Preliminary Design Report

Cambolasse Bridge #2170
over
Cambolasse Stream

Lincoln, Maine

PIN 016712.00

Maine Department of Transportation

Bridge Program

BACKGROUND INFORMATION

TOWN - Lincoln **PIN -** 16712.00 **BRIDGE NO. -** 2170

FUNDING - Surface Transportation Program **STATE ROUTE -** US 2

TRANSPORTATION INVESTMENT PROGRAM:

YEAR 10/11 **ESTIMATE** $400,000

TOTAL $400,000

PROGRAM SCOPE - Bridge Replacement

PROGRAM DESCRIPTION – "*This project will be considered for eligibility for federal, state, general obligation bond and TransCAP Bond bridge funding.* Bridge Replacement: Cambolasse Bridge (#2170) over Cambolasse Stream, located 0.50 of a mile northerly of Reed Drive."

PROJECT BACKGROUND – Structural problems were identified in the 2006 bridge inspection including ½ inch wide cracks and undermining of the abutments resulting in a Condition Rating of 3 – Serious. It was also noted that the center (oldest) section of the structural slab has settled 1.5 inches and shifted north 2 inches. Environmental permitting has already been acquired, though it may be reviewed. The bridge replacement project received complete funding in the 10/11 BTIP.

HIGHWAY SYSTEM - State Highway

FUNCTIONAL CLASSIFICATION - Minor Arterial

URBAN/RURAL - Rural

FHWA SUFFICIENCY RATING - 24

LOAD POSTING - None

POSTED SPEED - 35 mph

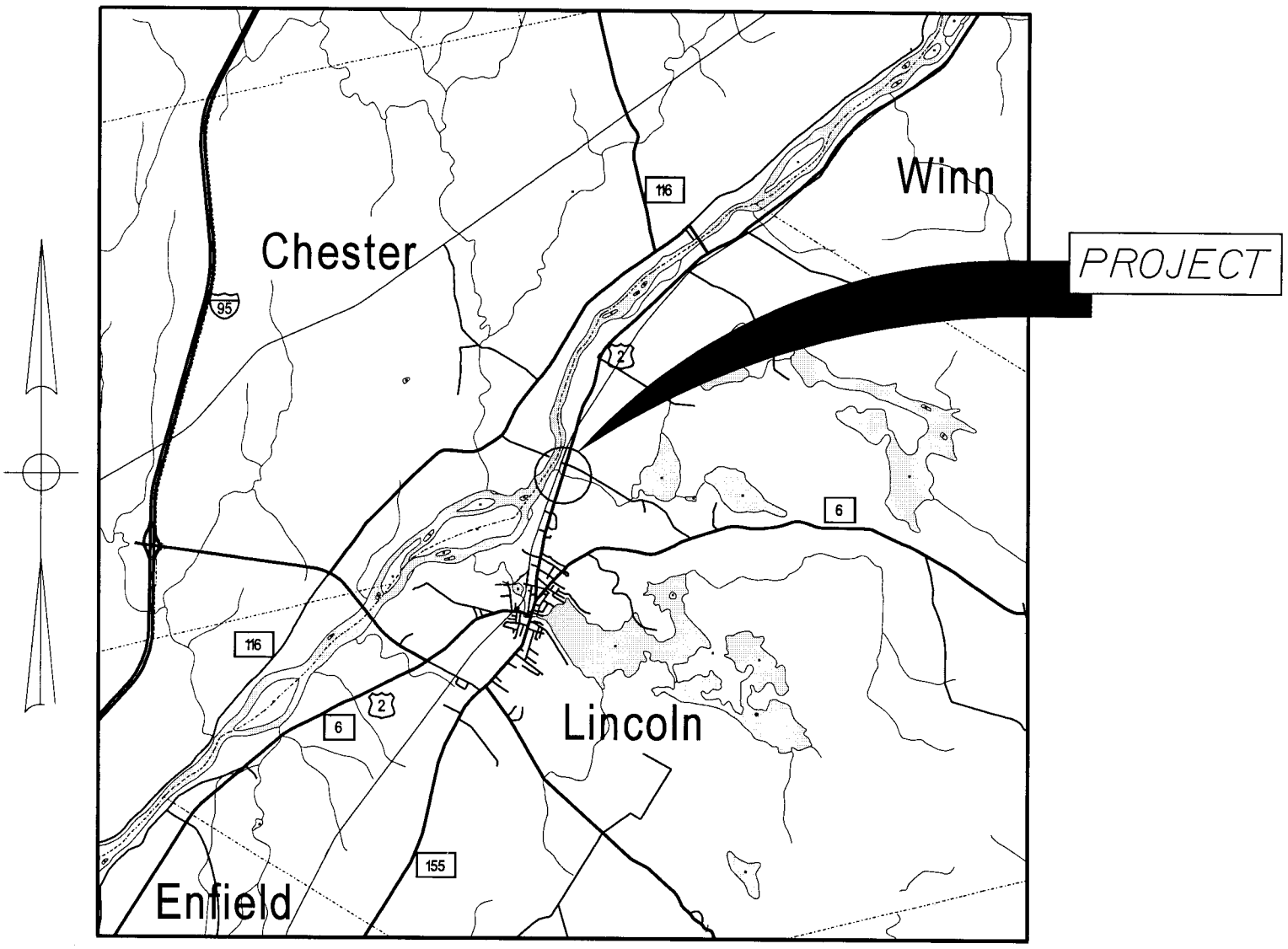
STRUCTURALLY DEFICIENT - Yes

FUNCTIONALLY OBSOLETE - No

TRAFFIC - **2010** **AADT** 4290

ACCIDENT DATA, CRF - 0.38

2030 **AADT** 5150 **DHV** 515



LOCATION MAP

2 0 2 4

Scale of Miles

CAMBOLASSE BRIDGE
over
THE CAMBOLASSE STREAM
in
LINCOLN
on
U.S. ROUTE 2

Hydrology and Hydraulics Report

HYDROLOGY

Dr. Charlie Hebson used the 1999 U.S.G.S. Full Regression Method for Maine to determine the magnitudes of storm discharges at Cambolasse Bridge over Cambolasse Stream in Lincoln. The results for this standard method are very reliable. Rounding discharge slightly, the hydrology parameters are:

SUMMARY OF HYDROLOGY DATA
Drainage Area = 18.4 sq. mi.
Discharge (Q25) = 900 c.f.s.
Design Discharge (Q50) = 1040 c.f.s.
Discharge (Q100) = 1195 c.f.s.
Ordinary High Water (Q1.1) = 200 c.f.s.

HYDRAULICS

It is clear from local observations and from quantitative analysis that the flow through Cambolasse Bridge is controlled by outlet tailwater. HY-8 runs were made to analyze the hydraulics of the existing bridge and to simulate the hydraulic behavior of the alternate replacement structures. A dam only 400 feet upstream of Cambolasse Bridge is used, at least in part to prevent flooding by limiting discharge magnitudes. Flow from the dam is split into two channels. The subject bridge, Bridge #2170, normally handles about 70% of the flow.

The Haskell Lumber Company controls two separate spillways, one for each channel. About 190 feet north of the subject bridge is a smaller 12 foot-span and 4-foot rise culvert, Bridge #2128. Lumber company managers stated that the flow can be closed off from either channel without causing flooding. They also stated that flooding only occurs when the stream is backed up from the Penobscot River. They noted that flooding has happened three times in the past forty years, usually rising to a certain point on the westerly embankments. It appears that the observed floodline is near Elevation 177.0 feet. This elevation provides a check for tailwater in the Q10 to Q20 range.

Because the Penobscot River is only 830 feet downstream from the bridge, the analysis needs to consider the Penobscot River stage elevations at the river's confluence with Cambolasse Stream, at least at the higher storm events. These values cannot be found directly. In order to develop reasonable values, stage elevations were interpolated using: "Water Resources Date Maine" for years 1987, 1990, 1991, and 2004; the 1991 "USGS Estimating ...Peak Flows...Maine"; and "Flood Insurance Studies" for Mattawamkeag 1988 (upstream), Lincoln 1987, and Howland 1996 (downstream).

For every storm event at the Cambolasse Bridge, this study assumes that the Penobscot stage elevation is at the same storm event frequency. This is a questionable assumption considering the differences in drainage area boundaries and Times of Concentration. However, this assumption seemed necessary for developing a viable tailwater profile. In addition, it seems realistic to assume simultaneous occurrence of very similar storm frequencies.

Hydrology and Hydraulics Report

HY-8 analyses indicate that without the dam, the roadway would flood very frequently, at about the five year storm event even without tailwater from the Penobscot River. Flow through the north structure was not utilized in this analysis, making it somewhat conservative. Greater complexity is not warranted in the analysis since the model, cobbled tailwater profile, and other assumptions make the analyses very rough in any case. Still, it seems that the dam operators effectively dampen natural storm events.

Ignoring the dam and using Penobscot stages for tailwater, the channel's natural stream flow depths control flow characteristics up to and including the five year storm, Q5. Above Q15, the Penobscot River stages controls tailwater and controls all other flow characteristics. At un-dampened Q50 and Q100 flows, where most of flow would run over the roadway, the magnitude of the flow through the bridge opening is an interesting indicator of relative hydraulic performance. At the 100 year storm, the discharge rate through the barrel is calculated as : 200 cfs for the existing bridge; 300 cfs for the 14 foot precast box; and 400 cfs for the 22 foot precast box. Still, the analysis indicates for all the structures that most of a Q100 discharge will run over the roadway.

Following are the hydraulic characteristics:

HYDRAULICS SUMMARY

	Alt. #1 14 x 6.54 Box	Alt. #2 22 x 6.13 Box	Exist. Bridge 12' x 5' barrel
HW Elev. @ Q50	178.7 ft.	178.7 ft.	178.6 ft.
HW Elev. @ Q100	180.8 ft.	180.8 ft.	180.8 ft.
DS Velocity @ Q50	3.3 ft/sec	3.0 ft/sec	9.8 ft/sec
DS Velocity @ Q100	2.2 ft/sec	3.0 ft/sec	9.8 ft/sec
Ord. High Elev.(Q1.1)	Elev.173.37 ft.	Elev. 173.25 ft	Elev. 173.73 ft
DS Velocity @ Q1.1	7.76 f.p.s.	5.69 f.p.s.	8.14 f.p.s.
Clearance at Q50	-2.56 ft.	-3.1 ft.	-3.6 ft.
$Q_{Rdwy\ Flood}$	670 cfs	845 cfs	565 cfs

SCOUR

The analysis indicates maximum outlet velocities at intermediate storm events, when there is little roadway flooding. The highest outlet velocities are: 11.5 fps for Alternate #1; 9.4 fps for Alternate #2; and 11.6 fps for the existing bridge. Use toe walls at both inverts, plain riprap on sideslopes steeper than 2:1 and near wingwalls, and use five foot long riprap aprons outside the toe walls.

Respectfully Submitted,

Robert S. Bulger

Robert S. Bulger

Hydrology Data

Project Name:	Lincoln	**PIN:**	16712.00
Stream Name:	Combellassie Stream	**Town:**	Lincoln
Bridge Name:	Combellassie Stream Bridge	**Bridge No.**	2170
Route No.	2	**USGS Quad:**	
Analysis by:	AWMann	**Date:**	9/28/2009

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

Enter data in blue cells only!

	km²	mi²	ac	
A	45.62	17.615	11273.9	***Enter data in [mi²]*** Watershed Area
W	7.34	2.836	1814.7	Wetlands area (by NWI)
P_c	544353	5027745		watershed centroid (E, N; UTM 19N; meters)
County	Penobscot S			*choose county from drop-down menu*
pptA	39.5			mean annual precipitation (inches; by look-up)
SG	0.00			sand & gravel aquifer as decimal fraction of watershed A

A (km²)	45.62	Conf Lvl	0.67
W (%)	16.10		

Worksheet prepared by:
Charles S. Hebson, PE
Chief Hydrologist
Maine Dept. Transportation
Augusta, ME 04333-0016
207-287-1105
Charles.Hebson@maine.gov

Ret Pd T (yr)	Peak Flow Estimate Lower	Q_T (m³/s)	Upper	Q_T (ft³/s)
1.1		5.33		188.1
2	7.33	10.24	14.31	361.5
5	10.99	15.40	21.57	543.7
10	13.50	19.12	27.09	675.3
25	16.75	24.07	34.57	849.8
50	19.18	27.88	40.52	984.5
100	21.74	31.98	47.04	1129.3
500	27.57	41.87	63.58	1478.5

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

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

Hydraulic Data

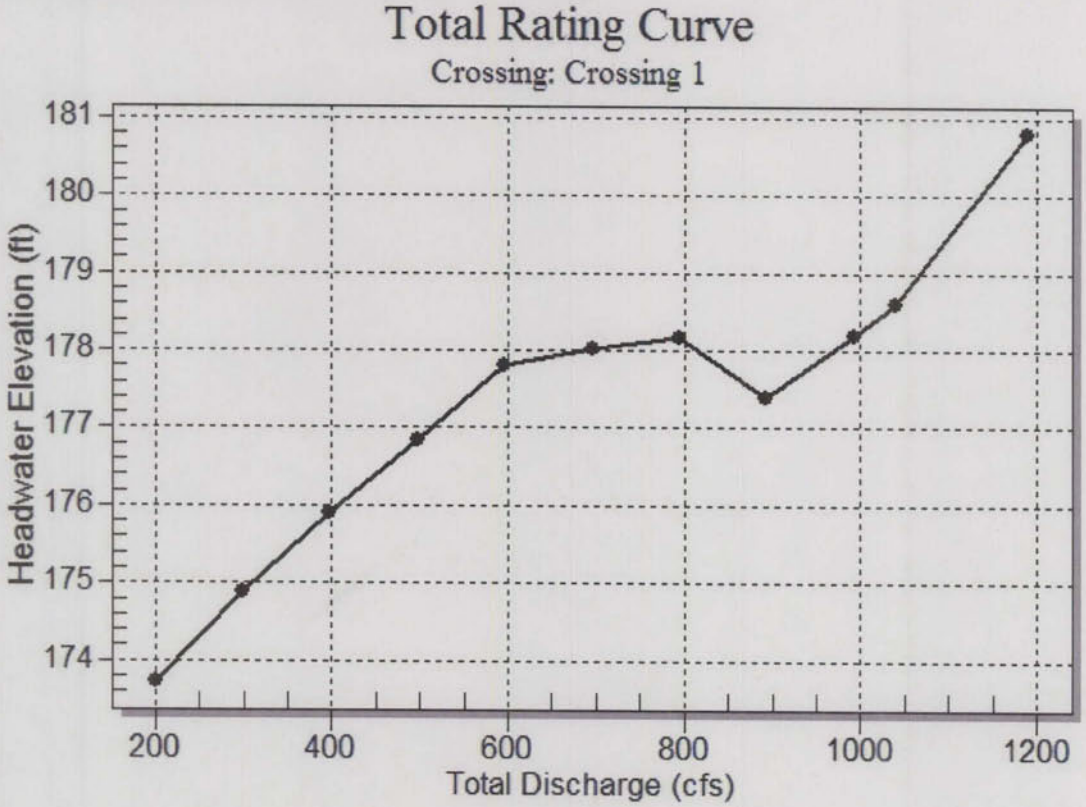
HY-8 Report for Existing Bridge w/ Penobscot TW

Headwater Elevation (ft)	Total Discharge (cfs)	Existing Bridge Discharge (cfs)	Roadway Discharge (cfs)	Iterations
173.73	200.00	200.00	0.00	1
174.88	299.00	299.00	0.00	1
175.91	398.00	398.00	0.00	1
176.85	497.00	497.00	0.00	1
177.81	596.00	566.55	29.33	4
178.03	695.00	579.17	115.18	7
178.18	794.00	588.15	207.55	9
177.40	893.00	398.00	503.34	14
178.20	992.00	299.00	692.24	6
178.60	1040.00	200.00	839.15	5
180.80	1190.00	197.10	993.88	3

Floods roadway → at El. 177.5± 565 c.f.s.

Table 1 - Summary of Culvert Flows at Crossing: Crossing 1

Rating Curve Plot for Crossing: Crossing 1



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)
200.00	200.00	173.73	3.187	3.731	2-M2c	2.186	2.048	2.048	1.517	8.137	0.000
299.00	299.00	174.88	4.209	4.882	2-M2c	2.878	2.676	2.676	1.900	9.310	0.000
398.00	398.00	175.91	5.205	5.909	2-M2c	3.515	3.240	3.240	2.223	10.237	0.000
497.00	497.00	176.85	6.694	6.850	2-M2c	4.115	3.759	3.759	2.506	11.019	0.000
596.00	566.55	177.81	7.812	7.474	2-M2c	5.000	4.104	4.104	2.800	11.505	0.000
695.00	579.17	178.03	8.029	7.588	2-M2c	5.000	4.163	4.163	4.000	11.592	0.000
794.00	588.15	178.18	8.183	5.600	2-M2c	5.000	4.206	5.000	5.600	9.802	0.000
893.00	398.00	177.40	5.205	7.400	2-M2c	3.515	3.240	5.000	7.400	9.802	0.000
992.00	299.00	178.20	4.209	8.200	2-M2c	2.878	2.676	5.000	8.200	9.802	0.000
1040.00	200.00	178.60	3.187	8.600	2-M2c	2.186	2.048	5.000	8.600	9.802	0.000
1190.00	197.10	180.80	3.157	10.800	2-M2c	2.165	2.029	5.000	10.800	9.802	0.000

Table 2 - Culvert Summary Table: Existing Bridge

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Inlet Elevation (invert): 170.00 ft, Outlet Elevation (invert): 169.92 ft

Culvert Length: 40.00 ft, Culvert Slope: 0.0020

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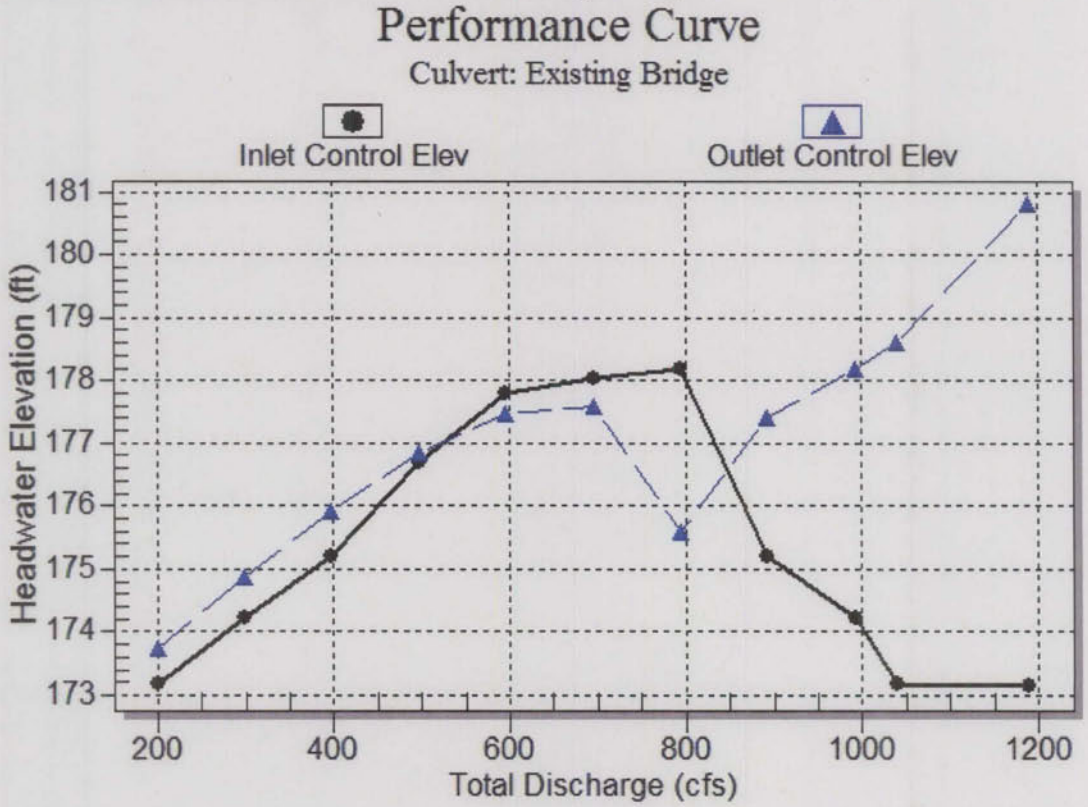
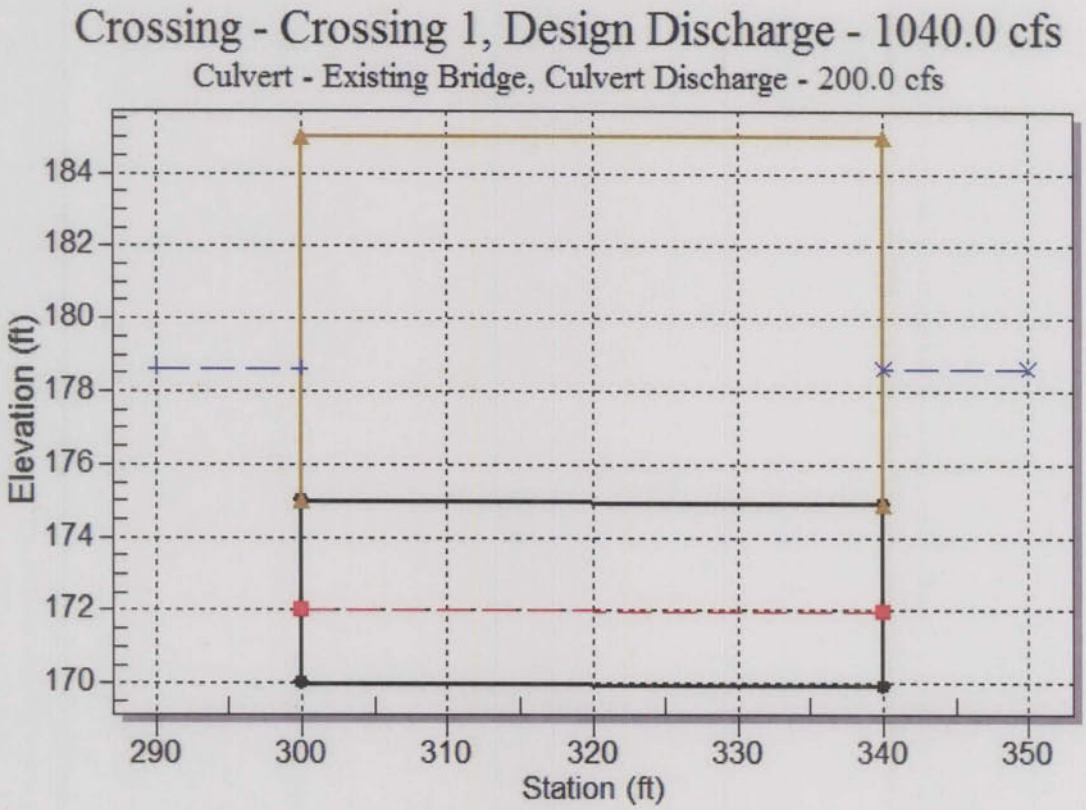
Culvert Performance Curve Plot: Existing Bridge



Water Surface Profile Plot for Culvert: Existing Bridge



Site Data - Existing Bridge

Site Data Option: Culvert Invert Data

Inlet Station: 300.00 ft

Inlet Elevation: 170.00 ft

Outlet Station: 340.00 ft

Outlet Elevation: 169.92 ft

Number of Barrels: 1

Culvert Data Summary - Existing Bridge

Barrel Shape: User Defined

Barrel Span: 12.00 ft

Barrel Rise: 5.00 ft

Barrel Material: Concrete

Barrel Manning's n: 0.0120 (top and sides)

Manning's n: 1.4lf (bottom)

Inlet Type: Conventional

Inlet Edge Condition: Mitered to Conform to Slope

Inlet Depression: None

Roadway Data for Crossing: Crossing 1

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
1	100.00	185.00
2	150.00	180.78
3	200.00	179.79
4	300.00	178.45
5	400.00	177.77
6	500.00	177.52
7	575.00	177.92
8	600.00	185.00

Roadway Surface: Paved

Roadway Top Width: 40.00 ft

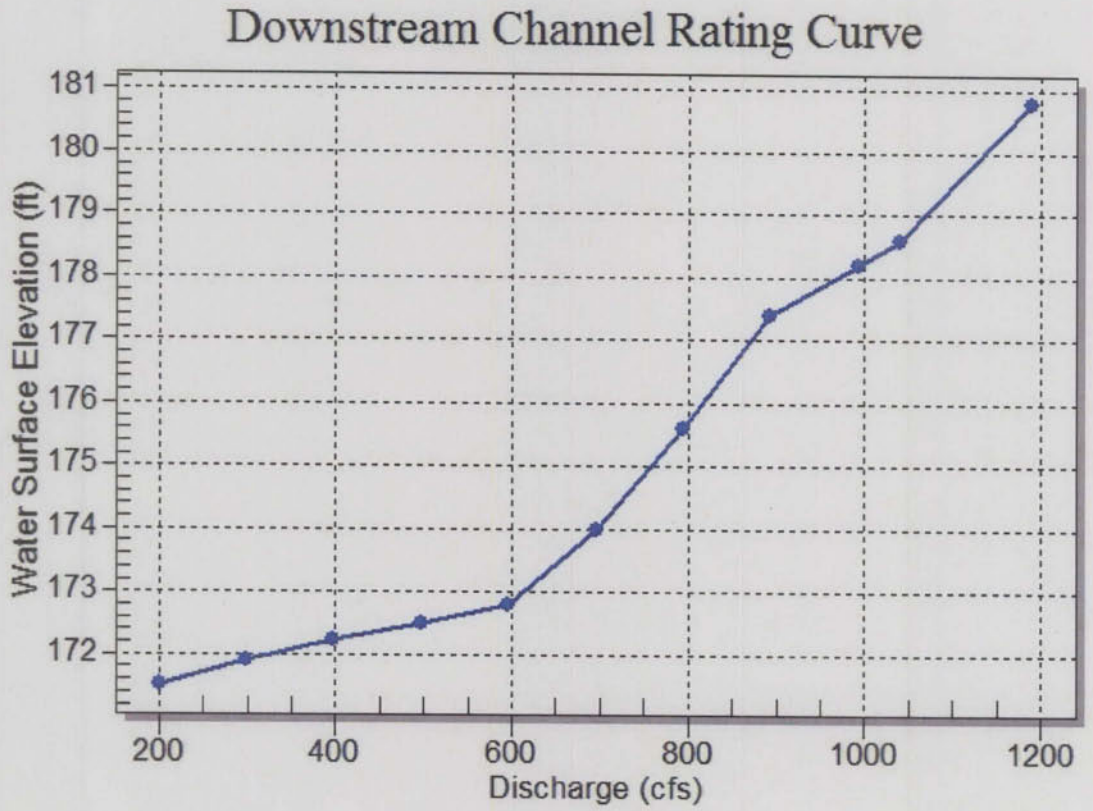
Table 3 - Downstream Channel Rating Curve (Crossing: Crossing 1)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
200.00	171.52	1.52
299.00	171.90	1.90
398.00	172.22	2.22
497.00	172.51	2.51
596.00	172.80	2.80
695.00	174.00	4.00
794.00	175.60	5.60
893.00	177.40	7.40
992.00	178.20	8.20
1040.00	178.60	8.60
1190.00	180.80	10.80

Tailwater Channel Data - Crossing 1

Tailwater Channel Option: Enter Rating Curve

Tailwater Rating Curve Plot for Crossing: Crossing 1



HY-8 Report for 14-Foot Box w/ Penobscot TW

Headwater Elevation (ft)	Total Discharge (cfs)	14-Footer Discharge (cfs)	Roadway Discharge (cfs)	Iterations
173.37	200.00	200.00	0.00	1
174.42	299.00	299.00	0.00	1
175.35	398.00	398.00	0.00	1
176.20	497.00	497.00	0.00	1
177.00	596.00	596.00	0.00	1
177.69	695.00	687.22	7.50	9
178.00	794.00	695.00	98.27	10
178.42	893.00	497.00	394.93	7
178.64	992.00	368.16	623.30	4
178.75	1040.00	299.00	742.76	4
180.81	1190.00	200.04	990.17	4

Floods @ 670 c.f.s.

Table 1 - Summary of Culvert Flows at Crossing: Crossing 1

Rating Curve Plot for Crossing: Crossing 1

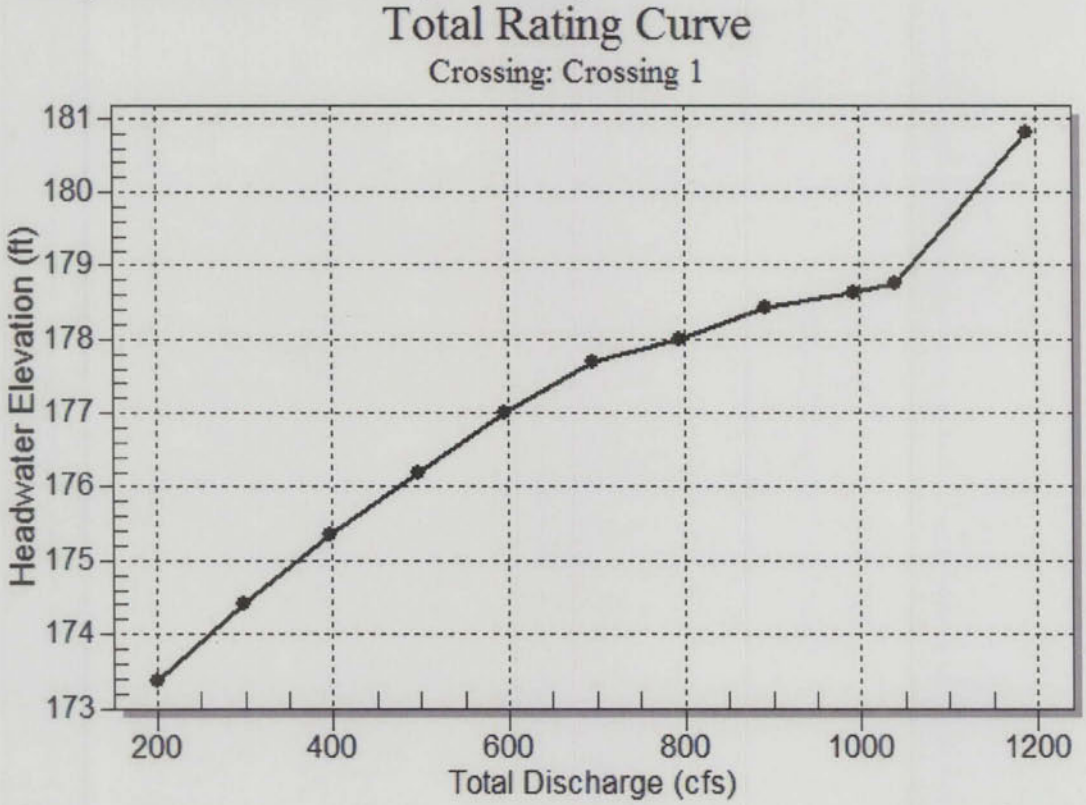


Table 2 - Culvert Summary Table: 14-Footer

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)
200.00	200.00	173.37	2.945	3.370	2-M2c	1.944	1.842	1.842	1.517	7.758	0.000
299.00	299.00	174.42	3.777	4.415	2-M2c	2.537	2.410	2.410	1.900	8.862	0.000
398.00	398.00	175.35	4.551	5.346	2-M2c	3.079	2.919	2.919	2.223	9.740	0.000
497.00	497.00	176.20	5.318	6.199	2-M2c	3.589	3.391	3.391	2.506	10.470	0.000
596.00	596.00	177.00	6.064	6.997	2-M2c	4.078	3.829	3.829	2.800	11.119	0.000
695.00	687.22	177.69	6.752	7.693	2-M2c	4.512	4.208	4.208	4.000	11.666	0.000
794.00	695.00	178.00	6.811	7.679	7-M1t	4.549	4.239	5.680	5.600	8.740	0.000
893.00	497.00	178.42	5.318	8.204	4-FFf	3.589	3.391	6.540	7.400	5.428	0.000
992.00	368.16	178.64	4.318	8.641	4-FFf	2.918	2.773	6.540	8.200	4.021	0.000
1040.00	299.00	178.75	3.777	8.891	4-FFf	2.537	2.410	6.540	8.600	3.266	0.000
1190.00	200.04	180.81	2.945	10.930	4-FFf	1.944	1.842	6.540	10.800	2.185	0.000

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Inlet Elevation (invert): 170.00 ft, Outlet Elevation (invert): 169.92 ft

Culvert Length: 40.00 ft, Culvert Slope: 0.0020

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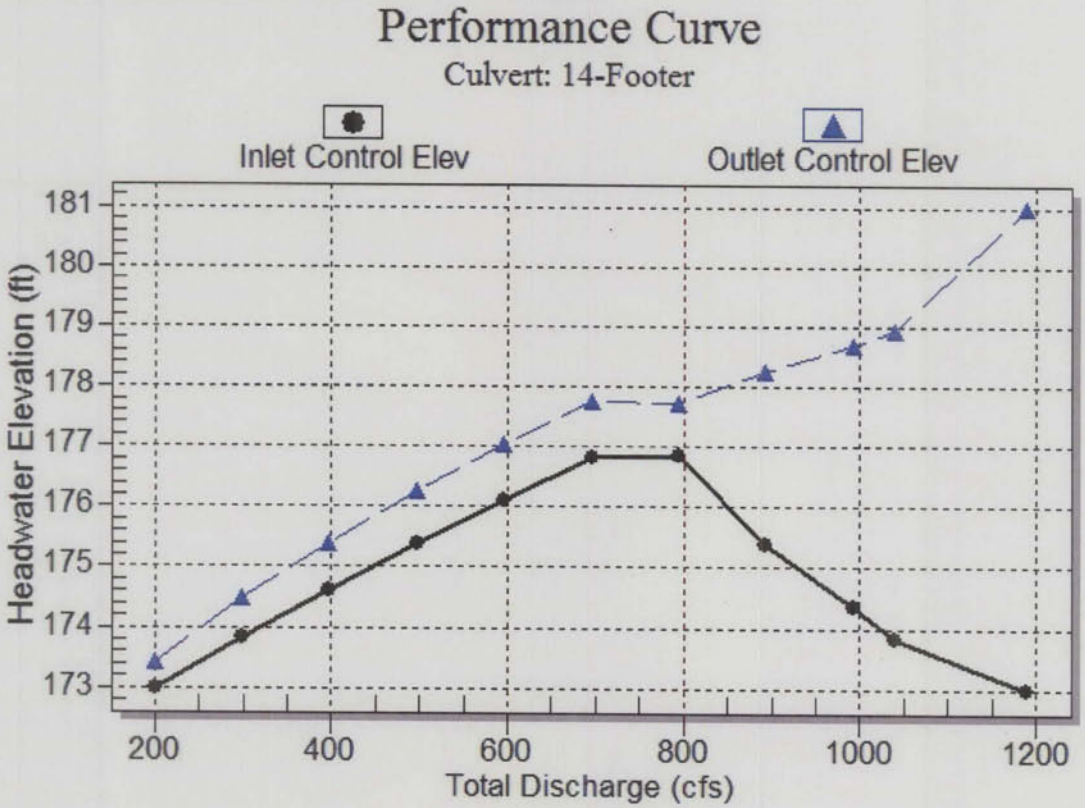
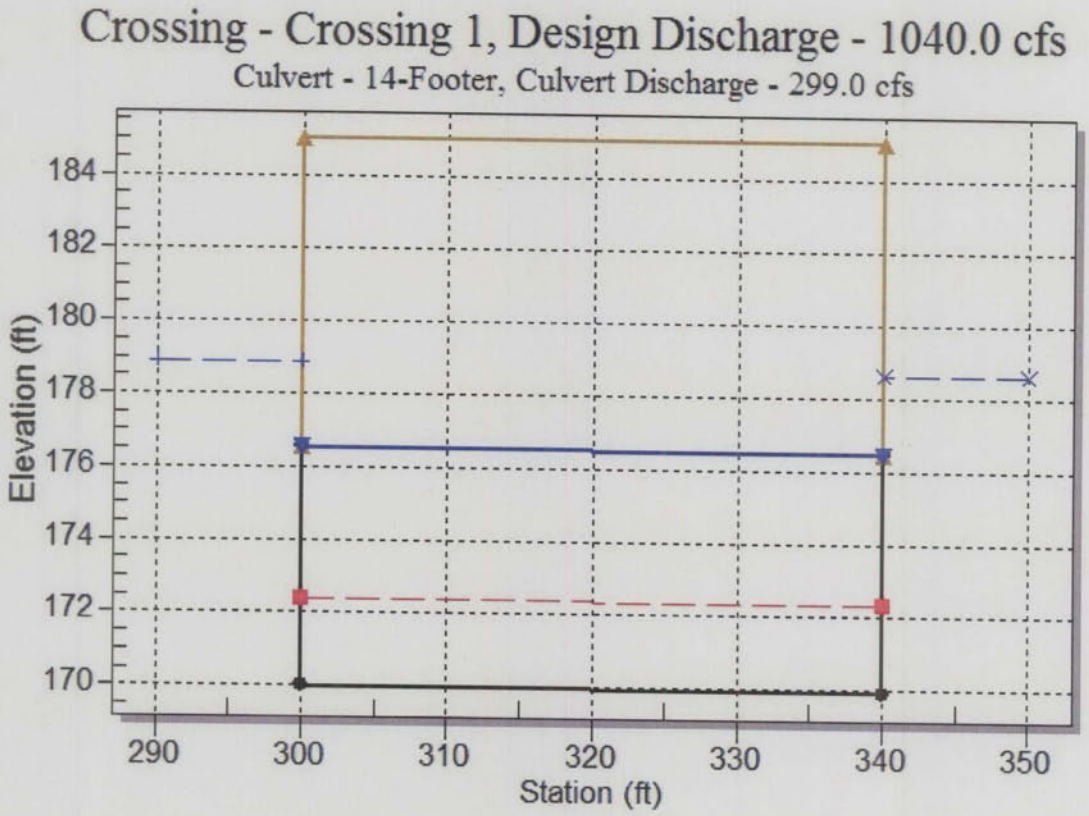
Culvert Performance Curve Plot: 14-Footer



Water Surface Profile Plot for Culvert: 14-Footer



Site Data - 14-Footer

Site Data Option: Culvert Invert Data

Inlet Station: 300.00 ft

Inlet Elevation: 170.00 ft

Outlet Station: 340.00 ft

Outlet Elevation: 169.92 ft

Number of Barrels: 1

Culvert Data Summary - 14-Footer

Barrel Shape: User Defined

Barrel Span: 14.00 ft

Barrel Rise: 6.54 ft

Barrel Material: Concrete

Barrel Manning's n: 0.0120 (top and sides)

Manning's n: 1.4lf (bottom)

Inlet Type: Conventional

Inlet Edge Condition: Mitered to Conform to Slope

Inlet Depression: None

Roadway Data for Crossing: Crossing 1

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
1	100.00	185.00
2	150.00	180.78
3	200.00	179.79
4	300.00	178.45
5	400.00	177.77
6	500.00	177.52
7	575.00	177.92
8	600.00	185.00

Roadway Surface: Paved

Roadway Top Width: 40.00 ft

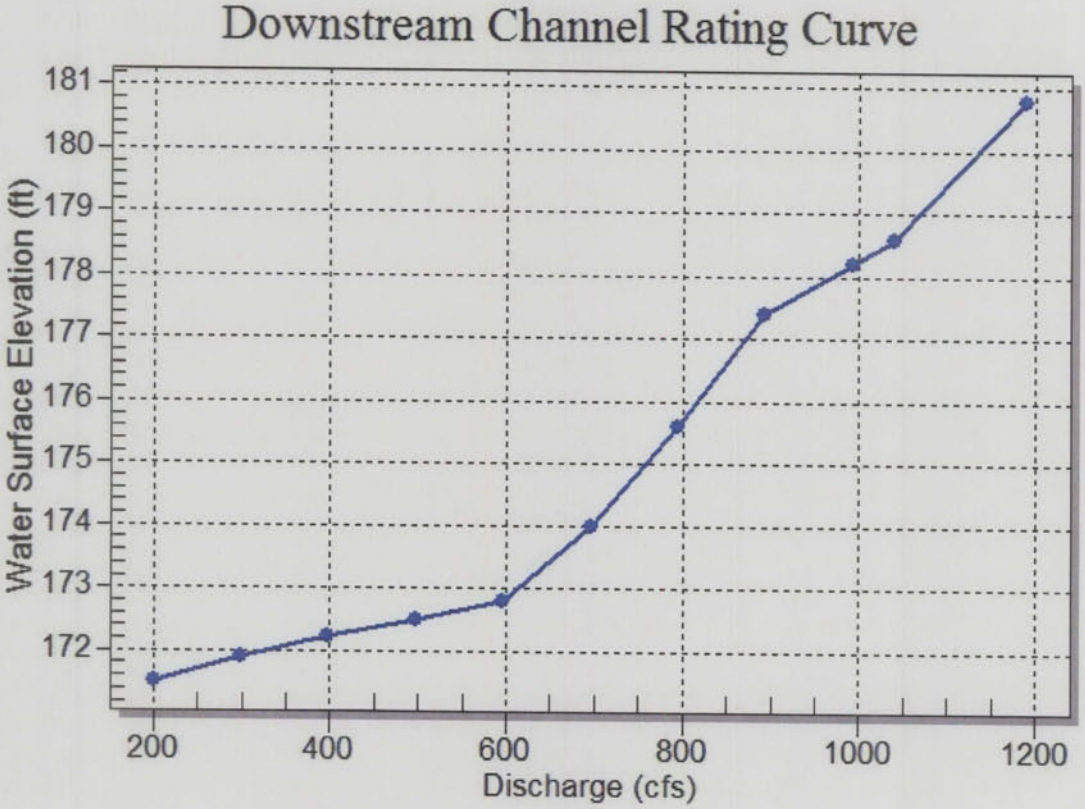
Table 3 - Downstream Channel Rating Curve (Crossing: Crossing 1)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
200.00	171.52	1.52
299.00	171.90	1.90
398.00	172.22	2.22
497.00	172.51	2.51
596.00	172.80	2.80
695.00	174.00	4.00
794.00	175.60	5.60
893.00	177.40	7.40
992.00	178.20	8.20
1040.00	178.60	8.60
1190.00	180.80	10.80

Tailwater Channel Data - Crossing 1

Tailwater Channel Option: Enter Rating Curve

Tailwater Rating Curve Plot for Crossing: Crossing 1



HY-8 Report for 22-Foot w/ Penobscot TW

Headwater Elevation (ft)	Total Discharge (cfs)	22-Footer Discharge (cfs)	Roadway Discharge (cfs)	Iterations
173.25	200.00	200.00	0.00	1
173.79	299.00	299.00	0.00	1
173.96	398.00	398.00	0.00	1
174.63	497.00	497.00	0.00	1
175.24	596.00	596.00	0.00	1
175.65	695.00	695.00	0.00	1
176.70	794.00	794.00	0.00	1
178.24	893.00	695.00	248.34	13
178.54	992.00	480.67	511.47	5
178.70	1040.00	398.00	645.04	11
180.81	1190.00	398.00	793.41	4

Floods roadway at El. 177.5 ft.

845 c.f.s.

Table 1 - Summary of Culvert Flows at Crossing: Crossing 1

Rating Curve Plot for Crossing: Crossing 1

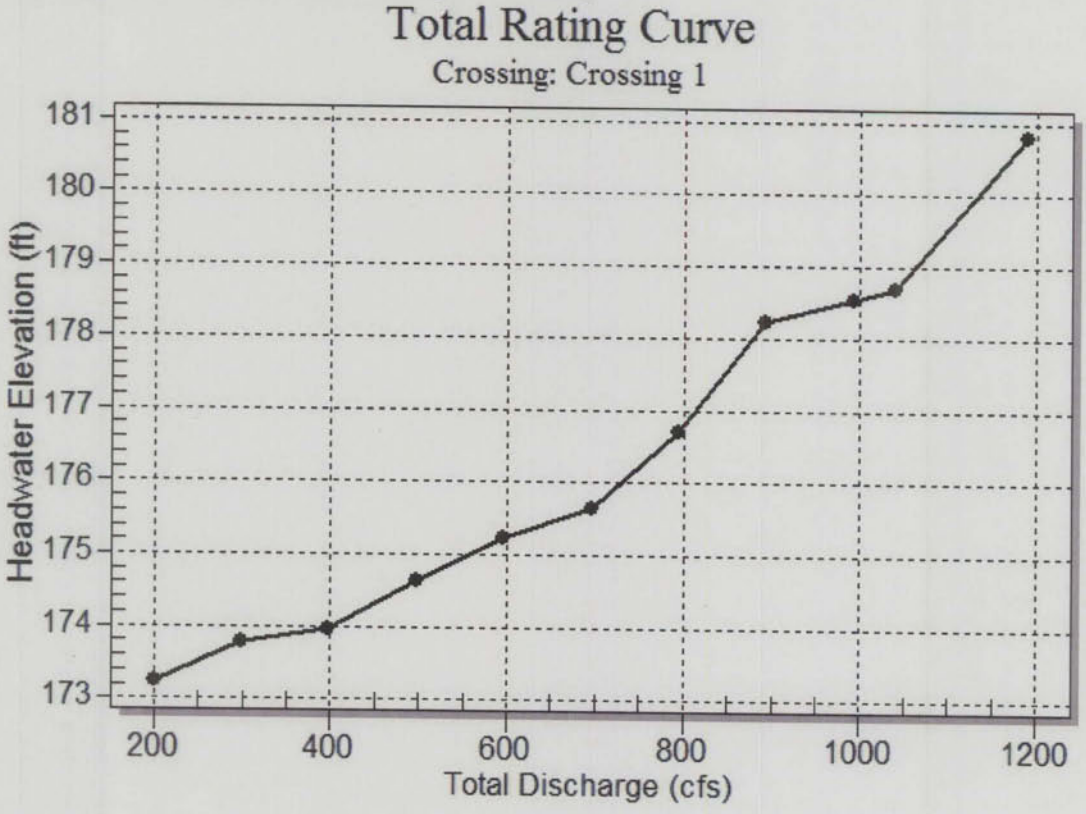


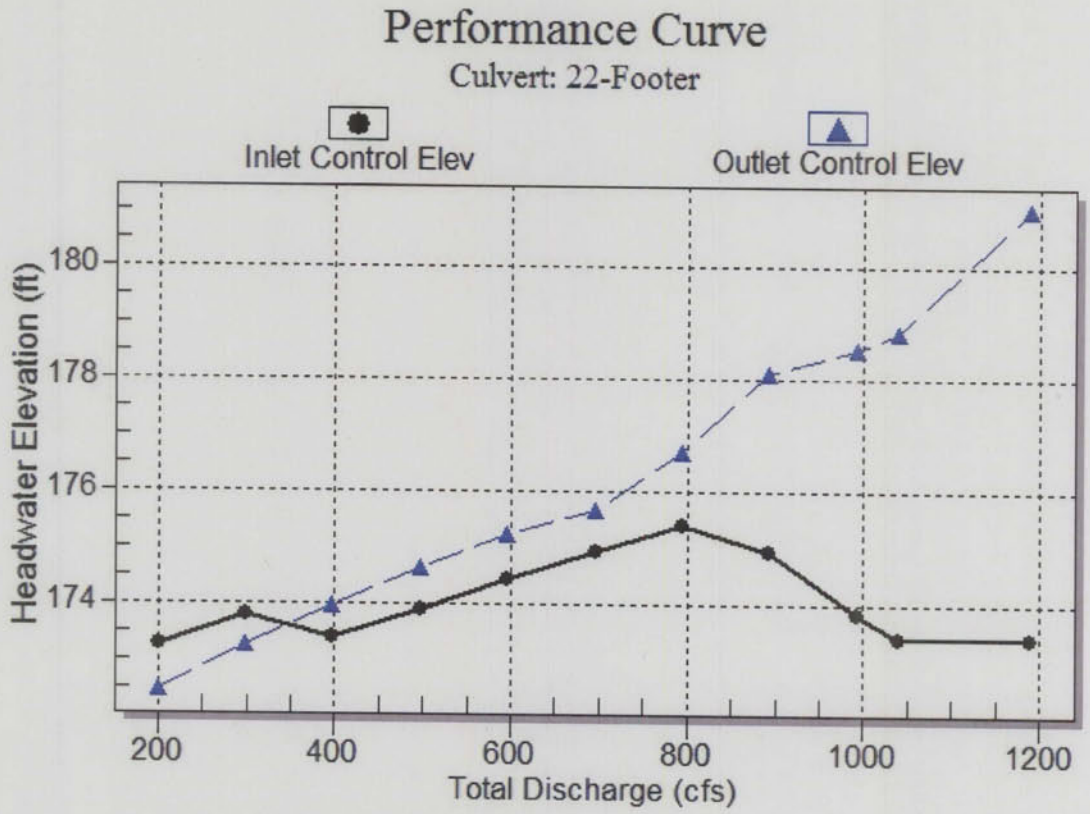
Table 2 - Culvert Summary Table: 22-Footer

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)
200.00	200.00	173.25	3.247	2.462	3-M1t	1.397	1.358	1.597	1.517	5.692	0.000
299.00	299.00	173.79	3.792	3.245	3-M1t	1.818	1.786	1.980	1.900	6.864	0.000
398.00	398.00	173.96	3.395	3.962	3-M1t	2.174	2.155	2.303	2.223	7.855	0.000
497.00	497.00	174.63	3.903	4.633	3-M1t	2.518	2.509	2.586	2.506	8.736	0.000
596.00	596.00	175.24	4.412	5.240	3-M1t	2.831	2.827	2.880	2.800	9.407	0.000
695.00	695.00	175.65	4.916	5.647	1-S1t	3.137	3.138	4.080	4.000	7.743	0.000
794.00	794.00	176.70	5.407	6.697	5-S1t	3.422	3.426	5.680	5.600	6.354	0.000
893.00	695.00	178.24	4.916	8.112	4-FFf	3.137	3.138	6.130	7.400	5.153	0.000
992.00	480.67	178.54	3.820	8.541	4-FFf	2.467	2.456	6.130	8.200	3.564	0.000
1040.00	398.00	178.70	3.395	8.834	4-FFf	2.174	2.155	6.130	8.600	2.951	0.000
1190.00	398.00	180.81	3.395	11.034	4-FFf	2.174	2.155	6.130	10.800	2.951	0.000

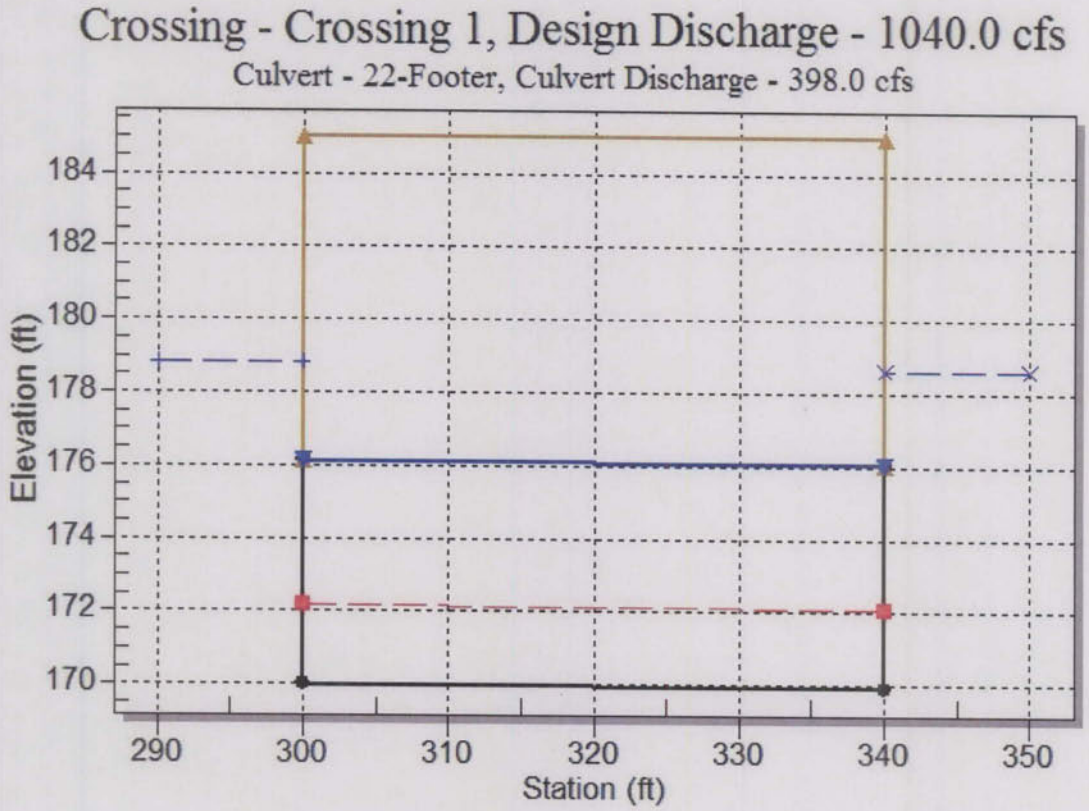
Inlet Elevation (invert): 170.00 ft, Outlet Elevation (invert): 169.92 ft

Culvert Length: 40.00 ft, Culvert Slope: 0.0020

Culvert Performance Curve Plot: 22-Footer



Water Surface Profile Plot for Culvert: 22-Footer



Site Data - 22-Footer

Site Data Option: Culvert Invert Data

Inlet Station: 300.00 ft

Inlet Elevation: 170.00 ft

Outlet Station: 340.00 ft

Outlet Elevation: 169.92 ft

Number of Barrels: 1

Culvert Data Summary - 22-Footer

Barrel Shape: User Defined

Barrel Span: 22.00 ft

Barrel Rise: 6.13 ft

Barrel Material: Concrete

Barrel Manning's n: 0.0120 (top and sides)

Manning's n: 1.4lf (bottom)

Inlet Type: Conventional

Inlet Edge Condition: Mitered to Conform to Slope

Inlet Depression: None

Roadway Data for Crossing: Crossing 1

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
1	100.00	185.00
2	150.00	180.78
3	200.00	179.79
4	300.00	178.45
5	400.00	177.77
6	500.00	177.52
7	575.00	177.92
8	600.00	185.00

Roadway Surface: Paved

Roadway Top Width: 40.00 ft

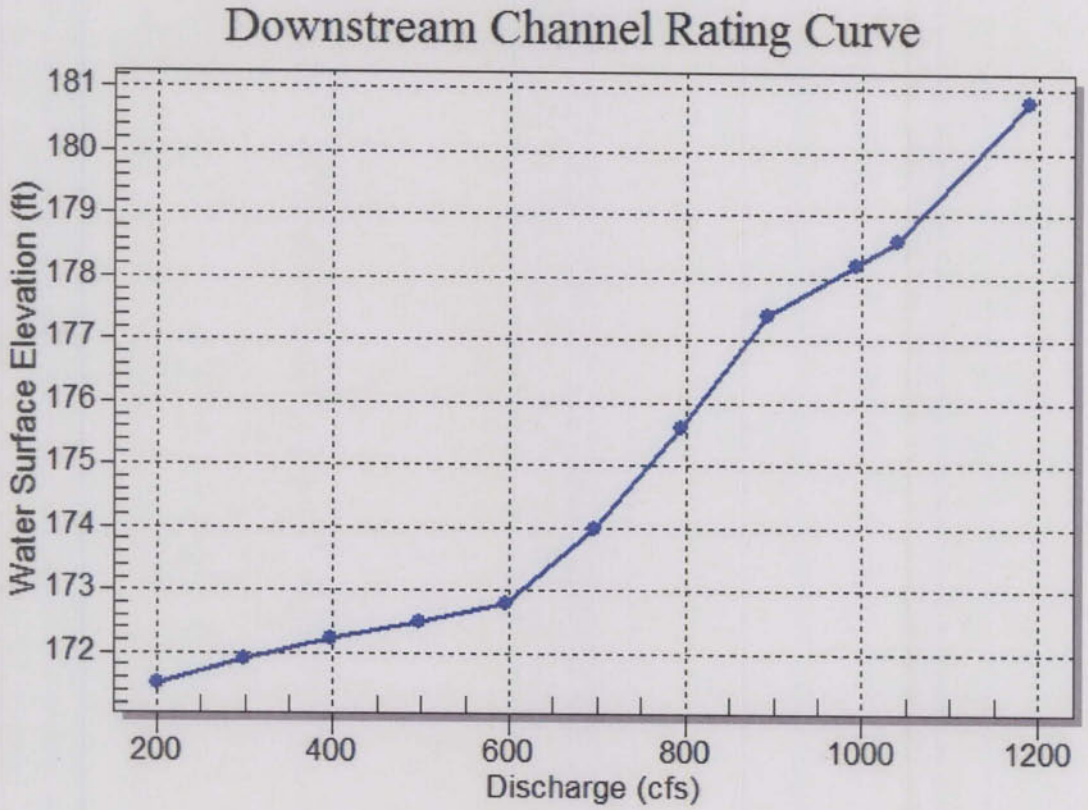
Table 3 - Downstream Channel Rating Curve (Crossing: Crossing 1)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
200.00	171.52	1.52
299.00	171.90	1.90
398.00	172.22	2.22
497.00	172.51	2.51
596.00	172.80	2.80
695.00	174.00	4.00
794.00	175.60	5.60
893.00	177.40	7.40
992.00	178.20	8.20
1040.00	178.60	8.60
1190.00	180.80	10.80

Tailwater Channel Data - Crossing 1

Tailwater Channel Option: Enter Rating Curve

Tailwater Rating Curve Plot for Crossing: Crossing 1



PRELIM. BY R.S. Bulger DATE 6/7/2010 PROJ. NO. 16712.00 FILE NO. _____ OF _____
FINAL CHK. BY _____ DATE _____ LOCATION Lincoln Cambolasse SH. NO. 1 OF 5
ITEM NO. _____ SUBJECT Existing Hydraulics

APPROXIMATION OF TAILWATER ELEVATIONS

As is usual, there is no ready resource for Tailwater elevations for the Cambolasse Bridge on Cambolasse Stream. However, it is clear that flood conditions have always been the result of water backing up from the nearby Penobscot River. So, the procedure will be to collect, analyze, and interpret data for the nearby reach of the Penobscot River as tailwater elevations.

Information Sources & Some Basic Data

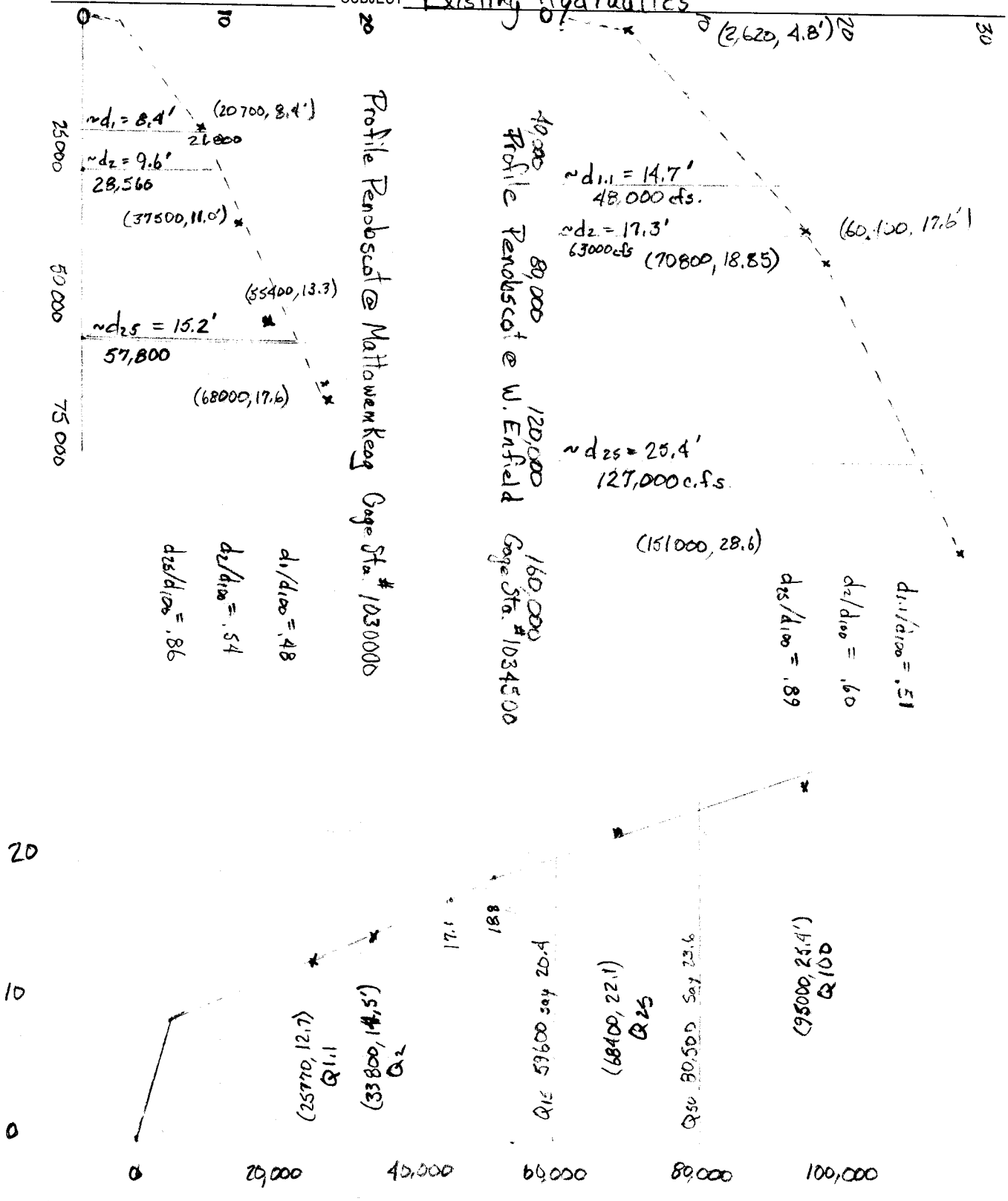
"Water Resources Data Maine, Water Year 2004" 1987, 1990, 1991
'99 "USGS Estimating...Peak Flows.. Maine" updated for methods & '87 flood statistics
Flood Insurance Studies: Mattawamkeag '88 (U.S.); Lincoln '87; Howland '96 (D.S.)

The only gage station in this area is at W. Enfield, across the river from Howland. It is just below the confluence with the Piscataquis, but provides the only contemporary link to flood stage information for this reach of the Penobscot.

Cambolasse Stream outlets into the Penobscot River 830 feet downstream of Cambolasse Bridge. Locating this confluence along the Penobscot and using the Town of Lincoln Flood Study, Cambolasse Stream flows into the Penobscot approximately 1/3 the distance from the confluence of MedunKeunk/Penobscot to the southerly end of Hersey Island. So the Cambolasse mouth is near 38000 feet upstream from the southerly Lincoln corporate limit, near Flood Study Penobscot River section 'R'.

The following page is plots of the depth/Flow profiles for the Penobscot at Gage Stations 1030000, 1034500 and an interpolated curve at Cambolasse

PRELIM. BY R.S. Bulger DATE 6/8/2010 PROJ. NO. 16712.00 FILE NO. ____ OF ____
FINAL CHK. BY ____ DATE ____ LOCATION Lincoln Cambolasse SH. NO. 2 OF 5
ITEM NO. ____ SUBJECT Existing Hydraulics



Interpolated Penobscot Profile $\frac{d_1}{d_{100}} \approx .5$ $\frac{d_2}{d_{100}} \approx .57$ $\frac{d_{25}}{d_{100}} = .87$ near Lincoln Flood Study Section R, the approximate conjunction with Cambolasse Stream.

PRELIM. BY R.S. Bulger DATE 6/8/2010 PROJ. NO. 16712.00 FILE NO. ____ OF ____
FINAL CHK. BY ____ DATE ____ LOCATION Lincoln Cambolasse Br. SH. NO. 3 OF 5
ITEM NO. ____ SUBJECT Existing Hydraulics

APPROXIMATION OF TAILWATER ELEVATIONS (CONT'D)

DATUM DIFFERENCE

The datum for the elevations in the "Flood Studies..", "Water Resources..." and previous two sheets is 1929 NGVD. Going forward the survey's 1988 NAVD datum will be used. Subtract 0.63 feet from 1929 Elevations for correct 1988 NAVD elevations

DATUM CONVERTED ELEVATION AT PENOBSCOT/CAMBOLASSE CONJUNCTION

Streambed 156.0 - .63' ≈ 155.4' above M.S.L.

$TW_{Q1.1} \simeq 155.4 + 12.7 = 168.1$ ft. $TW_{Q2} \simeq 169.8'$ $TW_{Q10} \simeq 175.8'$

$TW_{Q25} \simeq 177.5'$ $TW_{Q50} \simeq$ ~~179.0~~ 178.6' 7/16/2010 $TW_{Q100} \simeq 180.8$ ft.

NATURAL STREAM HYDRAULICS

Use the stream section upstream of the bridge, 850 feet from the Penobscot. The stream shape is very trapezoidal with the upstream invert at 170.0ft. and the upstream slope ~ 1ft./50ft. 0.02

$\frac{170 - 155.4}{850} = 0.01718 \sim 0.02$ OK.

The base of the upstream trapezoid stream channel measures about 14' and the sideslopes are 2.5:1

TRY! Backwater between Penobscot & Cambolasse Bridge will obviously be very flat Say ~ 6.6 ft./mi at all flows. Add 1' to Penobscot TW's for Bridge Outlet TW's. Results Seem No Good When Penobscot peaks, water levels will be very flat and higher on the Penobscot end than the bridge end. Use the Penobscot stages w/out change as bridge TW elevations.

ANALYSIS WITH HY-8

HY-8 is a capable, easy to use computer program with some limitations. The user is only allowed to input 3 discharge values: a minimum value, a design value, and a maximum value. The program run generates some additional values. Hower, in making a run for Q1.1, Q50, and Q100, the interval values are not good matches for other storm events of interest: Q2, Q10, or Q25.

Say $Q_{1.1}$ = 200cfs Q_2 = 380cfs Q_{10} = 715cfs Q_{25} = 900cfs Q_{50} = 1040 Q_{100} = 1195cfs

In one run with $Q_{dsgn} = Q50 = 1040$cfs, HY-8 provides flow calculations for: 200cfs; 299cfs; 398cfs; 497cfs; 596cfs; 695cfs; 794cfs; 893cfs. 992cfs; 1040cfs; and 1195cfs.

As stated on the previous page, <u>when</u> it is assumed that the Penobscot & Cambolasse experience the same storm event, the TW used at the bridge should be the unaltered storm stage at the conjunction. Read the depth for the appropriate Penobscot storm event from the "Interpolated Penobscot Profile" on sheet 2; add the datum converted streambed elevation, 155.4 ft.; and interpolate as necessary for HY-8 discharge values. Extra runs with Q2, Q15, and Q25 may also be useful.

HY-8 Flow:	200	299	398	497	596	695	794	893	992	7/16/2010
Penob TW:	168.1	169.0	170.0	171.4	172.8	174.0	175.6	177.4	178.2 ~~178.5~~	

Table 2 - Culvert Summary Table: 22-Footer

Q1.1

Q25 = 900

Q50

Q100

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)
200.00	200.00	173.25	3.247	2.462	3-M1t	1.397	1.358	1.597	1.517	5.692	0.000
299.00	299.00	173.79	3.792	3.245	3-M1t	1.818	1.786	1.980	1.900	6.864	0.000
398.00	398.00	173.96	3.395	3.962	3-M1t	2.174	2.155	2.303	2.223	7.855	0.000
497.00	497.00	174.63	3.903	4.633	3-M1t	2.518	2.509	2.586	2.506	8.736	0.000
596.00	596.00	175.24	4.412	5.240	3-M1t	2.831	2.827	2.880	2.800	9.407	0.000
695.00	695.00	175.65	4.916	5.647	1-S1t	3.137	3.138	4.080	4.000	7.743	0.000
794.00	794.00	176.70	5.407	6.697	5-S1t	3.422	3.426	5.680	5.600	6.354	0.000
893.00	695.00	178.24	4.916	8.112	4-FFf	3.137	3.138	6.130	7.400	5.153	0.000
992.00	0.00	178.33	0.000	8.500	0-NF	0.000	0.000	0.000	8.500	5.153	0.000
1040.00	0.00	178.37	0.000	9.000	0-NF	0.000	0.000	0.000	9.000	5.153	0.000
1190.00	398.00	180.11	3.395	10.334	4-FFf	2.174	2.155	6.130	10.100	2.951	0.000

178.2 ~~178.5~~
178.6 ~~179.0~~
180.1 180.8

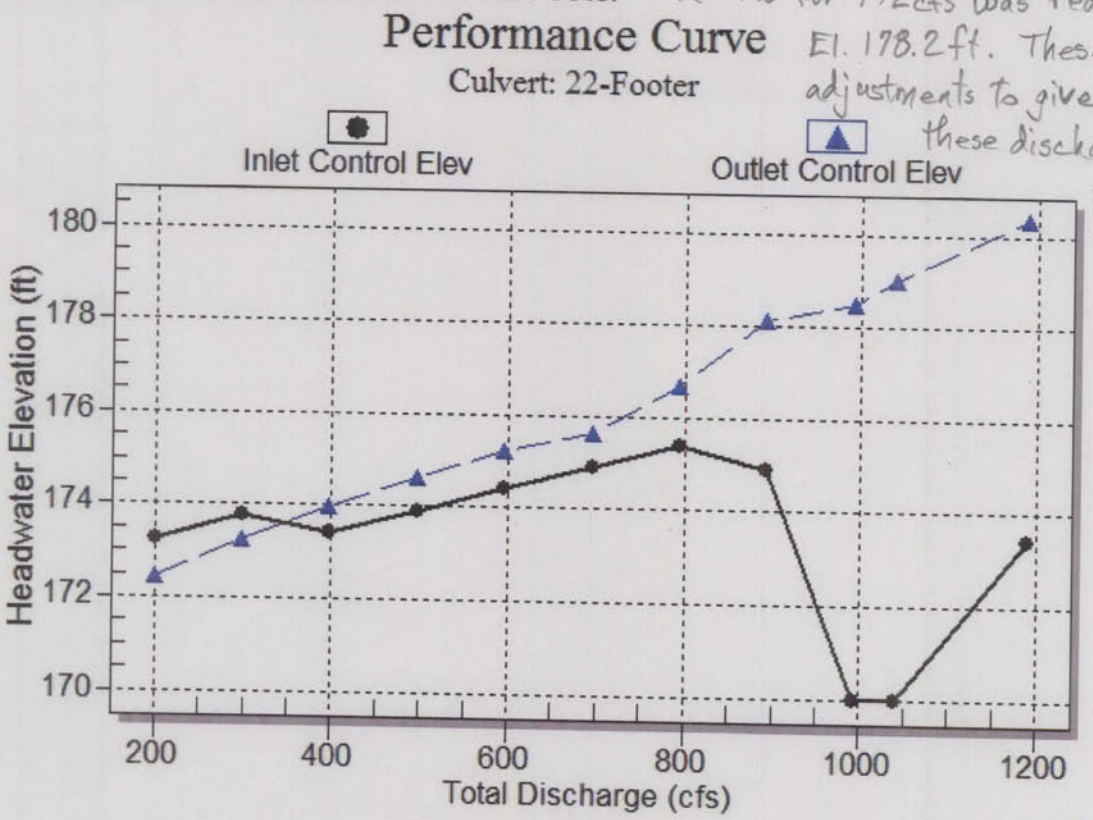
Inlet Elevation (invert): 170.00 ft, Outlet Elevation (invert): 169.92 ft

Culvert Length: 40.00 ft, Culvert Slope: 0.0020

This run made on 7/14/2010, with a slight adjustment of the 22-footer top slab thickness encounters an execution problem. In order to produce consistent comparative results at all 3 structures, the Q50, 1040 cfs, TW was reduced from 179.0' to El. 178.6' and the TW for 992 cfs was reduced from El. 178.5 to El. 178.2 ft. These were the smallest adjustments to give sensible results at these discharge values. See shts #3 & 4 of this file.

7/16/2010

Culvert Performance Curve Plot: 22-Footer



PRELIM. BY R.S. Bulger DATE 6/9/2010 PROJ. NO. 16712.00 FILE NO. ____ OF ____
FINAL CHK. BY ____ DATE ____ LOCATION Lincoln Camboloasse SH. NO. 1 OF ____
ITEM NO. ____ SUBJECT Trial Precast Box Section

TRY INCREASED HEIGHT AND SPAN

Even w/out Penobscot River T.W., the existing roadway north of the bridge starts flooding at 550 c.f.s., less than the uncontrolled 5-year storm: Q5 = 575 c.f.s. At Q5, the TW from the Penobscot is the same, so the roadway flooding stays at 30 c.f.s., 5% of the total Without Penobscot T.W., the roadway flood is 125 c.f.s, 17.4% of Q10, and 285 c.f.s or 32% of Q25. With Penobscot TW, the roadway flood is 160 c.f.s. or 22.2% of Q10, and 610 c.f.s. or 68% of Q25.

CONCLUSIONS: Without increasing the width the structure would always flood for the natural Q5 if not dam-controlled. At any width the bridge seems likely to flood when the TW reaches near elevation 174.0 ft. Still,

Try a 14.0 ft. clear width and a 6'4" rise. (8'4" w/ 2' buried)

PRELIMINARY COST ESTIMATE

PROJECT: Town, Lincoln Bridge # 2170 Bridge Replacement - Alternate #2 Project description - 22-ft. box culvert w/ in-line wings 11-ft lanes, 6-ft shoulders, 7 inches bit. Pavement Alternating 1-lane traffic via temporary signal & staging Box Plan Area: 68' x 22' = 1496 SF	PIN: 16712.00 ESTIMATED BY: R.S. Bulger

BOX CULVERT: 22 ' span x 8' 6" rise	1500	SF x $174	=	$265,000
ABUTMENTS: N/A	0	SF x $0	=	$0
PIERS:N/A	0	SF x $0	=	$0
COFFERDAMS:	2	EA x $20,000	=	$40,000
STRUCTURAL EXCAVATION:	450	CY x $31	=	$14,000
COMMON AND GRANULAR BORROW:	280	CY x $33	=	$10,000
RIPRAP:Plain	50	CY x $60	=	$3,000
EXISTING BRIDGE REMOVAL:	616	SF x $37	=	$23,000
DETOUR: N/A	0	SF x $0	=	$0
REHABILITATION CONTINGENCIES:N/A		0%	=	$0
MISCELLANEOUS (TCP'S, FIELD OFFICE, ETC.):		11%	=	$40,000
MOBILIZATION:		11%	=	$40,000
STRUCTURE SUBTOTAL			=	**$435,000**
APPROACHES:	276	ft x $400	=	$111,000
MISCELLANEOUS:		10%	=	$12,000
MOBILIZATION:		10%	=	$12,000
APPROACHES SUBTOTAL			=	**$135,000**
TOTAL CONSTRUCTION COST			=	**$570,000**
PRELIMINARY ENGINEERING:		11%	=	$65,000
RIGHT OF WAY:			=	$10,000
CONSTRUCTION ENGINEERING:		11%	=	$65,000
OTHER:			=	$0
TOTAL PROJECT COST			=	**$710,000**