURY ROAD
WEST HILL ROAD
PRIVATE ROAD
CONRAIL
CORPORATE
RM7
Mattatuck

ELEVATION REFERENCE MARKS

REFERENCE MARK	ELEVATION IN FT. (NGVD)[1]	DESCRIPTION OF LOCATION
RM 1	385.23	USC&GS monument 16 feet west of centerline of Bidwell Hill Road and 72.6 feet southwest of SNET pole 1970.

[1] National Geodetic Vertical Datum of 1929



APPROXIMATE SCALE

400 0 400 FEET

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

TOWN OF
WATERTOWN,
CONNECTICUT
LITCHFIELD COUNTY

PANEL 2 OF 11
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
090058 0002 B

EFFECTIVE DATE:
NOVEMBER 5, 1980

federal emergency management agency
federal insurance administration

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov was developed between the log of the 2-year flood and the drainage area and it was found that for New England, discharges vary in accordance with the drainage area raised to the exponent power of 0.70.

There are no discharge records for Branch Brook. In 1970, the COE completed Black Rock Dam, located on Branch Brook about two miles above the mouth. Discharges from the dam are controlled by gate operations. The anticipated releases for the 10- and 50-year events would probably not exceed the nondamaging downstream channel capacity and these releases would not be made until downstream flood conditions subsided. The 100- and 500-year discharges are estimated based on hydrographs of major events routed through the reservoir. On Branch Brook above Wigwam Reservoir, peak discharge frequencies were determined by using relationships based on records for the USGS gaging station on nearby Leadmine Brook and then relating it to the Branch Brook watershed based on a direct drainage area relationship. A regional study was not undertaken to determine the drainage area-discharge relationship for Leadmine and Branch Brooks. However, the runoff characteristics of Leadmine Brook are considered to be similar to those of Branch Brook.

A summary of drainage area-peak discharge relationships is shown in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-YEAR	50-YEAR	100-YEAR	500-YEAR
NAUGATUCK RIVER					
At downstream corporate limits	137	5,300	5,400	8,000	21,600
At upstream corporate limits	131	5,000	5,000	5,200	14,000
BRANCH BROOK					
At mouth	22.8	800	800	900	2,300
At Black Rock Dam	20.4	800	800	900	2,300
At Wigwam Dam	17.5	2,200	5,300	7,600	16,500
STEELE BROOK					
At downstream corporate limits	12.4	1,410	2,740	3,550	6,245
Above Wattles Brook	9.0	1,130	2,200	2,840	5,000
At Hemingway Pond	5.7	820	1,600	2,060	3,600
Below Smith Pond Brook confluence	4.0	640	1,250	1,600	2,800

Attachment E
PHOTOGRAPHS

Picture 1 – Roadway on Bridge – Looking South

Picture 2 – Roadway on Bridge – Looking North

Picture 3 – Southeast Corner of Parapet

Picture 4 – Easterly Parapet


Picture 5 – Southwest Corner of Parapet


Picture 6 – Westerly Parapet and Upstream Channel


Picture 7 – Underside of Arch and Downstream Channel – Looking South


Picture 8 – Underside of Arch – Looking South


Picture 9 – Underside of Arch – Looking North


Picture 10 – Downstream (East) Fascia with Wingwalls

Picture 11 – Upstream Fascia and Northwest Wingwall

Picture 12 – Upstream Fascia and Southwest Wingwall


Picture 13 – Downstream Fascia


Picture 14 – Westerly Embankment – Upstream

Picture 15 – Southwest Embankment

Picture 16 – Downstream Channel

Attachment F
CONSTRUCTION COST ESTIMATE

Estimate

Estimated Cost:$309,335.15

Contingency: 15.00%

Estimated Total: $355,735.42

REHABILITATION OF OLD CONCRETE TROLLEY BRIDGE OVER THE BRANCH BROOK TOWNS OF WATERTOWN AND THOMASTON

Base Date: 03/20/17

Spec Year: 11

Unit System: E

Work Type: STRUCTURAL CONCRETE

Highway Type: LOCAL USE - Local

Urban/Rural Type: Rural

Season: SUMMER 6/21 - 9/20

County: WATERTOWN

Latitude of Midpoint: 413830

Longitude of Midpoint: 730450

District: 4

Federal/State Project Number: N/A

Estimate Type: Preliminary Evaluation

Prepared by Lenard Engineering, Inc.
Checked by PM
Approved by PM

Estimate:

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension

Group 0001: **Group**

Initial Group

Line #	Item Number / Description	Quantity	Units	Unit Price	Extension
0001	0201001 CLEARING AND GRUBBING	1.000	LS	$10,000.00000	$10,000.00
0002	0201012 REMOVAL OF TREES	20.000	ea.	$200.00000	$4,000.00
0003	0202000 Earth Excavation	106.000	c.y.	$15.00000	$1,590.00
0004	0204151 HANDLING WATER	1.000	LS	$10,000.00000	$10,000.00
0005	0209001 FORMATION OF SUBGRADE	86.000	s.y.	$4.33333	$372.67
0006	0212000 Subbase	19.000	c.y.	$37.46667	$711.87
0007	0216000 Pervious Structure Backfill	87.000	c.y.	$61.34924	$5,337.38
0008	0219001 SEDIMENTATION CONTROL SYSTEM	100.000	l.f.	$7.94857	$794.86
0009	0406172 HMA S0.375	7.200	ton	$284.75209	$2,050.22
0010	0406173 HMA S0.25	6.000	ton	$329.09971	$1,974.60
0011	0503031 REMOVAL OF SUPERSTRUCTURE CONCRETE	1.000	LS	$3,500.00000	$3,500.00
0012	0601201 CLASS "F" CONCRETE	28.000	c.y.	$2,001.80709	$56,050.60
0013	0601893 VARIABLE DEPTH PATCH FOR HISTORIC CONCRETE BRIDGES	500.000	c.f.	$250.00000	$125,000.00
0014	0601923 SAW CUTTING CONCRETE	189.000	l.f.	$98.00000	$18,522.00
0015	0602006 DEFORMED STEEL BARS - EPOXY COATED	2,100.000	lb.	$2.35273	$4,940.73
0016	0602910 DRILLING HOLES AND GROUTING DOWELS	63.000	ea.	$49.97676	$3,148.54
0017	0703010 STANDARD RIPRAP	65.000	c.y.	$79.42000	$5,162.30

Estimate:

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
0018	0707009 MEMBRANE WATERPROOFING (COLD LIQUID ELASTOMERIC)	133.000	s.y.	$170.52169	$22,679.38
0019	0904602 OPEN BRIDGE RAIL (BICYCLE RAIL)	100.000	l.f.	$185.00000	$18,500.00
0020	0975004 MOBILIZATION AND PROJECT CLOSEOUT	1.000	LS	$15,000.00000	$15,000.00

Total for Group 0001:$309,335.15

Lenard Engineering, Inc.
Civil, Environmental and Hydrogeological Consultants

Job WATERTOWN, CT TROLLEY BR.
Sheet No. 1 Of 3
Calculated By: PM Date: 3/21/17
Checked By: Date:
Scale

CALCULATION OF QUANTITIES

003 EARTH EXCAVATION

$[(50')(11') - (50')(\frac{2}{3})(12')](11') =$ (OVER ARCH) 1,650 CF

$(2)(11')(11')(10')/2$ = (OUTSIDE ARCH) 1,210 CF

2,860 CF

2,860 CF / 27 = 106 CY

005 FORMATION OF SUBGRADE

(70')(11') = 770 SF = 770 SF/9 = 86 SY

006 SUBBASE

(770 SF)(8"/12) = 513 CF = 513 CF/27 = 19 CY

007 PERVIOUS STRUCTURE BACKFILL

EARTH EX. – SUBBASE = 106 CY – 19 CY = 87 CY

008 SEDIMENTATION CONTROL SYSTEM

(4)(25 LF) = 100 LF

Rev. 9/24/09

Z:\Forms\LEI GRAPH PAPER - PROTOTYPE.doc

Lenard Engineering, Inc.
Civil, Environmental and Hydrogeological Consultants

Job WATERTOWN, CT TROLLEY BR.
Sheet No. 2 Of 3
Calculated By: PM Date: 3/21/17
Checked By: Date:
Scale

009 HMA S 0.375

(770 SF)(1.5"/12)(150 PCF)/2,000 = 7.2 TON

010 HMA S 0.25

(770 SF)(1.25"/12)(150 PCF)/2,000 = 6.0 TON

011 REMOVAL OF SUPERSTRUCTURE CONC.

(45' + 50' + 12' + 7' + 50' + 25')(2')(2')/27 = 28 CY

(1 LS)

012 CLASS "F" CONCRETE

(SAME AS CONCRETE REMOVAL) 28 CY

014 SAW - CUTTING CONCRETE

45' + 50' + 12' + 7' + 50' + 25' = 189 LF

015 DEFORMED STEEL BARS

(28 CY OF CONC.)(75 LBS/CY) = 2,100 LBS

016 DRILLING HOLES AND GROUTING DOWELS

(189 LF)(1 DOWEL / 3 LF) = 63 EA.

Lenard Engineering, Inc.
Civil, Environmental and Hydrogeological Consultants

Job: WATERTOWN, CT TROLLEY BR.
Sheet No. 3 Of 3
Calculated By: PM Date: 3/21/17
Checked By: Date:
Scale

017 STANDARD RIPRAP

$(70')(10')(2.5')/27 =$ 65 CY

018 MEMBRANE WATERPROOFING

OVER THE ARCH -

$[(2)(40')(\pi)/4] \times (11' + 4' + 4') = 1{,}194$ SF =

$= 1{,}194$ SF$/9 =$ 133 SY

0013 VARIABLE DEPTH PATCH

FASCIAS: $[50' \times 17' - 50' \times (\frac{2}{3}) \times 10'] \times 2 =$ 1,033 SF

UNDERSIDE OF ARCH: $(2 \times 38')\pi/4 \times 11' =$ 557 SF

NW WINGWALL $\left(\frac{15'+3'}{2}\right)(25') =$ 225 SF

SW WINGWALL $20' \times 7' =$ 140 SF

NE WINGWALL: $12' \times \left(\frac{17'+8'}{2}\right) =$ 150 SF

SE WINGWALL $\left(\frac{18'+6'}{2}\right) \times 45' =$ 540 SF

2,645 SF

ASSUME 1.5" THICKNESS:

$(2{,}645 \text{ SF})(1.5''/12) =$ 330 CF

USE 500 CF TO ACCOUNT FOR THE INSIDE FACE OF THE WALLS