Preliminary Design Report

Bootfoot Bridge #5495
Over
N. Branch Whitney Brook

Bridgewater, Maine

BR-1786(800)X
PIN 17868.00

Maine Department of Transportation

Bridge Program

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BACKGROUND INFORMATION

TOWN - Bridgewater **PIN -** 17868.00 **BRIDGE NO. -** 5495

FUNDING - Federal/State **STATE ROUTE -** Bootfoot Road

TRANSPORTATION INVESTMENT PROGRAM:

YEAR 12/13	**ESTIMATE**	$450,000
	FUNDS TRANSFERRED IN/OUT	$400,000
	TOTAL	$50,000

PROGRAM SCOPE - Bridge Culvert Replacement

PROGRAM DESCRIPTION - Replacement of Bootfoot Bridge #5495 in Bridgewater which carries West Road over North Branch Whitney Brook.

PROJECT BACKGROUND - This bridge was constructed in 1953. The steel structural plate arch has excessive damage to the upstream opening and in need of replacement. ~~Preconstruction engineering is funded in the 12/13 BTIP.~~

HIGHWAY SYSTEM - State Aid **FUNCTIONAL CLASSIFICATION -** Minor Collector

URBAN/RURAL - Rural **FHWA SUFFICIENCY RATING -** 49.6

LOAD POSTING - N/A **POSTED SPEED -** 45 mph

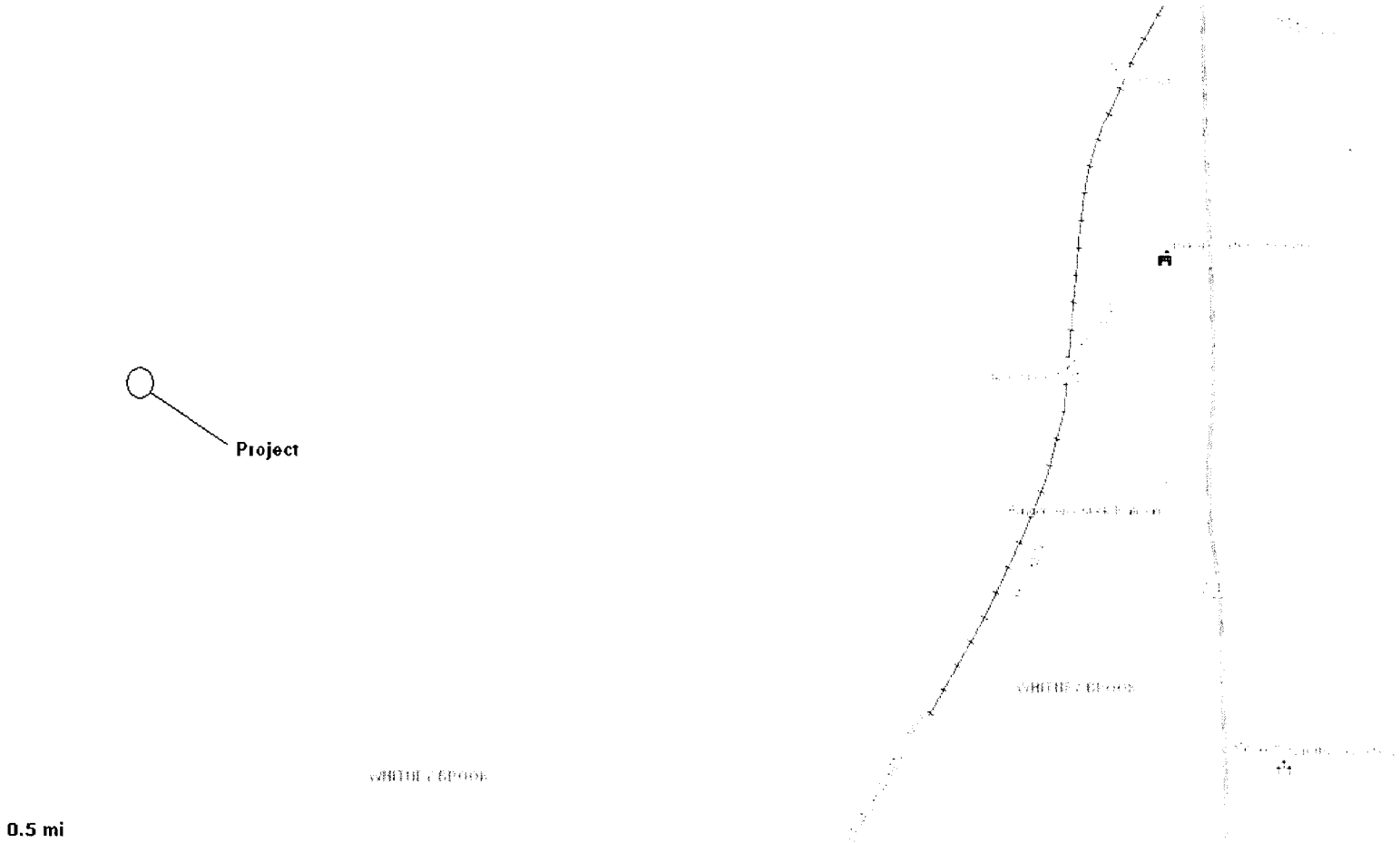
STRUCTURALLY DEFICIENT - Yes **FUNCTIONALLY OBSOLETE -** N/A

TRAFFIC - **2011** **AADT** 190 **ACCIDENT DATA, CRF -** 0.0

2031 **AADT** 230 **DHV** 23

Site Location

Bridgewater, Maine
Bootfoot Bridge
Bridge No. 5495
PIN 017868.00



Longitude -67.872604, Latitude 46.419523

HYDROLOGY REPORT

The drainage basin characteristics for Bootfoot Bridge #5495 in Bridgewater on Bootfoot Road over N Branch Whitney Brook were provided by the Maine Department of Transportation Office of the Environmental Hydrology. The flows were computed based on the 1999 USGS full regression equation. During the public meeting March 3, 2011, two audience members stated that this past December after a large rain storm the water was the highest they had ever seen it, but that it did not overtop the roadway. No other flow data was available from either gage data or existing studies, therefore the hydrology data was used as provided. Provided Data is as follows:

Summary

Drainage Area	=	8.79 mi^2
Fish Passage Flow (Low)	=	1.77 cfs
Fish Passage Flow (High)	=	26.35 cfs
Ordinary High Water ($Q_{1.1}$)	=	118.6 cfs
Q_{25}	=	607.8 cfs
Design Discharge (Q_{50})	=	712.9 cfs
Check Discharge (Q_{100})	=	826.3 cfs
Q_{500}	=	1105.2 cfs

Reported By: Brian Reeves
Date: April 22, 2011

HYDRAULICS REPORT
(Existing Bridge)

Bootfoot Bridge #5495 is located in the town of Bridgewater on Bootfoot Road over N Branch Whitney Brook. The existing bridge consists of a steel structural plate arch on concrete footings built in 1953.

The existing bridge was analyzed using the HY-8 program version 7.2. Two different HY-8 models were used for the existing structure. The first model was an attempt to model the bridge in "as built" condition, prior to the upstream opening damage. The "as built" bridge was modeled as a 15' span, 7'-5" rise arch with 1.5' of the footing exposed. The second model attempted to model the bridge "as is," with the folded end plates on the upstream end of the culvert. The "as is" bridge was modeled by leaving the top, center of the original arch intact, blocking two feet of either side with two feet of the footing exposed to account for known scour. Higher velocity flows caused by the folded end plates has caused scour below the footings of the existing steel arch approximately half way along the length.

Both models have a natural bottom and tail water based on an irregular channel. Whitney Brook above the structure has a moderately steep slope which levels after the culvert creating several wide, shallow pools downstream. The existing bridge is adequate in terms of hydraulics. The "as is" structure has a Hw/D of 1.12 at Q50 flows.

Summary

	Existing Structure (as built)	Existing Structure (as is)
Total Area of Waterway Opening	109 ft^2	85 ft^2
Headwater elevation @ Low Fish Flow	452.45 ft	452.45 ft
Water Depth @ Low Fish Flow	0.49 ft	0.99 ft
Headwater elevation @ High Fish Flow	453.08 ft	452.91 ft
Water Depth @ High Fish Flow	1.12 ft	1.45 ft
Headwater elevation @ $Q_{1.1}$	454.53 ft	454.1 ft
Headwater elevation @ Q_{25}	459.21 ft	460.32 ft
Headwater elevation @ Q_{50}	460.09 ft	461.56 ft
Headwater elevation @ Q_{100}	460.99 ft	462.91 ft
Hw/D @ Q_{50}	0.97	1.12

*elevations based NAVD of 1988

	Existing Structure (as built)	Existing Structure (as is)
Outlet Velocity @ Low Fish Flow	0.27 ft/s	0.13 ft/s
Outlet Velocity @ High Fish Flow	2.29 ft/s	1.43 ft/s
Outlet Velocity @ $Q_{1.1}$	6.38 ft/s	4.97 ft/s
Outlet Velocity @ Q_{25}	11.21 ft/s	12.85 ft/s
Outlet Velocity @ Q_{50}	11.88 ft/s	13.77 ft/s
Outlet Velocity @ Q_{100}	12.55 ft/s	14.74 ft/s

*elevations based NAVD of 1988

Reported By: Brian Reeves
Date: April 25, 2011

HYDRAULIC REPORT
(Proposed Bridge)

Bootfoot Bridge #5495 is located in Bridgewater on Bootfoot Road over N Branch Whitney Brook. The estimated bankfull width provided was 23.6'. The proposed bridge was analyzed using the HY-8 program version 7.2.

The existing straight alignment matches stream alignment well, no change is required. The existing bridge is a 15' span, 7'-5" rise steel structural plate arch on concrete footings. Three alternatives for replacement and one for rehabilitation were considered.

The first alternative is to replace in kind with a 15' span, 7'-5" rise steel structural plate arch (total opening area 109 ft^2). To analyze this, a 15' span, 7'-5" rise arch with one foot of the footing exposed was used. The headwater depth and outlet velocities would be the similar to the existing "as built."

The second alternative is to slipline the existing bridge with a 12'-11" span, 11'-3" rise steel structural plate underpass culvert (total opening area 104 ft^2). The underpass culvert was analyzed based on 1' embedment and an invert elevation of 449.02'. The Hw/D ratio at Q50 is 0.97 which is above the 0.90 design criteria. At Q50 flow headwater depth decreases and outlet velocity is higher than existing "as built," but both headwater depth and outlet velocity are lower than the existing "as is." At the Q100 flow, headwater elevation decreases by 0.77' over "as built" and 2.69' over "as is." Alternative #2 will have no negative impact on abutting properties.

Alternative #3 is to replace the existing bridge with a 15' span, 9' rise concrete box culvert (total opening area 105 ft^2). Alternative #4 is to replace the existing bridge with a 16' span, 7' rise concrete arch or three sided frame (total opening area 112 ft^2). Alternative #5 is to replace the existing with a 28' span, 10' rise concrete box culvert (total opening area 181 ft^2). Alternative #5 satisfies 1.2 bankfull based on the estimated bankfull width of 23.6'. These alternatives were not analyzed using HY-8 as they were ruled out for other engineering issues such as cost and maintenance of traffic.

Plain riprap will be adequate for slope protection and aprons at each end.

The preferred alternative in terms of hydraulics is #1, replacement in kind with a 15' span, 7'-5" rise steel structural plate arch. At Q50 headwater elevation and outlet velocity should match the existing "as built" structure. The final decision on what alternative to use will be based on other factors besides hydraulics such as initial cost, constructability, traffic control and life cycle cost.

Summary

	Existing Structure (as built)	Existing Structure (as is)	12'-11" S x 11'-3" R Underpass
Total Area of Waterway Opening	109 ft^2	85 ft^2	104 ft^2
Headwater elevation @ Low Fish Flow	452.45 ft	452.45 ft	452.45 ft
Water Depth @ Low Fish Flow	0.49 ft	0.99 ft	3.43 ft
Headwater elevation @ High Fish Flow	453.08 ft	452.91 ft	452.83 ft
Water Depth @ High Fish Flow	1.12 ft	1.45 ft	3.81 ft
Headwater elevation @ $Q_{1.1}$	454.53 ft	454.1 ft	453.65 ft
Headwater elevation @ Q_{25}	459.21 ft	460.32 ft	458.30 ft
Headwater elevation @ Q_{50}	460.09 ft	461.56 ft	459.23 ft
Headwater elevation @ Q_{100}	460.99 ft	462.91 ft	460.22 ft
Hw/D @ Q_{50}	0.97	1.20	0.97
Outlet Velocity @ Low Fish Flow	0.27 ft/s	0.13 ft/s	0.06 ft/s
Outlet Velocity @ High Fish Flow	2.29 ft/s	1.43 ft/s	0.82 ft/s
Outlet Velocity @ $Q_{1.1}$	6.38 ft/s	4.97 ft/s	3.19 ft/s
Outlet Velocity @ Q_{25}	11.21 ft/s	12.85 ft/s	11.65 ft/s
Outlet Velocity @ Q_{50}	11.88 ft/s	13.77 ft/s	12.37 ft/s
Outlet Velocity @ Q_{100}	12.55 ft/s	14.74 ft/s	13.10 ft/s

*elevations based on North American Vertical Datum (NAVD) of 1988

Reported by: Brian Reeves
Date: April 25, 2011

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

BRIDGEWATER
AROOSTOOK COUNTY
BOOTFOOT BRIDGE
OVER
NORTH BRANCH OF WHITNEY BROOK
BOOTFOOT ROAD
FEDERAL AID PROJECT NO. STP-1786(800)X
PIPE ARCH SLIPLINING, GRAVEL SHOULDER REHABILITATION and GUARDRAIL UPDATE
BRIDGE NO. 5495

SPECIFICATIONS

Design: Load and Resistance Factor Design per AASHTO LRFD Bridge Design Specifications, Fifth Edition and Interim Specifications through 2010.

DESIGN LOADING

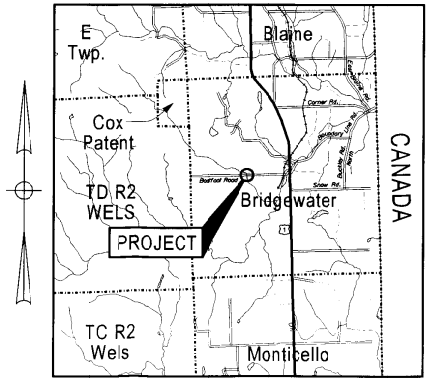
Live Load ..... HL - 93 Modified

TRAFFIC DATA

Current (2011) AADT	190
Future (2031) AADT	230
DHV - % of AADT	10
Design Hour Volume	23
Heavy Trucks (% of AADT)	24
Heavy Trucks (% of DHV)	16
Directional Distribution (% of DHV)	54
18 kip Equivalent P 2.0	45
18 kip Equivalent P 2.5	43
Design Speed (mph)	45

HYDROLOGIC DATA

Drainage Area	8.79 sq mi
Design Discharge (Q50)	712.9 cfs
Check Discharge (Q100)	826.3 cfs
Headwater Elevation (Q50)	426.77 ft
Headwater Elevation (Q100)	463.7 ft
Discharge Velocity (Q50)	12.46 fps
Discharge Velocity (Q100)	13.16 fps
Headwater Elevation (Q1.1)	456.63 ft
Discharge Velocity (Q1.1)	6.85 fps
Headwater Elevation (Q25)	461.84 ft



LOCATION MAP

2 0 2 4
Scale of Miles

LIST OF DRAWINGS

Title Sheet 1
General Plan 2
Pipe Details 3

UTILITIES

Maine Public Service Company
Northern New England Telephone Operations LLC
Polaris Cable Services

MAINTENANCE OF TRAFFIC

The roadway will remain open to two-way traffic at all times. It may be reduced to one lane with flaggers during the duration of construction.

APPROXIMATE COST

Including Engineering $315,000

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

APPROVED | DATE

COMMISSIONER:

PROJECT INFORMATION

PROGRAM	BRIDGE	
PROJECT MANAGER	S. BRIDGE	SIGNATURE
DESIGNER	B. REYES	
CONSULTANT		P.E. NUMBER
PROJECT RESIDENT		
CONTRACTOR		DATE

PIN 17868.00

STP-1786(800)X

BRIDGEWATER
BOOTFOOT BRIDGE

TITLE SHEET

SHEET NUMBER

1

OF 3

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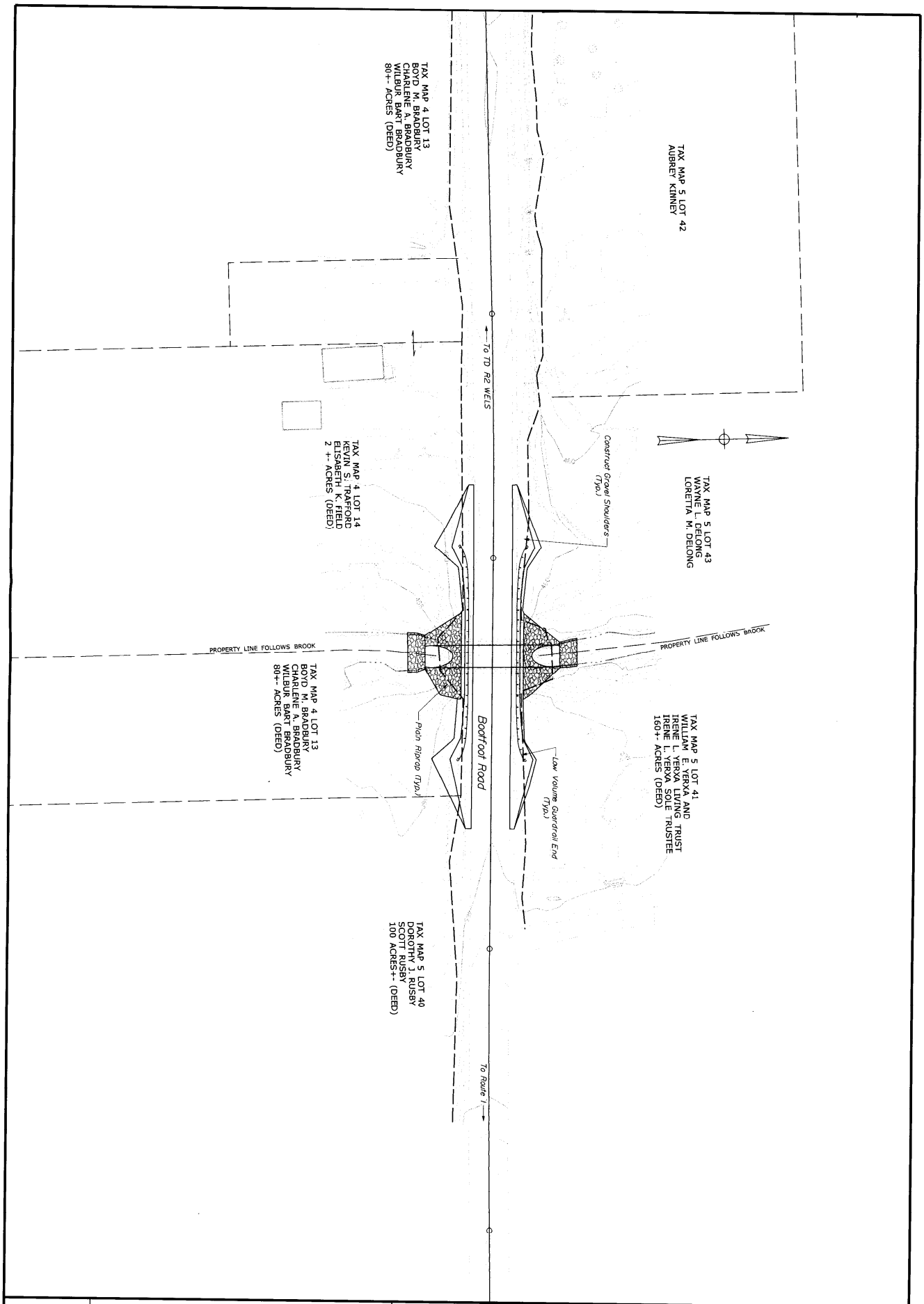
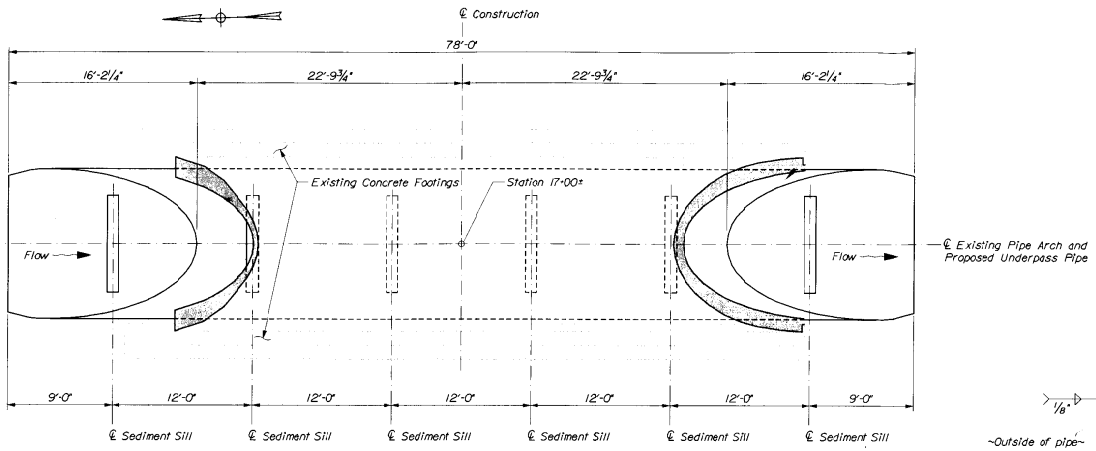
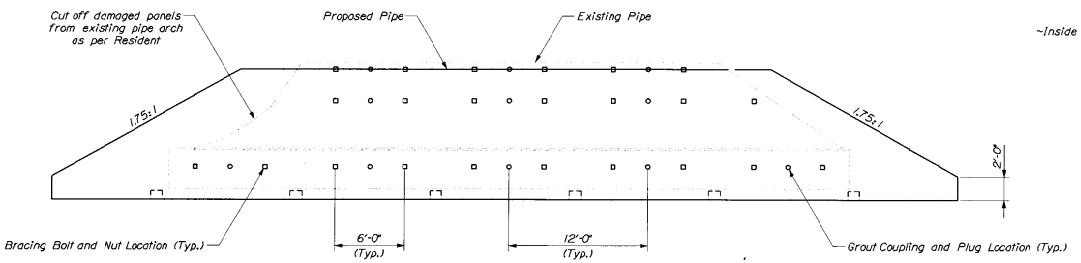


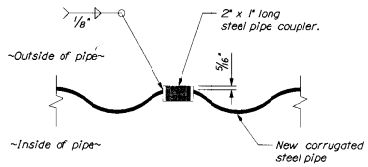
SHEET NUMBER 2 OF 3	BOOTFOOT BRIDGE NORTH BRANCH OF WHITNEY BROOK BRIDGEWATER AROOSTOOK COUNTY GENERAL PLAN	PROJ. MANAGER S. BODGE DESIGN-DETAILED M. WRIGHT CHECKED-REVIEWED DESIGN2-DETAILED2 DESIGN3-DETAILED3 REVISIONS 1 REVISIONS 2 REVISIONS 3 REVISIONS 4 FIELD CHANGES	BY D. SHAW	DATE SIGNATURE P.E. NUMBER DATE	STATE OF MAINE DEPARTMENT OF TRANSPORTATION STP-1786(800)X BRIDGE NO. 5495 PIN 17868.00 BRIDGE PLANS



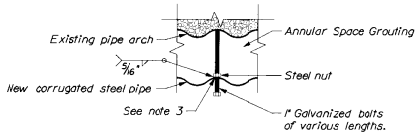
PLAN



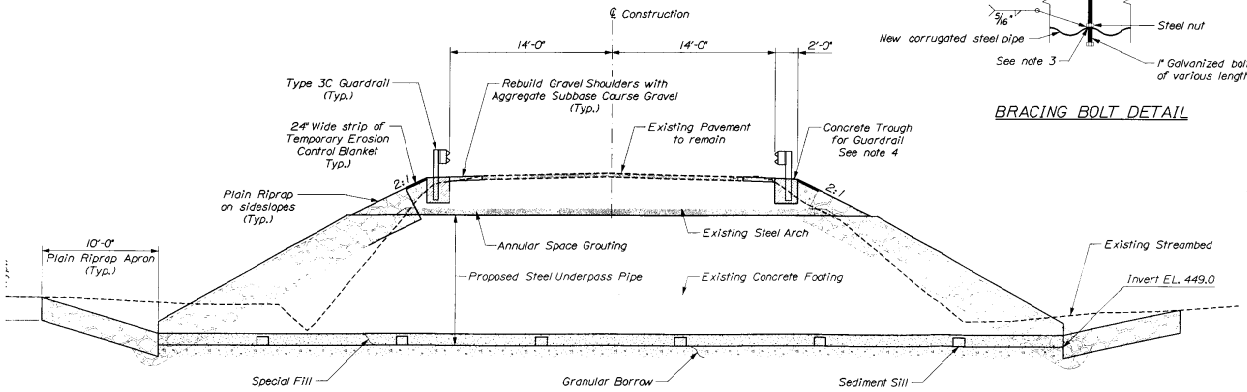
GROUT NIPPLE AND BRACING BOLT LAYOUT



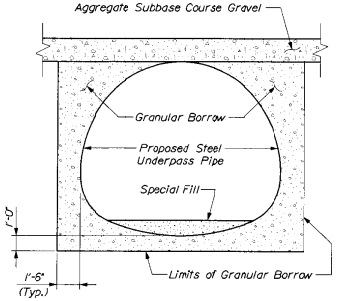
GROUT NIPPLE DETAIL



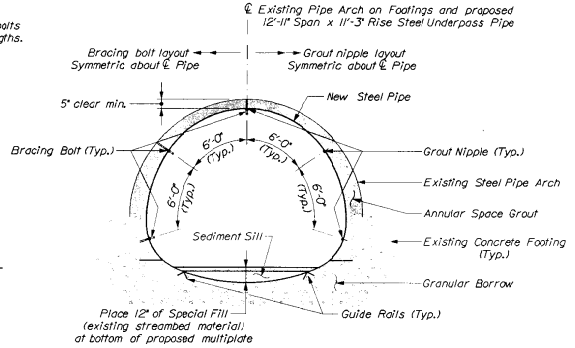
BRACING BOLT DETAIL



TRANSVERSE SECTION



SECTION
Not sliplined



SECTION
Through sliplline

STRUCTURAL PLATE STRUCTURE NOTES

1. One 12'-11" span x 11'-3" rise steel underpass pipe is required. All plates shall be 0.25 inch (3 Ga.) thick.

2. The steel underpass pipe shall be constructed in the dry. The approximate weight of the structure is 35,000 pounds. The Contractor should contact the pipe manufacture for exact weight of pipe before determining the equipment size needed for pipe placement.

3. Riprap adjacent to the pipe shall be carefully placed so as not to damage the pipe and so that the finished slope will match the ends of the pipe. Any extra labor, material or equipment used will be considered incidental to Item No. 610.08, Plain Riprap. Any damage done to the structure during construction shall be repaired or replaced as determined by the Resident at the Contractor's expense.

4. For concrete trough, see Standard Details, Section 606, Guardrail Treatment Over Buried Structures. Payment shall be incidental to Pay Item 606.23, Guardrail Type 3C - Single Rail.

5. The damaged portion of the existing pipe arch shall be cut and removed as directed by the Resident. Payment will be incidental to Pay Item 509.202, Culvert Sliplining.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-1786(800)X

PIN 17868.00

BRIDGE NO. 5495

BRIDGE PLANS

PROJ. MANAGER	S. BRIDGE	BY	DATE
DESIGN ENGINEER	M. WRIGHT	D. SHAW	
CHECKED BY			SIGNATURE
DESIGN CALCULATED			
REVISIONS 1			P.E. NUMBER
REVISIONS 2			
REVISIONS 3			DATE
REVISIONS 4			
FIELD CHANGES			

BOOTFOOT BRIDGE
NORTH BRANCH OF WHITNEY BROOK
BRIDGEWATER AROOSTOOK COUNTY

PIPE DETAILS

SHEET NUMBER
3
OF 3

Filename: ...\MSTA\003_Pipe_Details.dgn Division: BRIDGE Username: david.shaw Date:4/27/2011

Appendix A

Photographs

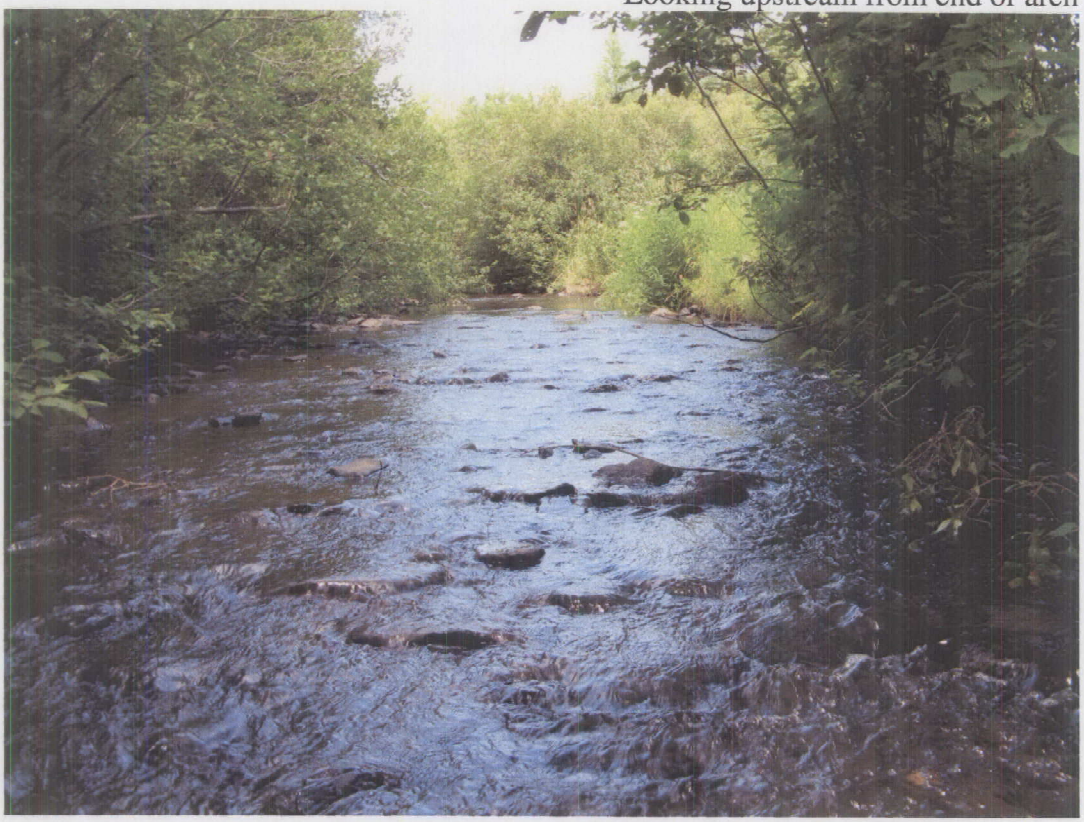
Bridgewater
Bootfoot Bridge #5495
Looking east along Bootfoot Road

Looking west along Bootfoot Road

Upstream looking south through arch, folded end plates

Downstream looking north through arch

Looking upstream from end of arch



Looking downstream from top of arch

View of bent end plate from inside arch

Footing damage, rusting of arch at footing

Appendix B

Site Inspection Reports

Structure Inventory and Appraisal Sheet (English Units)

Bridge Key: 5495 Agency ID: 5495 SR: 49.6 SD/FO: N

IDENTIFICATION

State 1: 23 Maine Struc Num 8: 5495
Facility Carried 7: WEST ROAD (SA6) Location 9: 1.8 MI E TOWNLINE
Rte.(On/Under)5A: Route On Structure Rte. Signing Prefix 5B: 4 County Hwy
Level of Service 5C: 0 None of the below Rte. Number 5D: 00000
Directional Suffix 5E: 0 N/A (NBI) % Responsibility : 0
SHD District 2: 05 Northern County Code 3: 003 Aroostook
Place Code 4: 03070 Bridgewater Mile Post 11: 1.810 mi
Feature Intersected 6: N BR WHITNEY STREAM
Latitude 16: 46d 25' 10" Longitude 17: 067d 52' 21"
Border Bridge Code 98: Not Applicable (P)
Border Bridge Number 99: n/a

STRUCTURE TYPE AND MATERIALS

Number of Approach Spans 46: 0 Number of Spans Main Unit 45: 1
Main Span Material/Design 43A/B:
3 Steel 11 Arch-Deck
Deck Type 107: 0
Wearing Surface 108A: N N/A (no deck (NBI))
Membrane 108B: N N/A (no deck (NBI))
Deck Protection 108C: N N/A (no deck (NBI))

AGE AND SERVICE

Year Built 27: 1953 Year Reconstructed 106: 0
Type of Service on 42A: 1 Highway
Type of Service under 42B: 5 Waterway
Lanes on 28A: 2 Lanes Under 28B: 0 Detour Length 19: 99.9 mi
ADT 29: 190 Truck ADT 109: 8 % Year of ADT 30: 2009

GEOMETRIC DATA

Length Max Span 48: 15.0 ft Structure Length 49: 13.0 ft
Curb/Sdwlk Width L 50A: 0.0 ft Curb/Sidewalk Width R 50B: 0.0 ft
Width Curb to Curb 51: 0.0 ft Width Out to Out 52: 0.0 ft
Approach Roadway Width 32: (w/ shoulders) 26.0 ft Median 33: 0 No median
Deck Area: 325. sq. ft
Skew 34: 0.00 ° Structure Flared 35: 0 No flare
Vertical Clearance 10: 99.99 ft Horiz. Clearance 47: 25.00 ft
Minimum Vertical Clearance Over Bridge 53: 327.8 ft
Minimum Vertical Underclearance Reference 54A: N Feature not hwy or RR
Minimum Vertical Underclearance 54B: 0.0 ft
Minimum Lateral Underclearance Reference R 55A: N Feature not hwy or RR
Minimum Lateral Underclearance R 55: 327.8 ft
Minimum Lateral Underclearance L 56: 327.8 ft

INSPECTION

Frequency 91: 24 months Inspection Date 90: 7/30/2009 Next Inspection: 07/30/2011
FC Frequency 92A: NA FC Inspection Date 93A: NA Next FC Inspection: NA
UW Frequency 92B: NA UW Inspection Date 93B: NA Next UW Inspection: NA
SI Frequency 92C: NA SI Date 93C: NA Next SI: NA
Element Frequency: 24 months Element Inspection Date: 07/30/2009 Next Elem. Insp. Due: 07/30/2011

CLASSIFICATION

Defense Highway 100: 0 Not a STRAHNET hwy Parallel Structure 101: No || bridge exists
Direction of Traffic 102: 2 2-way traffic Temporary Structure 103: Not Applicable (P)
Highway System 104: 0 Not on NHS NBIS Length 112: Too Short
Toll Facility 20: 3 On free road Functional Class 26: 08 Rural min Collector
Defense Hwy 110: 0 Not a STRAHNET hwy Historical Significance 37: 5 Not eligible for NRHP
Owner 22: 01 State Highway Agency
Custodian 21: 01 State Highway Agency

CONDITION

Deck 58: N N/A (NBI) Super 59: N N/A (NBI) Sub 60: N N/A (NBI)
Culvert 62: 3 Excessive Damage Channel/Channel Protection 61: 6 Bank Slumping

LOAD RATING AND POSTING

Inventory Rating Method 65: 2 AS Allowable Stres Operating Rating Method 63: 2 AS Allowable Stress
Inventory Rating 66: HS15.0 Operating Rating 64: HS21.0
Design Load 31: 2 M 13.5 (H 15) Posting 70: 5 At/Above Legal Loads
Posting status 41: A Open, no restriction

APPRAISAL

Bridge Rail 36A: N N/A or not required Approach Rail 36C: 0 Substandard
Transition 36B: N N/A or not required Approach Rail Ends 36D: 0 Substandard
Str. Evaluation 67: 6 Deck Geometry 68: N Not applicable (NBI)
Underclearance, Vertical and Horizontal 69: N Not applicable (NBI)
Waterway Adequacy 71: 7 Above Minimum Approach Alignment 72: 8 Equal Desirable Crit
Scour Critical 113: 6 Calcs not made

PROPOSED IMPROVEMENTS

Bridge Cost 94: NA Type of Work 75: Unknown (P)
Roadway Cost 95: Unknown Length of Improvement 76:
Total Cost 96: Unknown Future ADT 114: 285
Year of Cost Estimate 97: Unknown Year of Future ADT 115: 2029

NAVIGATION DATA

Navigation Control 38: 0 Permit Not Required
Vertical Clearance 39: 0.0 ft Horizontal Clearance 40: 0.0 ft
Pier Protection 111: Not Applicable (P) Lift Bridge Vertical Clearance 116: 0.0 ft

ELEMENT CONDITION STATE DATA

Str Unit	Elm/Env	Description	Units	Total Qty	% in 1	Qty. St. 1	% in 2	Qty. St. 2	% in 3	Qty. St. 3	% in 4	Qty. St. 4	% in 5	Qty. St. 5
1	243/2	Misc Culvert	(LF)	77	10 %	8	60 %	46	10 %	8	20 %	15	0 %	0

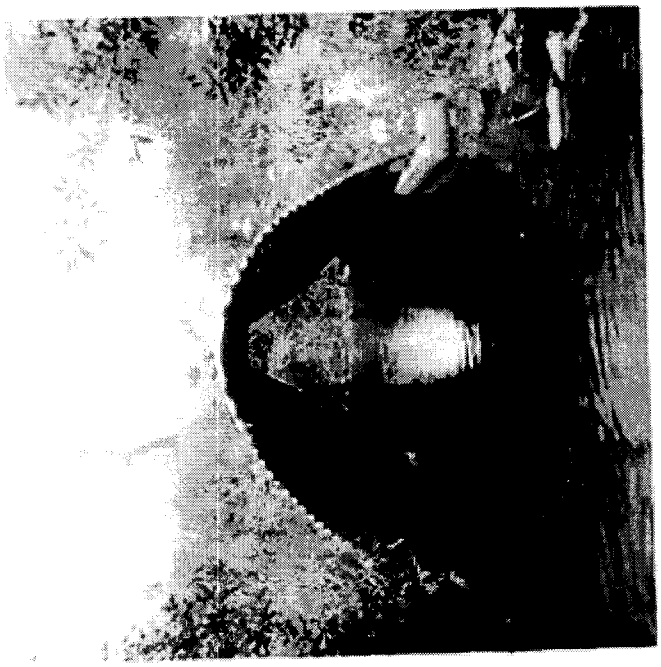
Structure in Poor and Serviceable condition.
Not able to access inside of culvert due to extremely high water and aggressive current.

ACTION REQUIRED: Up stream end plates folding in since 2001. Water is way above its normal height and is slammir into the folded end plates on the upstream end. Called main office and they are getting ahold of the regional office to send out someone to determin if plates should be cut.

Guardrail is too and too short.

Notes from previous report:
Up stream end plates are folding over the stream.
Condition has existed since the 2001 inspection, but is getting worse and should be addressed.
Distortion of end and top of plates for the first 1/3rd of culvert at up stream end.
Footings are exposed up to 2'.
Ice cover prevented entry to see if plates are unzipping from footing.
Previous inspection showed a 7' unzip from footing.
Debris in bushes indicates a water level as much as 3' higher and onto bankings which could create a dangerous high flow condition if end plates fold in any more.

Channel:
Alignment - Fair
Gradient - Moderate
Opening - Fair
Composition - Gravel and cobbles



Looking upstream

Looking downstream

Erosion effecting shoulder. Note steepness of embankment

Looking downstream, note distortion on both sides

Br.#5495	BRIDGEWATER	BOOTFOOT	9-22-2005

Roadway looking West

General view

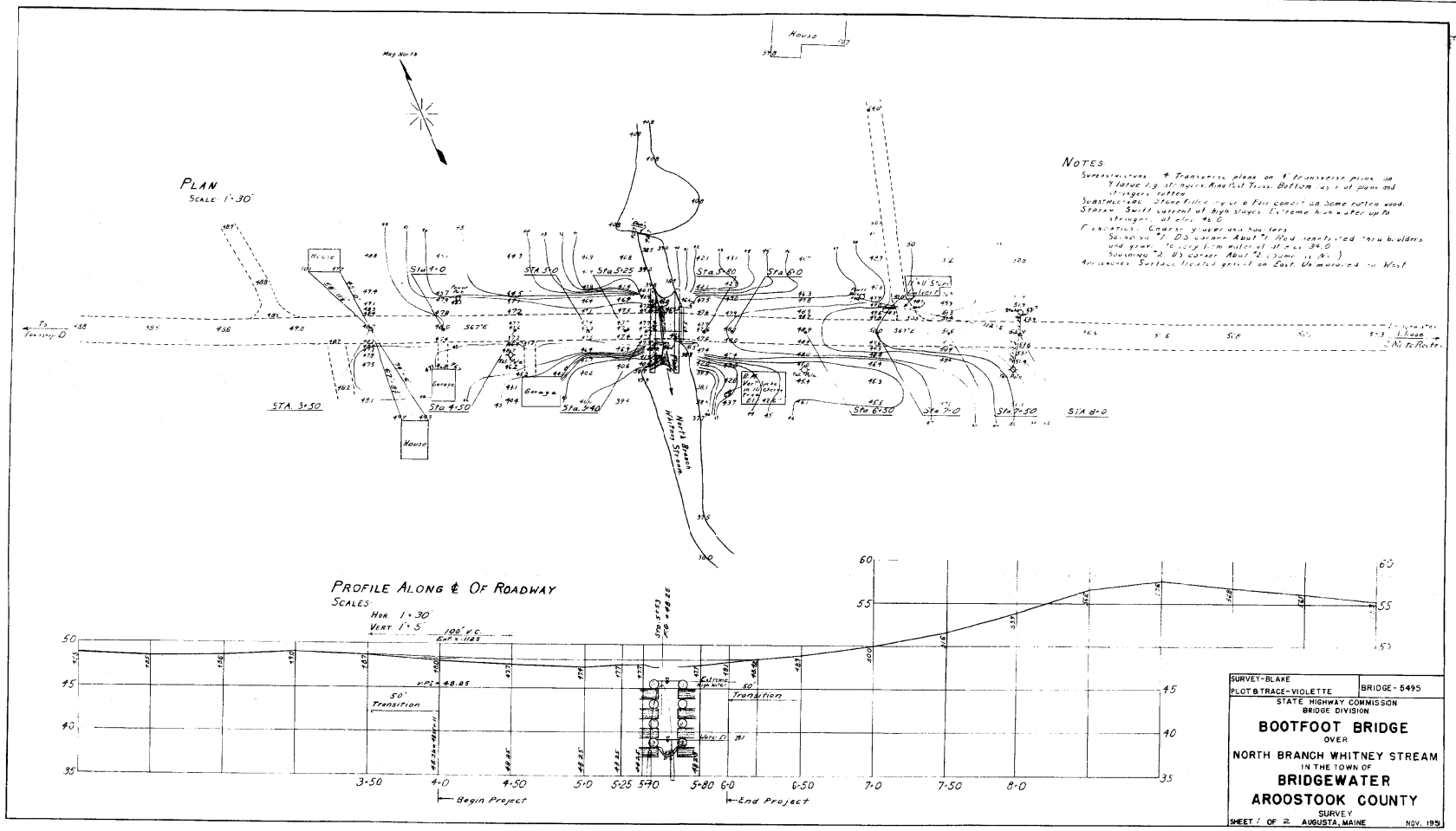
Looking upstream

Looking downstream

5495	Bridgewater	Bootfoot	7/30/09

Appendix C

Existing Bridge Plans



SURVEY-BLAKE
PLOT & TRACE-VIOLETTE

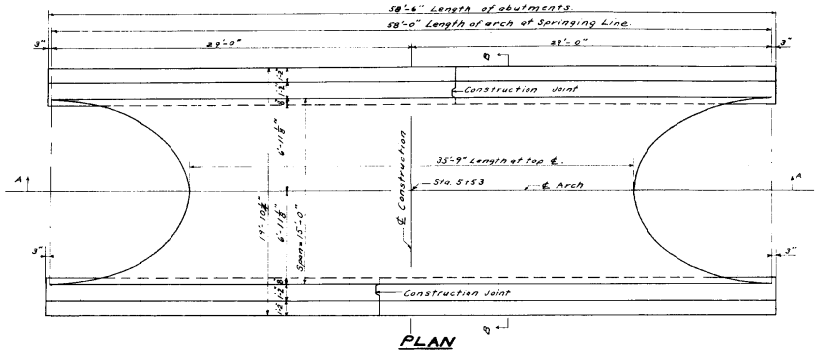
BRIDGE-5495

STATE HIGHWAY COMMISSION
BRIDGE DIVISION

BOOTFOOT BRIDGE
OVER
NORTH BRANCH WHITNEY STREAM
IN THE TOWN OF
BRIDGEWATER
AROOSTOOK COUNTY

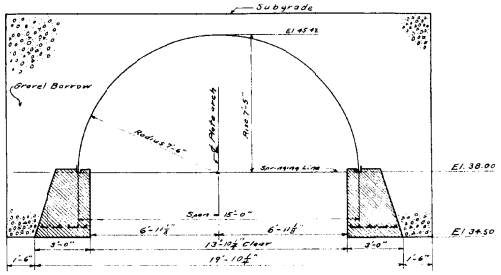
SURVEY
SHEET 1 OF 2 AUGUSTA, MAINE NOV. 195

56-185

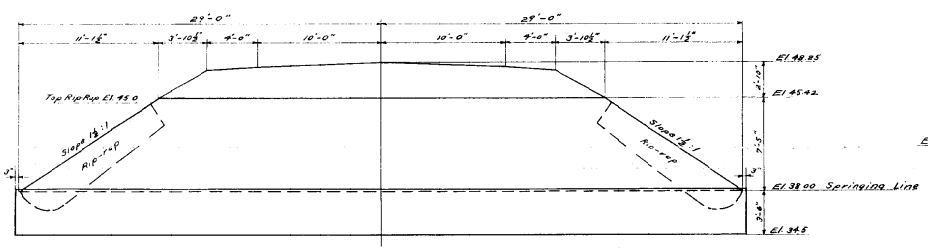


PLAN

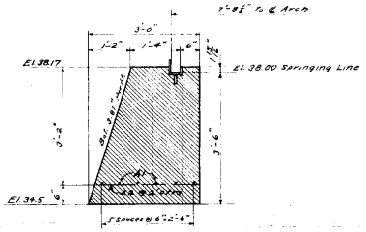
Galvanized Sectional Plate Arch



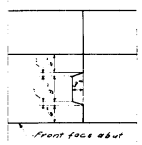
SECTION B-B



SECTION A-A

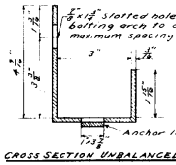


ABUTMENT SECTION



CONSTRUCTION JOINT

Place construction joint at point mid point of each abut. Build joint with asphalt to break bond.



CROSS SECTION UNBALANCED CHANNEL

NOTE

Unbalanced channels to be furnished in lengths not less than 6' to make up 58'-0" for each abut. Total 11 6'-0". All channels shall be hot dipped galvanized after fabrication. Bolts shall be ⅝" in dia and shall be hot dipped galvanized.

MATERIAL REQUIRED

One sectional plate arch as shown, with bolts and unbalanced channels. Plates to have a minimum thickness of #16 Gage with corrugations of 6"x2". The span and rise may be varied slightly if approved by the Engineer.

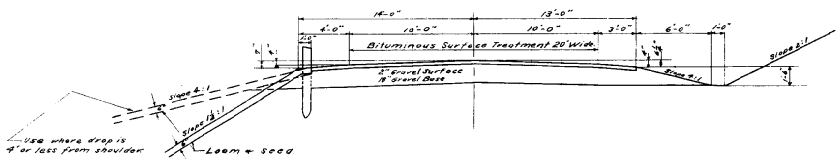
REINFORCING STEEL

24 bars, #6 (¾") x 28'-6", A1
60 bars, #6 (¾") x 2'-7", A2

All reinforcing steel bars shall conform to A.S.T.M. Specifications A 305-49.

NOTE

A.A.S.H.O. Standard Specifications for Highway Bridges 1949
Concrete Construction - B
Loading H-15-44.



NORMAL HALF FILL SECTION — NORMAL HALF CUT SECTION

DESIGN & TRACE	HERSUM	BRIDGE 5495
CHECK	STANBEL	

STATE HIGHWAY COMMISSION
BRIDGE DIVISION

BOOTFOOT BRIDGE

OVER

NORTH BRANCH WHITNEY STREAM

IN THE TOWN OF

BRIDGEWATER

AROOSTOOK COUNTY

STRUCTURE

SHEET 2 OF 2 AUGUSTA MAINE APRIL 1952

56-186

0 1 2 3 4 5 INCHES

Appendix D

Hydrology/Hydraulic Data

Project Name:	Bridgewater	**PIN:**	17868.00
Stream Name:	Whitney Stream	**Town:**	Bridgewater
Bridge Name:	Bootfoot Bridge	**Bridge No.**	5495
Route No.	West Road	**USGS Quad:**	
Analysis by:	AWMann	**Date:**	12/13/2010

Peak Flow Calculations by USGS Regression Equations (Hodgkins, 1999)

Enter data in blue cells only!

	km^2	mi^2	ac	*Enter data in [mi^2]*
A	22.77	8.79	5627.3	Watershed Area
W	2.99	1.15	738.4	Wetlands area (by NWI)

P_c	582964	5143267	watershed centroid (E, N; UTM 19N; meters)
County	Aroostook C		*choose county from drop-down menu*
pptA	36.1		mean annual precipitation (inches; by look-up)
SG	0.00		sand & gravel aquifer as decimal fraction of watershed A

A (km^2)	22.77	**Conf Lvl**	0.67
W (%)	13.12		

Worksheet prepared by:
Charles S. Hebson, PE
Environmental Office
Maine Dept. Transportation
Augusta, ME 04333-0016
207-557-1052
Charles.Hebson@maine.gov

Ret Pd T (yr)	Peak Flow Estimate Lower	Q_T (m^3/s)	Upper	Q_T (ft^3/s)
1.1		3.36		118.6
2	4.87	6.81	9.54	240.6
5	7.55	10.61	14.90	374.6
10	9.45	13.42	19.05	473.7
25	11.95	17.21	24.80	607.8
50	13.84	20.19	29.44	712.9
100	15.85	23.40	34.55	826.3
500	20.52	31.30	47.75	1105.2

Reference:

Hodgkins, G., 1999.
Estimating the magnitude of peak flows for streams in Maine for selected recurrence intervals
Water-Resources Investigations Report 99-4008
US Geological Survey, Augusta, Maine

$Q_T = b \times A^a \times 10^{-wW}$

Project Name:	Bridgewater	**PIN:**	17868.00
Stream Name:	Whitney Stream	**Town:**	Bridgewater
Bridge Name:	Bootfoot Bridge	**Bridge No.**	3987
Route No.	West Road	**USGS Quad:**	
Analysis by:	AWMann	**Date:**	12/1/2008

DO NOT ENTER ANY DATA ON THIS PAGE; EVERYTHING IS CALCULATED

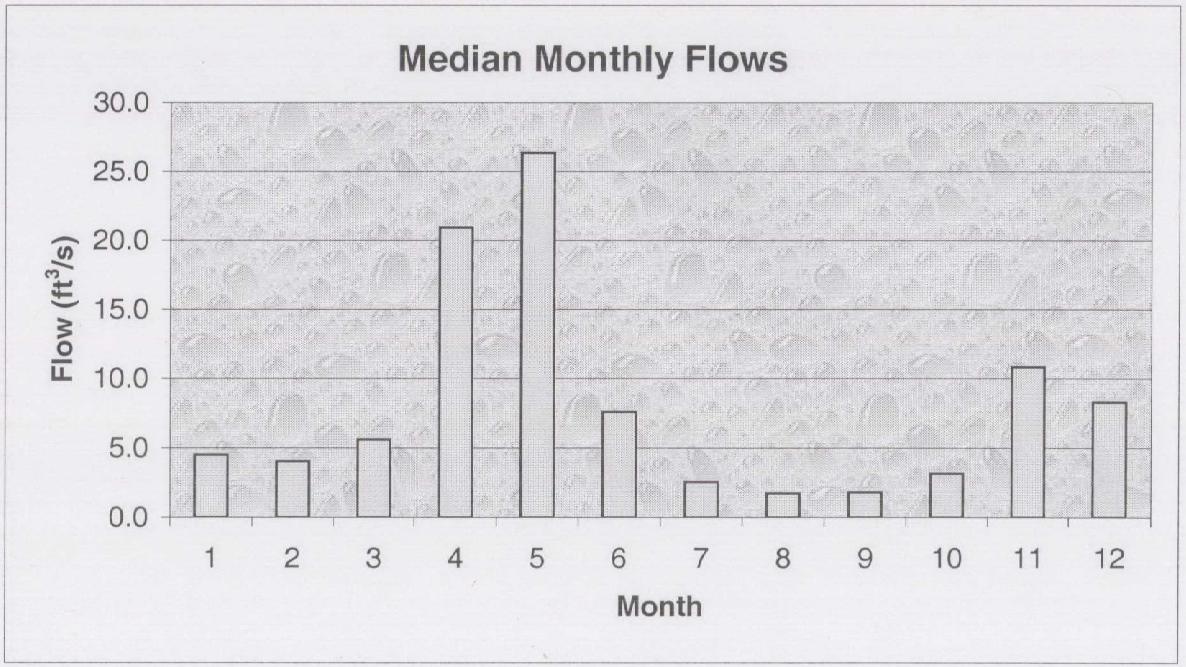
MAINE MONTHLY MEDIAN FLOWS BY USGS REGRESSION EQUATIONS (2004)

Worksheet prepared by:
Charles S. Hebson, PE
Chief Hydrologist
Maine Dept. Transportation
Augusta, ME 04333-0016
207-624-3073
Charles.Hebson@maine.gov

	Value	Variable	Explanation
	8.793	*A*	Area (mi^2)
582964	5143267	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
	142.06	*DIST*	Distance from Coastal reference line (mi)
	36.1	*pptA*	Mean Annual Precipitation (inches)
	0.00	*SG*	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q_{median} (ft3/s)	(m^3/s)
Jan	**4.51**	0.1278
Feb	**4.05**	0.1147
Mar	**5.61**	0.1590
Apr	**20.91**	0.5926
May	**26.35**	0.7468
Jun	**7.61**	0.2157
Jul	**2.55**	0.0723
Aug	**1.73**	0.0492
Sep	**1.82**	0.0515
Oct	**3.17**	0.0898
Nov	**10.84**	0.3071
Dec	**8.30**	0.2352

Q_{bf}	**50.9**
ann avg	**16.0**
ann med	**7.0**
$Q_{1.002}$	**52.3**
$Q_{1.01}$	70.0
$Q_{1.05}$	99.4



Crossing Data - Bootfoot (as built)

Crossing Properties

Name: Bootfoot (as built)

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	118.60	cfs
Design Flow	712.90	cfs
Maximum Flow	826.30	cfs
TAILWATER DATA		
Channel Type	Irregular Channel	
Irregular Channel	Define...	
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Irregular	
Irregular Shape	Define...	
Roadway Surface	Paved	
Top Width	32.00	ft

Culvert Properties

Existing (user defined)

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Existing (user defined)	
Shape	User Defined	
Material	Corrugated Metal Riveted or Welded	
Coordinates	Define...	
Span	15.00	ft
Rise	8.58	ft
Embedment Depth	0.00	in
Manning's n (Top/Sides)	0.0350	
Manning's n (Bottom)	0.0350	
Inlet Type	Conventional	
Inlet Edge Condition	Thin Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	452.46	ft
Outlet Station	60.00	ft
Outlet Elevation	452.46	ft
Number of Barrels	1	

OK Cancel

Irregular Tailwater Channel

Tailwater File

Browse for existing .TW file Import...

Tailwater Channel

Slope of tailwater channel: 0.0600 ft/ft

Number of cross-sec points: 14

Irregular Channel Cross-Section

No.	Station (ft)	Elevation (ft)	Manning n
1	0.000	463.000	0.0400
2	25.000	460.250	0.0400
3	50.000	458.750	0.0400
4	75.000	456.000	0.0350
5	83.500	454.500	0.0350
6	108.500	453.250	0.0300
7	112.500	452.250	0.0300
8	135.250	453.000	0.0300
9	150.000	455.000	0.0350
10	158.500	457.250	0.0400
11	175.000	458.500	0.0400
12	200.000	459.750	0.0400

Plot

Help OK Cancel

User Defined Culvert Shape

Number of X points (2-19): 13

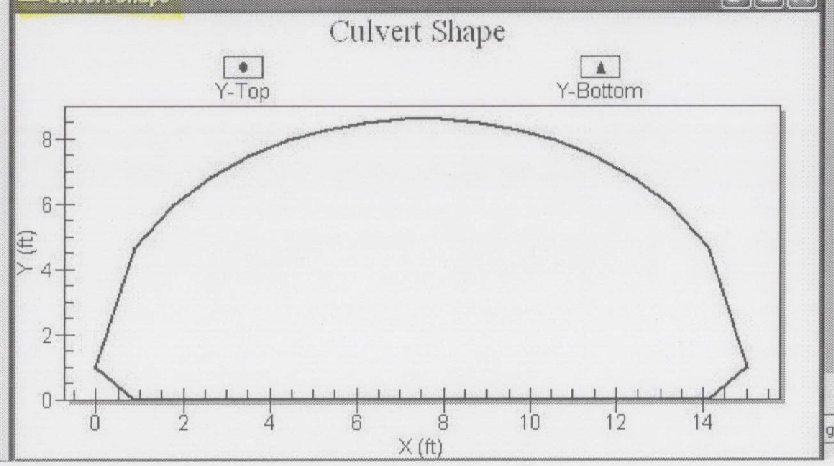
Each X has a Y-top and Y-Bottom

Irregular Culvert Cross Section

Number	X (ft)	Y-Top (ft)	Y-Bottom (ft)
1	0.0000	1.0000	1.0000
2	0.8800	4.6200	0.0000
3	1.7600	5.9300	0.0000
4	2.6500	6.8100	0.0000
5	3.5300	7.4600	0.0000
6	4.4100	7.9300	0.0000
7	5.2900	8.2600	0.0000
8	6.1800	8.4800	0.0000
9	7.0600	8.5800	0.0000
10	7.9400	8.5800	0.0000
11	8.8200	8.4800	0.0000
12	9.7100	8.2600	0.0000
13	10.5900	7.9300	0.0000
14	11.4700	7.4600	0.0000
15	12.3500	6.8100	0.0000

Plot OK Cancel

Culvert Shape



Crossing Data - Bootfoot (Crumpled #3)

Crossing Properties

Name: Bootfoot (Crumpled #3)

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	118.60	cfs
Design Flow	712.90	cfs
Maximum Flow	826.30	cfs
TAILWATER DATA		
Channel Type	Irregular Channel	
Irregular Channel	Define...	
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Irregular	
Irregular Shape	Define...	
Roadway Surface	Paved	
Top Width	32.00	ft

Culvert Properties

Exisiting Crumpled (user defin

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Exisiting Crumpled (user defined)	
Shape	User Defined	
Material	Corrugated Metal Riveted or Welded	
Coordinates	Define...	
Span	13.75	ft
Rise	9.58	ft
Embedment Depth	0.00	in
Manning's n (Top/Sides)	0.0350	
Manning's n (Bottom)	0.0350	
Inlet Type	Conventional	
Inlet Edge Condition	Thin Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	451.46	ft
Outlet Station	60.00	ft
Outlet Elevation	451.46	ft
Number of Barrels	1	

OK Cancel

Irregular Tailwater Channel

Tailwater File

Browse for existing .TW file Import...

Tailwater Channel

Slope of tailwater channel: 0.0600 ft/ft

Number of cross-sec points: 14

Irregular Channel Cross-Section

No.	Station (ft)	Elevation (ft)	Manning n
1	0.000	463.000	0.0400
2	25.000	460.250	0.0400
3	50.000	458.750	0.0400
4	75.000	456.000	0.0350
5	83.500	454.500	0.0350
6	108.500	453.250	0.0300
7	112.500	452.250	0.0300
8	135.250	453.000	0.0300
9	150.000	455.000	0.0350
10	158.500	457.250	0.0400
11	175.000	458.500	0.0400
12	200.000	459.750	0.0400

Plot

User Defined Culvert Shape

Number of X points (2-19): 10

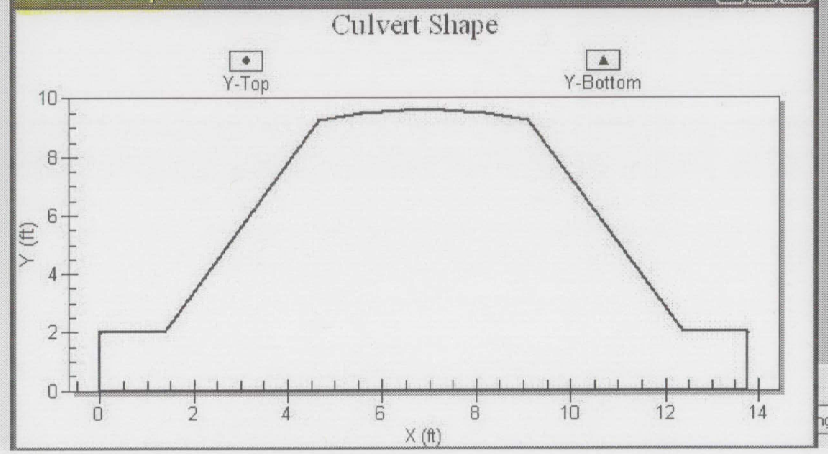
Each X has a Y-top and Y-Bottom

Irregular Culvert Cross Section

Number	X (ft)	Y-Top (ft)	Y-Bottom (ft)
1	0.0000	2.0000	0.0000
2	1.3700	2.0000	0.0000
3	4.6700	9.2600	0.0000
4	5.5500	9.4800	0.0000
5	6.4300	9.5800	0.0000
6	7.3200	9.5800	0.0000
7	8.2000	9.4800	0.0000
8	9.0800	9.2600	0.0000
9	12.3700	2.0000	0.0000
10	13.7500	2.0000	0.0000

Plot OK Cancel

Culvert Shape



4/5/11

Crossing Data - Bootfoot (1' embed)

Crossing Properties

Name: Bootfoot (1' embed)

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	118.60	cfs
Design Flow	712.90	cfs
Maximum Flow	826.30	cfs
TAILWATER DATA		
Channel Type	Irregular Channel	
Irregular Channel	Define...	
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Irregular	
Irregular Shape	Define...	
Roadway Surface	Paved	
Top Width	32.00	ft

Culvert Properties

Underpass 12'-11" S x 11'-3"

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Underpass 12'-11" S x 11'-3" R	
Shape	User Defined	
Material	Corrugated Metal Riveted or Welded	
Coordinates	Define...	
Span	12.89	ft
Rise	11.25	ft
Embedment Depth	12.00	in
Manning's n (Top/Sides)	0.0350	
Manning's n (Bottom)	0.0400	
Inlet Type	Conventional	
Inlet Edge Condition	Thin Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	449.02	ft
Outlet Station	78.00	ft
Outlet Elevation	449.02	ft
Number of Barrels	1	

Irregular Tailwater Channel

Tailwater File

Browse for existing .TW file: Import...

Tailwater Channel

Slope of tailwater channel: 0.0600 ft/ft

Number of cross-sec points: 14

Irregular Channel Cross-Section

No.	Station (ft)	Elevation (ft)	Manning n
1	0.000	463.000	0.0400
2	25.000	460.250	0.0400
3	50.000	458.750	0.0400
4	75.000	456.000	0.0350
5	83.500	454.500	0.0350
6	108.500	453.250	0.0300
7	112.500	452.250	0.0300
8	135.250	453.000	0.0300
9	150.000	455.000	0.0350
10	158.500	457.250	0.0400
11	175.000	458.500	0.0400
12	200.000	459.750	0.0400

Plot

Help OK Cancel

User Defined Culvert Shape

Number of X points (2-19): 13

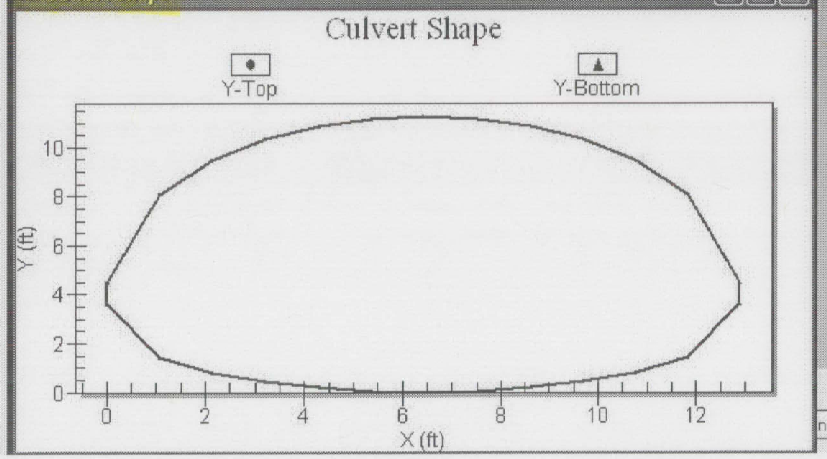
Each X has a Y-top and Y-Bottom

Irregular Culvert Cross Section

Number	X (ft)	Y-Top (ft)	Y-Bottom (ft)
1	0.0000	4.4800	3.6300
2	1.0700	8.0600	1.4200
3	2.1500	9.4700	0.8000
4	3.2200	10.3300	0.4400
5	4.3000	10.8600	0.1900
6	5.3700	11.1500	0.0500
7	6.4500	11.2500	0.0000
8	7.5200	11.1500	0.0500
9	8.6000	10.8600	0.1900
10	9.6700	10.3300	0.4400
11	10.7400	9.4700	0.8000
12	11.8200	8.0600	1.4200
13	12.8900	4.4800	3.6300

Plot OK Cancel

Culvert Shape



ng OK Cancel

4/5/11

HY-8 Analysis Results

Culvert Summary Table - Exisiting, "as built" (user defined)
Culvert Crossing: Bootfoot (as built)

Inlet Elevation 451.96

	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
Q1.1	118.60	118.60	454.53	2.21	2.57	2-M2c	9.08	1.28	1.33	0.95	6.38	7.95
	189.37	189.37	455.37	2.97	3.41	2-M2c	9.08	1.78	1.79	1.11	7.44	9.54
	260.14	260.14	456.13	3.67	4.17	2-M2c	9.08	2.16	2.19	1.26	8.29	10.53
	330.91	330.91	456.83	4.30	4.87	2-M2c	9.08	2.54	2.55	1.38	9.02	11.27
	401.68	401.68	457.48	4.92	5.52	2-M2c	9.08	2.88	2.89	1.49	9.66	11.86
	472.45	472.45	458.11	5.56	6.15	2-M2c	9.08	3.20	3.21	1.59	10.23	12.36
	543.22	543.22	458.71	6.20	6.75	2-M2c	9.08	3.51	3.52	1.69	10.76	12.79
	613.99	613.99	459.29	6.84	7.33	2-M2c	9.08	3.80	3.81	1.77	11.25	13.17
	684.76	684.76	459.84	7.47	7.88	2-M2c	9.08	4.08	4.10	1.85	11.70	13.52
Q50	712.90	712.90	460.09	7.70	8.13	2-M2c	9.08	4.20	4.21	1.88	11.88	13.64
Q100	826.30	826.30	460.99	8.63	9.03	2-M2c	9.08	4.63	4.64	2.00	12.55	14.11

Fish Passage Flow / Q25

	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
Fish (Low)	1.77	1.77	452.45	0.04	0.49	3-M2t	0.85	0.02	0.49	0.2	0.27	2.6
Fish (High)	26.35	26.35	453.08	0.56	1.12	3-M2t	5.18	0.36	0.84	0.55	2.29	5.11
	122.98	122.98	454.58	2.26	2.62	2-M2c	9.08	1.31	1.36	0.96	6.45	8.05
	183.58	183.58	455.31	2.91	3.35	2-M2c	9.08	1.74	1.75	1.1	7.35	9.44
	244.18	244.18	455.97	3.52	4.01	2-M2c	9.08	2.08	2.1	1.23	8.11	10.33
	304.78	304.78	456.58	4.07	4.62	2-M2c	9.08	2.4	2.42	1.34	8.77	11.02
	365.39	365.39	457.15	4.59	5.19	2-M2c	9.08	2.72	2.72	1.44	9.34	11.57
	425.99	425.99	457.7	5.14	5.74	2-M2c	9.08	2.99	3	1.53	9.86	12.04
	486.59	486.59	458.23	5.69	6.27	2-M2c	9.08	3.26	3.28	1.61	10.34	12.45
	547.2	547.2	458.74	6.24	6.78	2-M2c	9.08	3.53	3.54	1.69	10.79	12.82
Q25	607.8	607.8	459.21	6.79	7.25	2-M2c	9.08	3.78	3.79	1.76	11.21	13.14

HY-8 Analysis Results

Culvert Summary Table - Exisiting, "as is" (user defined)
Culvert Crossing: Bootfoot (as is)

Inlet Elevati 451.46

	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
Q1.1	118.6	118.6	454.1	2.58	2.64	3-M2t	9.58	1.28	1.74	0.95	4.97	7.95
	189.37	189.37	455.14	3.49	3.68	3-M2t	9.58	1.79	1.9	1.11	7.23	9.54
	260.14	260.14	456.1	4.45	4.64	2-M2c	9.58	2.19	2.09	1.26	9.14	10.53
	330.91	330.91	457	5.35	5.54	2-M2c	9.58	2.54	2.51	1.38	10.02	11.27
	401.68	401.68	457.86	6.2	6.4	2-M2c	9.58	2.9	2.91	1.49	10.82	11.86
	472.45	472.45	458.72	7.06	7.26	2-M2c	9.58	3.27	3.29	1.59	11.56	12.36
	543.22	543.22	459.56	7.89	8.1	2-M2c	9.58	3.63	3.64	1.69	12.25	12.79
	613.99	613.99	460.39	8.67	8.93	2-M2c	9.58	3.98	3.99	1.77	12.9	13.17
	684.76	684.76	461.23	9.45	9.77	2-M2c	9.58	4.31	4.33	1.85	13.53	13.52
Q50	712.9	712.9	461.56	9.76	10.1	2-M2c	9.58	4.44	4.45	1.88	13.77	13.64
Q100	826.3	826.3	462.91	11.02	11.45	2-M2c	9.58	4.95	4.96	2	14.74	14.11

Fish Passage Flow / Q25

	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
Fish (Low)	1.77	1.77	452.45	0.04	0.99	3-M1t	0.83	0.02	0.99	0.2	0.13	2.6
Fish (High)	26.35	26.35	452.91	0.6	1.45	3-M2t	9.58	0.35	1.34	0.55	1.43	5.11
	122.98	122.98	454.22	2.64	2.76	3-M2t	9.58	1.31	1.75	0.96	5.11	8.05
	183.58	183.58	455.06	3.42	3.6	3-M2t	9.58	1.75	1.89	1.1	7.06	9.44
	244.18	244.18	455.89	4.22	4.43	2-M2c	9.58	2.1	2	1.23	8.89	10.33
	304.78	304.78	456.62	5.03	5.16	2-M2c	9.58	2.41	2.36	1.34	9.71	11.02
	365.39	365.39	457.42	5.76	5.96	2-M2c	9.58	2.72	2.71	1.44	10.42	11.57
	425.99	425.99	458.16	6.5	6.7	2-M2c	9.58	3.03	3.04	1.53	11.08	12.04
	486.59	486.59	458.89	7.23	7.43	2-M2c	9.58	3.34	3.36	1.61	11.7	12.45
	547.2	547.2	459.6	7.94	8.14	2-M2c	9.58	3.65	3.66	1.69	12.28	12.82
Q25	607.8	607.8	460.32	8.6	8.86	2-M2c	9.58	3.95	3.96	1.76	12.85	13.14

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HY-8 Analysis Results

Culvert Summary Table - Underpass 12'-11" S x 11'-3" R (1' imbed)
Culvert Crossing: Bootfoot

Inlet Elevatio 449.02

	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
Q1.1	118.6	118.6	453.65	2.5	3.63	3-M2t	10.25	1.54	3.18	0.95	3.19	7.95
	189.37	189.37	454.32	3.35	4.3	3-M2t	10.25	2.13	3.34	1.11	4.81	9.54
	260.14	260.14	455	4.08	4.98	3-M2t	10.25	2.57	3.49	1.26	6.31	10.53
	330.91	330.91	455.7	4.73	5.68	3-M2t	10.25	3.02	3.61	1.38	7.72	11.27
	401.68	401.68	456.38	5.38	6.36	3-M2t	10.25	3.37	3.72	1.49	9.07	11.86
	472.45	472.45	457.05	6.08	7.03	3-M2t	10.25	3.72	3.82	1.59	10.37	12.36
	543.22	543.22	457.71	6.78	7.69	2-M2c	10.25	4.07	4.07	1.69	11.17	12.79
	613.99	613.99	458.36	7.47	8.34	2-M2c	10.25	4.37	4.38	1.77	11.7	13.17
	684.76	684.76	458.98	8.17	8.96	2-M2c	10.25	4.67	4.68	1.85	12.18	13.52
Q50	712.9	712.9	459.23	8.42	9.21	2-M2c	10.25	4.78	4.8	1.88	12.37	13.64
Q100	826.3	826.3	460.22	9.44	10.2	2-M2c	10.25	5.25	5.25	2	13.1	14.11

Fish Passage Flow / Q25

	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
Fish (Low)	1.77	1.77	452.45	0.05	2.43	3-M1t	1.19	0.03	2.43	0.2	0.06	2.6
Fish (High)	26.35	26.35	452.83	0.68	2.81	3-M2t	7.14	0.46	2.78	0.55	0.82	5.11
	122.98	122.98	453.69	2.56	3.67	3-M2t	10.25	1.58	3.19	0.96	3.29	8.05
	183.58	183.58	454.26	3.29	4.24	3-M2t	10.25	2.09	3.33	1.1	4.68	9.44
	244.18	244.18	454.84	3.92	4.82	3-M2t	10.25	2.47	3.46	1.23	5.98	10.33
	304.78	304.78	455.39	4.5	5.37	3-M2t	10.25	2.85	3.57	1.34	7.21	11.02
	365.39	365.39	456.03	5.04	6.01	3-M2t	10.25	3.2	3.67	1.44	8.39	11.57
	425.99	425.99	456.61	5.62	6.59	3-M2t	10.25	3.49	3.76	1.53	9.53	12.04
	486.59	486.59	457.15	6.22	7.13	3-M2t	10.25	3.79	3.84	1.61	10.63	12.45
	547.2	547.2	457.75	6.82	7.73	2-M2c	10.25	4.08	4.09	1.69	11.2	12.82
Q25	607.8	607.8	458.3	7.41	8.28	2-M2c	10.25	4.34	4.35	1.76	11.65	13.14

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Appendix E

Traffic and Accident Data