

HYDROLOGY REPORT

This 5.8 square mile watershed exists to the north and west of the bridge site. The mean basin elevation is 671 feet with the maximum basin elevation of 810 feet. Almost 5% of the basin area is occupied by known sand and gravel aquifers. Less than 1/10 of one percent of the basin is open water but total storage area including wetlands is almost 18% of the watershed area. Impervious area is less than 1% of the watershed area, presumably including the almost 5% of developed urban land. There are no free-draining Hydrologic Soil Type A soils mapped in the watershed. Mean flows during the summer months are predicted to be less than 2 cubic feet per second with spring runoff flows closer to 18 cubic feet per second. Soils are mapped as silt-loams with gravelly fractions increasing with depth. Mean annual precipitation is 38 inches.

Predicted peak storm flows at the culvert from the contributing watershed are listed below for the various design storms.

SUMMARY		
Drainage Area	5.8	mi ²
Q1.1	71.4	ft ³ /s
Q10	274.5	ft ³ /s
Q25	360.4	ft ³ /s
Q50	412.8	ft ³ /s
Q100	483.6	ft ³ /s
Q500	639.9	ft ³ /s

Reported by: Mark Gray with hydrologic
calculations by Charles
Hebson

Date: December 19, 2017

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.

HYDRAULIC REPORT

Otter Brook flows under US Route 1 from west to east at a 15 degree clockwise skew. When the roadway was reconstructed in 1960, the stream channel was diverted on the east side of the roadway and the stream crossing location was moved 250' to the north. The existing 10'-8" wide by 6'-11" high steel pipe arch culvert is predicted to pass the 50 year design storm with the head pool submerging the top of the culvert by about a foot. Mild scour holes exist on both the inlet and outlet apron areas of the culvert. The bank full width of Otter Brook along this reach is 22 feet. The stream bottom surface is gravelly sand with rock and cobbles with a range of sizes from 15" or so to 4" or less. Due to its diversion and realignment in 1960, the stream abruptly turns to the south on the east side and continues to the south diverging from the Route 1 roadbed to the east at about 16 degrees.

This existing culvert is severely corroded and near the end of its service life. It will be replaced with a concrete box culvert.

HY-8 version 7.3 was used to analyze both the existing culvert and the proposed 22' by 8' concrete box culvert. The tail water channel for both culverts was modelled as a trapezoid with a 22' wide bottom and 2 on 1 side slopes with a longitudinal slope of 0.47% and a Manning's n value of 0.035.

HY-8 contains the pipe arch culvert as a library culvert. The existing culvert was modelled with 6" of stream bank material in the invert with 0.035 n value for this portion. The culvert sides and top used an n value of 0.027. One foot of drop occurs from end to end. Entrance and exit losses were premised on a slope-tapered configuration.

The box culvert was modelled at 86' long with 1 foot of drop through the barrel and 24" of stream bed material in the invert. Stream bed material featured a Mannings n value of 0.035 with the culvert sides and top using $n = 0.012$. Inlet and outlet losses were calculated based on a slope-tapered configuration.

The following chart summarizes the results of the HY-8 analysis.

HY-8 Hydraulic Results							
Storm	Flow cfs	128" x 83" Steel Pipe Arch (Existing)			22' x 8' Concrete Box Culvert		
		Headwater Elevation feet	Outlet Velocity fps	Tailwater Velocity fps	Headwater Elevation feet	Outlet Velocity fps	Tailwater Velocity fps
Q1.1	71.4	546.7	6.2	2.8	545.2	3.1	2.8
Q10	274.5	549.7	9.4	4.5	547.1	5.4	4.5
Q25	360.4	550.8	10.5	4.9	547.7	6.1	4.9
Q50	412.8	551.6	11.2	5.1	548.0	6.4	5.1
Q100	483.6	553.0	12.1	5.4	548.5	6.9	5.4
Q500	639.9	554.2	12.8	5.8	549.4	7.8	5.8
Inside top elevation of culvert inlet side				550.5			550.0
Q50 Headwater Clearance				(1.1)			2.0
Q100 Headwater Clearance				(2.5)			1.5

The improved hydraulic performance of the box culvert over the existing culvert is apparent. Headwater elevations reduce by over 3.5 feet for the Q50 storm and outlet velocities reduce from 11.2 fps to 6.4 fps for the same storm.

Reported by: Mark Gray with hydrologic
calculations by Charles
Hebson

Date: December 19, 2017

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.

Appendix E

Hydraulics Data

WIN: 22228.00
 Town: Caribou
 Route No. US 1
 Asset ID: 5902
 Lat: 46.9202 Long: -68.01928

Project Name: Caribou Otter Brook 5902
 Stream Name: Otter Brook
 Bridge Name: US1 Otter Brook
 Analysis by: DFB
 Date: 8/15/2017

Peak Flow Calculations by USGS Regression Equations (Hodgkins, 1999 & Lombard/Hodgkins, 2015)

Enter data in blue cells only!

	km ²	mi ²	ac
A	15.02	5.80	3712.0
W	2.65	1.0	654.8
P _c	572594	5198694	
County	Somerset S		
pptA	39.5		
SG	0.05		
A (km ²)	15.02		
W (%)	17.64		

Enter data in [mi²]

Watershed Area *DRNAREA*
 Wetlands area (by NWI)

watershed centroid (E, N; UTM 19N; meters)
 choose county from drop-down menu
 mean annual precipitation (inches; by look-up)
 sand & gravel aquifer as decimal fraction of watershed A

Worksheet prepared by:

Charles S. Hebson, PE
 Environmental Office
 Maine Dept. Transportation
 Augusta, ME 04333-0016
 207-557-1052
Charles.Hebson@maine.gov
 ver. 2017 Jun. 09

Conf Lvl 0.67

NWI Wetlands % *STORNWI*

References:

Hodgkins, G.A., 1999.
 Estimating the magnitude of peak flows for streams
 in Maine for selected recurrence intervals
WRIR 99-4008, USGS Augusta, ME

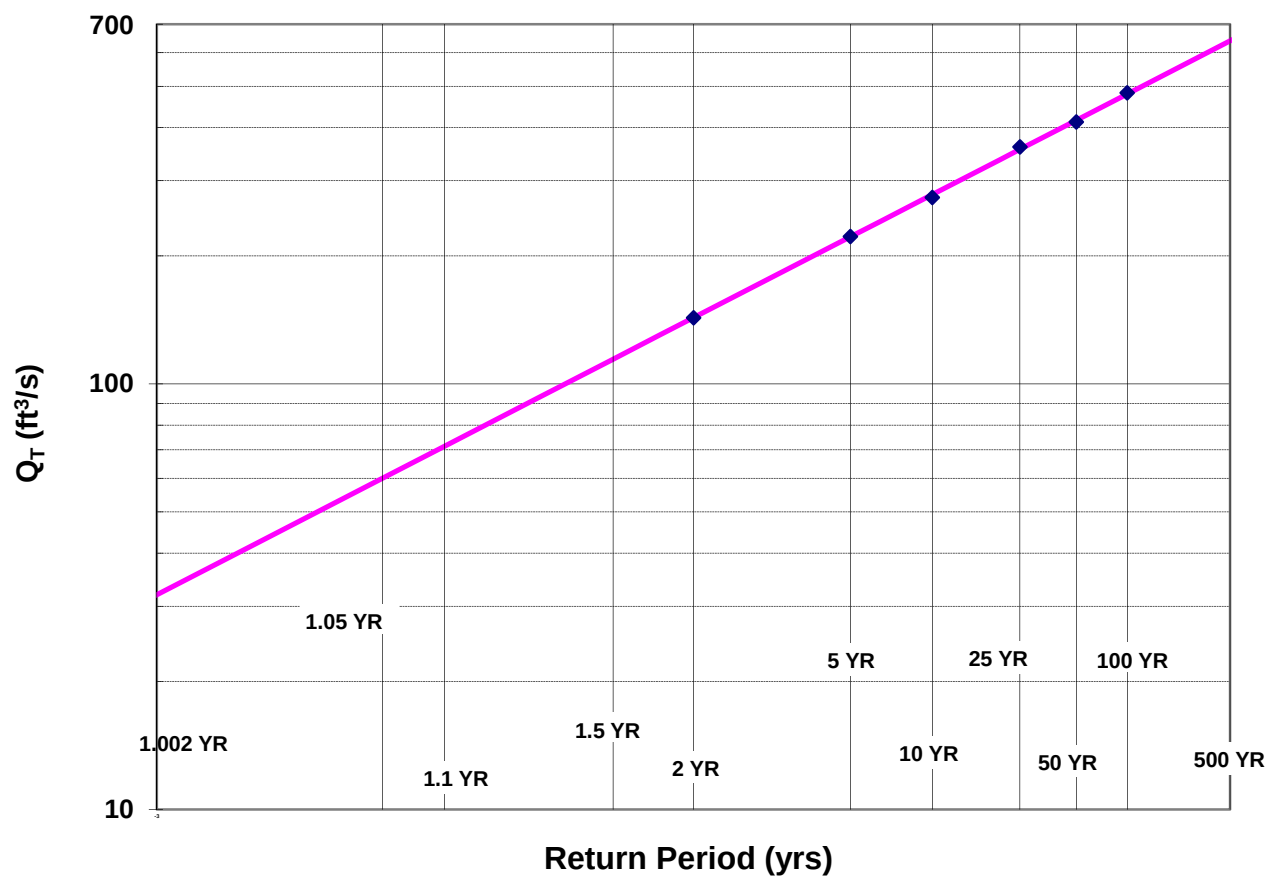
Lombard, P.J. & G.A. Hodgkins, 2015.
 Peak flow regression equations for small, ungaged streams in
 Maine - Comparing map-based to field-based variables
SIR 2015-4059, USGS, Augusta, ME

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

Ret Pd	Peak Flow Estimate		
T (yr)	Lower	Q _T (m ³ /s)	Upper
1.1		2.02	
2		4.05	
5		6.29	
10		7.77	
25		10.21	
50		11.69	
100		13.70	
500		18.12	

Q _T (ft ³ /s)
71.4
143.1
222.2
274.5
360.4
412.8
483.6
639.9

Log-Normal Probability Plot



WIN: 22228.00
 Town: Caribou
 Route No. US 1
 Asset ID: 5902
 Lat: 46.92023 Long: -68.01928

Project Name: Caribou Otter Brook 5902
 Stream Name: Otter Brook
 Bridge Name: US1 Otter Brook
 Analysis by: DFB
 Date: 8/15/2017

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

MAINE MONTHLY MEDIAN FLOWS and HYDRAULIC GEOMETRY BY USGS REGRESSION EQUATIONS (2004, 2013)

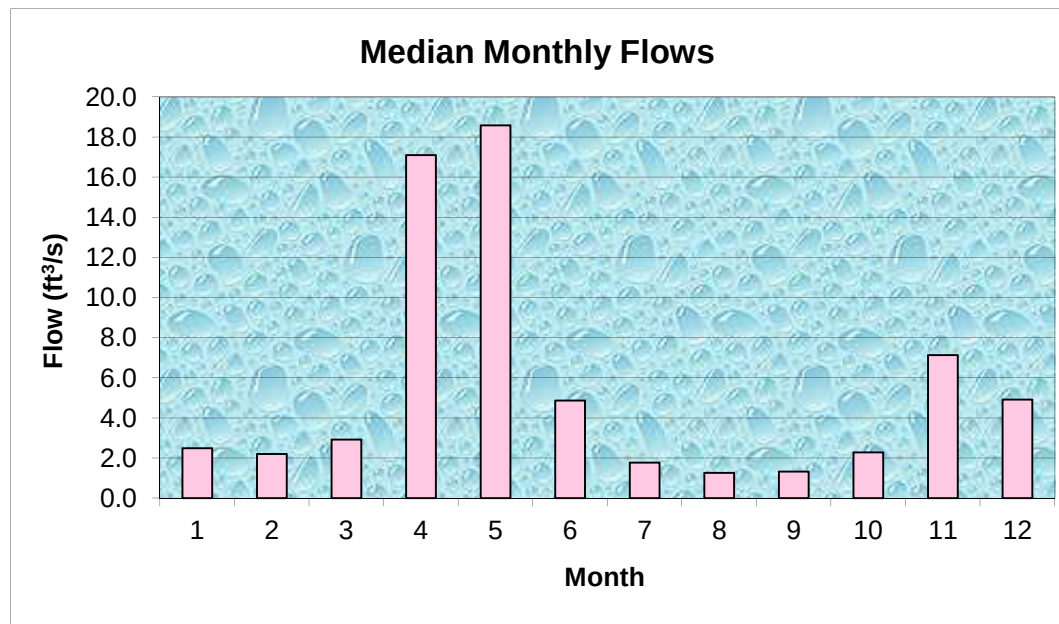
	Value	Variable	Explanation
	5.80	A	Area (mi ²)
572594	5198694	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
	174.89	DIST	Distance from Coastal reference line (mi)
	39.5	pptA	Mean Annual Precipitation (inches)
	0.05	SG	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q_{median} (ft ³ /s)	(m ³ /s)
Jan	2.50	0.0709
Feb	2.20	0.0624
Mar	2.92	0.0828
Apr	17.10	0.4847
May	18.58	0.5266
Jun	4.87	0.1379
Jul	1.77	0.0502
Aug	1.26	0.0357
Sep	1.33	0.0376
Oct	2.29	0.0650
Nov	7.14	0.2023
Dec	4.92	0.1395

Q_{bf}	32.9
ann avg	11.1
ann med	5.1
$Q_{1.002}$	32.0
$Q_{1.01}$	42.5
$Q_{1.05}$	60.0
Q_{bf}	97.3

assume v = 4ft/s

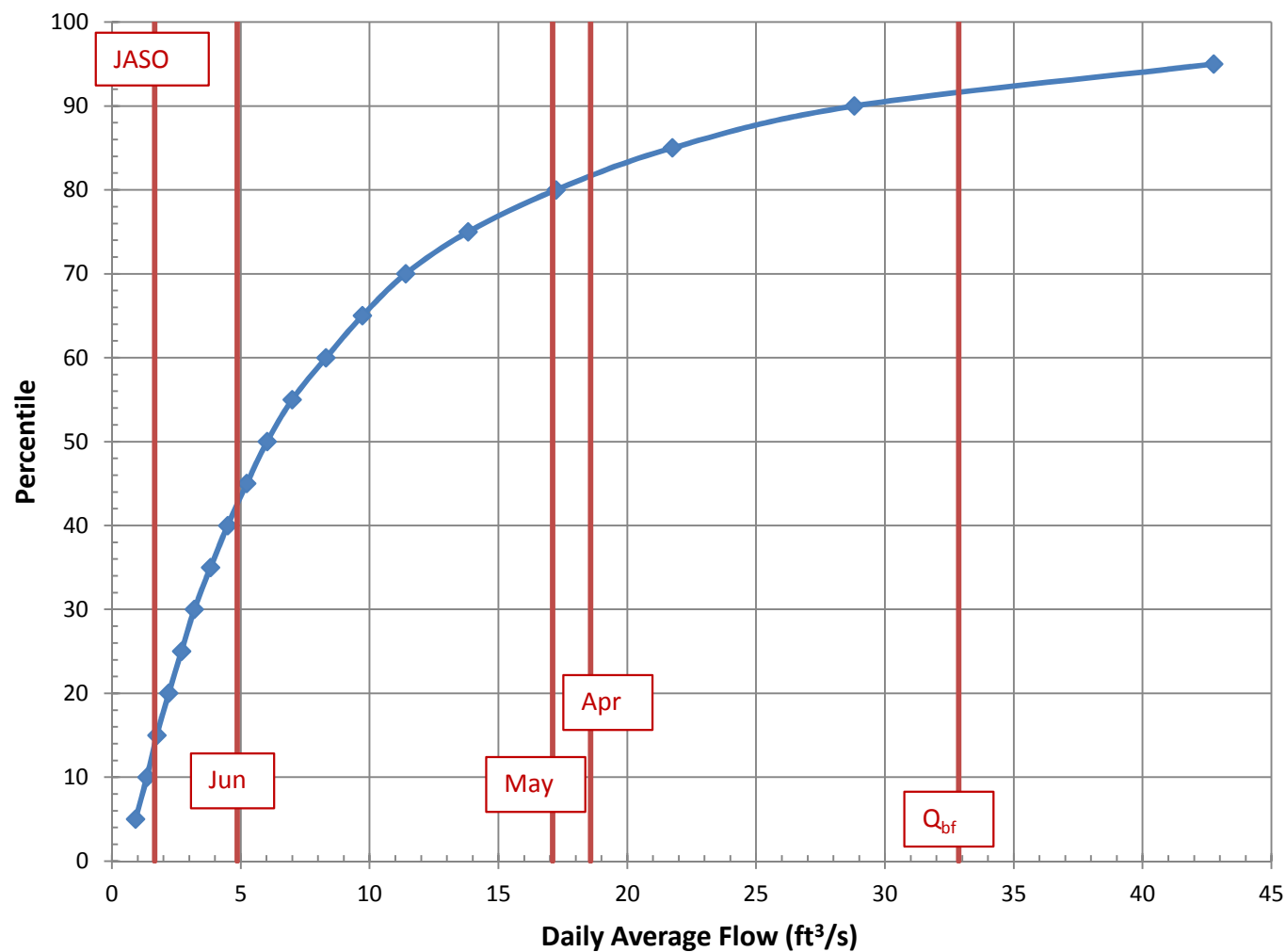
W_{bf}	22.5	estimated bankfull width (ft)
d_{bf}	1.1	estimated bankfull depth (ft)
A_{bf}	20.6	estimated bankfull flow area (ft ²)



References

Dudley, R.W., 2013. FY2013 Progress Report - Phase 1 ..., USFWS QRP Project
 Dudley, R.W., 2004. Estimating Monthly Streamflows ..., SIR 2004-5026

Daily Average Flow Distribution



Daily Avg Flow Dist

$A_{ws} = (mi^2)$ 5.8

$Q (ft^3/s)$

Pctl	Median	84 th pctl
5	0.91	1.47
10	1.36	2.04
15	1.74	2.55
20	2.21	3.09
25	2.70	3.62
30	3.20	4.12
35	3.83	4.71
40	4.49	5.42
45	5.23	6.13
50	6.02	7.23
55	7.00	8.42
60	8.31	9.88
65	9.72	11.51
70	11.40	13.43
75	13.82	16.15
80	17.24	19.28
85	21.75	24.71
90	28.81	33.18
95	42.76	51.60

Q_{bf} 32.9

$Q_{1.002}$ 32.0

$Q_{1.1}$ 71.4

Q_2 143.1

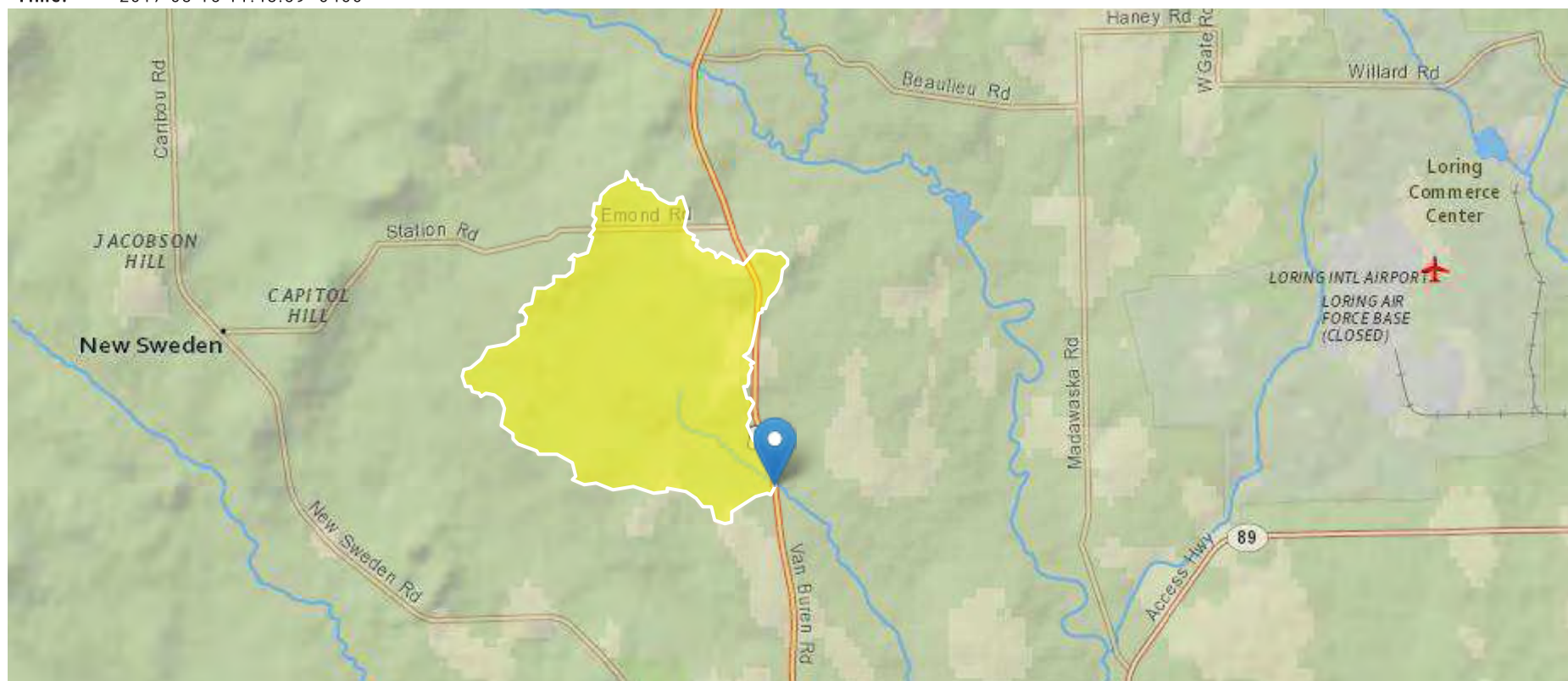
Caribou 22228 Otter Brook Br5902

Region ID: ME

Workspace ID: ME20170815114706682000

Clicked Point (Latitude, Longitude): 46.92023, -68.01928

Time: 2017-08-15 11:48:59 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	5.8	square miles
STORNWI	Percentage of storage (combined water bodies and wetlands) from the Nationa Wetlands Inventory	17.64	percent

Parameter Code	Parameter Description	Value	Unit
SANDGRAVAF	Fraction of land surface underlain by sand and gravel aquifers	0.048	dimensionless
ELEV	Mean Basin Elevation	671.1	feet
BSLDEM10M	Mean basin slope computed from 10 m DEM	3.47	percent
COASTDIST	Shortest distance from the coastline to the basin centroid	176	miles
ELEVMAX	Maximum basin elevation	809.7	feet
LC06WATER	Percent of open water, class 11, from NLCD 2006	0.07	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	4.72	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0.93	percent
PRECIP	Mean Annual Precipitation	38	inches
SANDGRAVAP	Percentage of land surface underlain by sand and gravel aquifers	4.78	percent
STATSGOA	Percentage of area of Hydrologic Soil Type A from STATSGO	0	percent

Peak-Flow Statistics Parameters [Statewide Peak Flow DA LT 12sqmi 2015 5049]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	5.8	square miles	0.31	12
STORNWI	Percentage of Storage from NWI	17.64	percent	0	22.2

Peak-Flow Statistics Flow Report [Statewide Peak Flow DA LT 12sqmi 2015 5049]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
1.01 Year Peak Flood	43.1	ft^3/s	38
2 Year Peak Flood	143	ft^3/s	34
5 Year Peak Flood	222	ft^3/s	35
10 Year Peak Flood	274	ft^3/s	37
25 Year Peak Flood	360	ft^3/s	39
50 Year Peak Flood	413	ft^3/s	41

Statistic	Value	Unit	SEp
100 Year Peak Flood	483	ft ³ /s	42
250 Year Peak Flood	536	ft ³ /s	44
500 Year Peak Flood	639	ft ³ /s	47

Peak-Flow Statistics Citations

Lombard, P.J., and Hodgkins, G.A., 2015, Peak flow regression equations for small, ungaged streams in Maine— Comparing map-based to field-based variables: U.S. Geological Survey Scientific Investigations Report 2015–5049, 12 p. (<http://dx.doi.org/10.3133/sir20155049>)

Low-Flow Statistics Parameters [Statewide LowFlow SIR 2004 5026]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	5.8	square miles	9.79	1418
SANDGRAVAF	Fraction of Sand and Gravel Aquifers	0.048	dimensionless	0	0.455

Low-Flow Statistics Disclaimers [Statewide LowFlow SIR 2004 5026]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Low-Flow Statistics Flow Report [Statewide LowFlow SIR 2004 5026]

Statistic	Value	Unit
7 Day 10 Year Low Flow	0.239	ft ³ /s

Low-Flow Statistics Citations

Dudley, R.W., 2004, Estimating Monthly, Annual, and Low 7-Day, 10-Year Streamflows for Ungaged Rivers in Maine: U.S. Geological Survey Scientific Investigations Report 2004-5026, 22 p. (<http://water.usgs.gov/pubs/sir/2004/5026/pdf/sir2004-5026.pdf>)

Flow-Duration Statistics Parameters [Statewide Annual SIR 2015 5151]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	5.8	square miles	14.9	1419
SANDGRAVAF	Fraction of Sand and Gravel Aquifers	0.048	dimensionless	0	0.212
ELEV	Mean Basin Elevation	671.1	feet	239	2120

Flow-Duration Statistics Disclaimers [Statewide Annual SIR 2015 5151]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Flow-Duration Statistics Flow Report [Statewide Annual SIR 2015 5151]

Statistic	Value	Unit
1 Percent Duration	0.0474	ft ³ /s
5 Percent Duration	0.21	ft ³ /s
10 Percent Duration	0.488	ft ³ /s
25 Percent Duration	1.94	ft ³ /s
50 Percent Duration	5.9	ft ³ /s
75 Percent Duration	14.4	ft ³ /s
90 Percent Duration	31.8	ft ³ /s
95 Percent Duration	50.2	ft ³ /s
99 Percent Duration	129	ft ³ /s

Flow-Duration Statistics Citations

Dudley, R.W., 2015, Regression equations for monthly and annual mean and selected percentile streamflows for ungaged rivers in Maine: U.S. Geological Survey Scientific Investigations Report 2015-5151, 35 p. (<http://dx.doi.org/10.3133/sir20155151>)

Annual Flow Statistics Parameters [Statewide Annual SIR 2015 5151]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	5.8	square miles	14.9	1419
SANDGRAVAF	Fraction of Sand and Gravel Aquifers	0.048	dimensionless	0	0.212
ELEV	Mean Basin Elevation	671.1	feet	239	2120

Annual Flow Statistics Disclaimers [Statewide Annual SIR 2015 5151]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Annual Flow Statistics Flow Report [Statewide Annual SIR 2015 5151]

Statistic	Value	Unit
Mean Annual Flow	13.5	ft ³ /s

Annual Flow Statistics Citations

Dudley, R.W., 2015, Regression equations for monthly and annual mean and selected percentile streamflows for ungaged rivers in Maine: U.S. Geological Survey Scientific Investigations Report 2015–5151, 35 p. (<http://dx.doi.org/10.3133/sir20155151>)

**HY-8 Exist 128" x 83" Steel Pipe Arch Culvert
US Route 1 over Otter Creek, Caribou
WIN 022228.00 Bridge # 5902**

Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 1 - Summary of Culvert Flows at Crossing: Existing Pipe Arch

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Exist 128" x 72" Steel Pipe Arch Discharge (cfs)	Roadway Discharge (cfs)	Iterations
546.74	1 year	71.40	71.40	0.00	1
547.96	2 year	143.10	143.10	0.00	1
549.06	5 year	222.20	222.20	0.00	1
549.71	10 year	274.50	274.50	0.00	1
550.78	25 year	360.40	360.40	0.00	1
551.59	50 year	412.80	412.80	0.00	1
553.00	100 year	483.60	483.60	0.00	1
553.36	200 year	501.50	501.50	0.00	1
554.20	500 year	639.90	541.54	98.09	5
553.90	Overtopping	528.17	528.17	0.00	Overtopping

Table 2 - Culvert Summary Table: Exist 128" x 72" Steel Pipe Arch

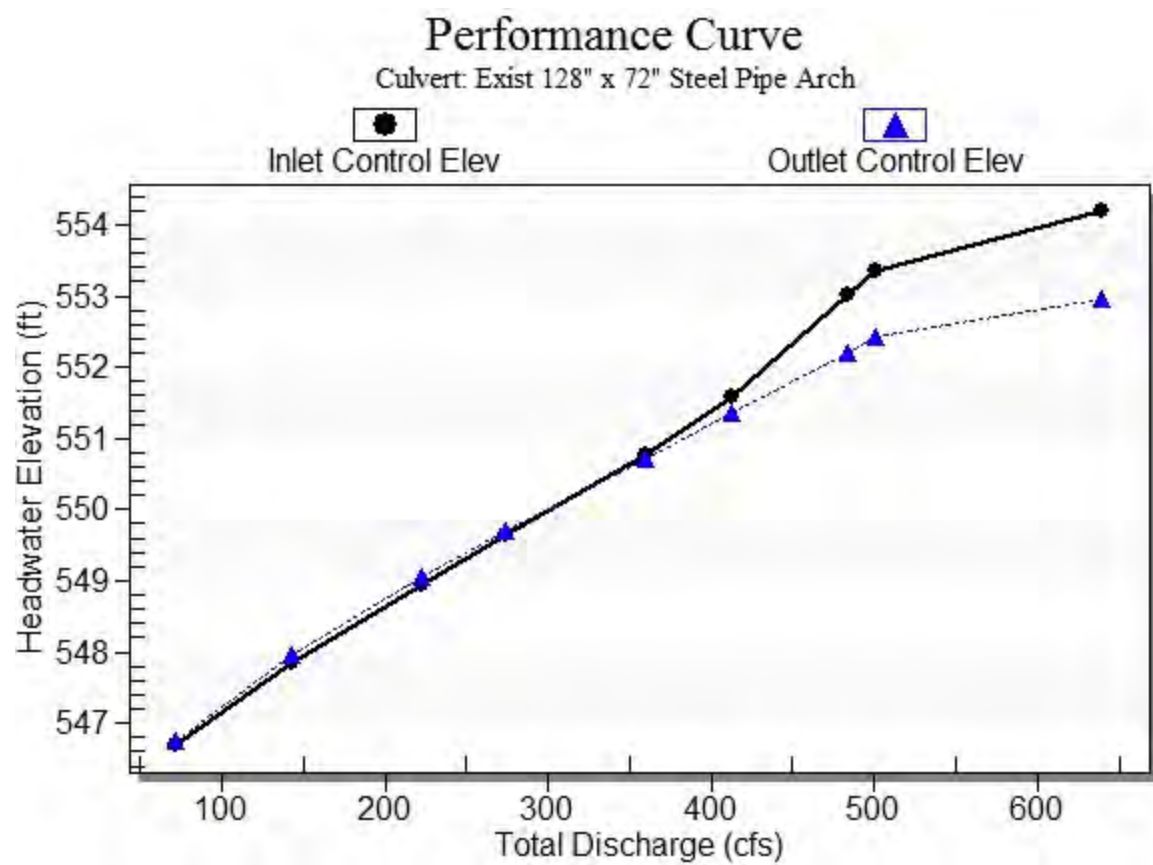
Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1 year	71.40	71.40	546.74	2.192	2.240	2-M2c	1.356	1.284	1.284	1.053	6.148	2.813
2 year	143.10	143.10	547.96	3.357	3.462	2-M2c	2.054	1.993	1.993	1.583	7.550	3.591
5 year	222.20	222.20	549.06	4.437	4.565	2-M2c	2.693	2.601	2.601	2.044	8.742	4.166
10 year	274.50	274.50	549.71	5.146	5.211	2-M2c	3.101	2.958	2.958	2.309	9.399	4.467
25 year	360.40	360.40	550.78	6.277	6.218	2-M2c	3.800	3.451	3.451	2.697	10.494	4.878
50 year	412.80	412.80	551.59	7.089	6.849	7-M2c	4.278	3.695	3.695	2.913	11.242	5.092
100 year	483.60	483.60	553.00	8.505	7.711	7-M2c	5.059	4.042	4.042	3.185	12.136	5.352
200 year	501.50	501.50	553.36	8.863	7.936	7-M2c	5.362	4.135	4.135	3.251	12.334	5.413
500 year	639.90	541.54	554.20	9.700	8.450	7-M2c	6.417	4.331	4.331	3.725	12.796	5.834

Straight Culvert

Inlet Elevation (invert): 544.50 ft, Outlet Elevation (invert): 543.50 ft

Culvert Length: 80.01 ft, Culvert Slope: 0.0125

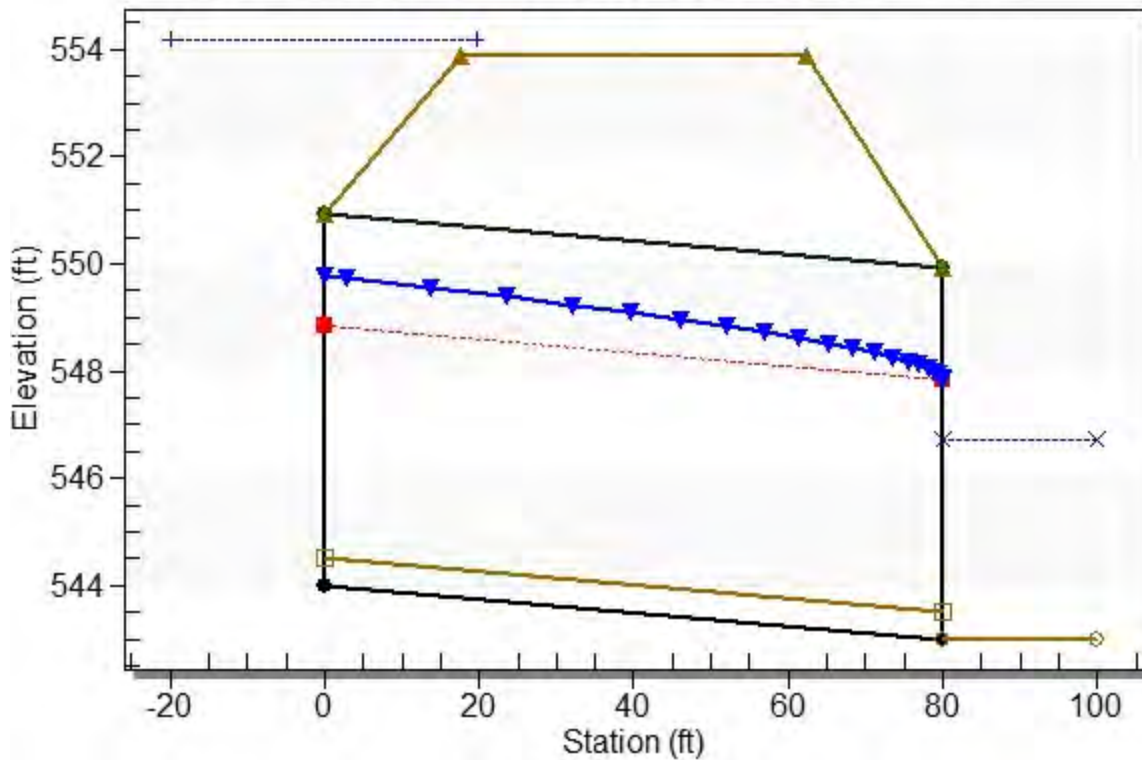
Culvert Performance Curve Plot: Exist 128" x 72" Steel Pipe Arch



Water Surface Profile Plot for Culvert: Exist 128" x 72" Steel Pipe Arch

Crossing - Existing Pipe Arch, Design Discharge - 639.9 cfs

Culvert - Exist 128" x 72" Steel Pipe Arch, Culvert Discharge - 541.5 cfs



Site Data - Exist 128" x 72" Steel Pipe Arch

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 544.00 ft

Outlet Station: 80.00 ft

Outlet Elevation: 543.00 ft

Number of Barrels: 1

Culvert Data Summary - Exist 128" x 72" Steel Pipe Arch

Barrel Shape: Pipe Arch

Barrel Span: 128.00 in

Barrel Rise: 83.00 in

Barrel Material: Steel or Aluminum

Embedment: 6.00 in

Barrel Manning's n: 0.0270 (top and sides)

Manning's n: 0.0350 (bottom)

Culvert Type: Straight

Inlet Configuration: Mitered to Conform to Slope Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Existing Pipe Arch)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
71.40	544.05	1.05	2.81	0.31	0.50
143.10	544.58	1.58	3.59	0.46	0.53
222.20	545.04	2.04	4.17	0.60	0.55
274.50	545.31	2.31	4.47	0.68	0.56
360.40	545.70	2.70	4.88	0.79	0.57
412.80	545.91	2.91	5.09	0.85	0.58
483.60	546.19	3.19	5.35	0.93	0.58
501.50	546.25	3.25	5.41	0.95	0.59
639.90	546.72	3.72	5.83	1.09	0.60

Tailwater Channel Data - Existing Pipe Arch

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 22.00 ft

Side Slope (H:V): 2.00 (2:1)

Channel Slope: 0.0047

Channel Manning's n: 0.0350

Channel Invert Elevation: 543.00 ft

Roadway Data for Crossing: Existing Pipe Arch

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 200.00 ft

Crest Elevation: 553.90 ft

Roadway Surface: Paved

Roadway Top Width: 45.00 ft

HY-8 Concrete Box Culvert 8' x 22'

US Route One over Otter Brook, Caribou

WIN 22228 Bridge# 5902

Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 1 - Summary of Culvert Flows at Crossing: 8' x 22' Concrete Box Culvert

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	8' x 22' Concrete Box Discharge (cfs)	Roadway Discharge (cfs)	Iterations
545.24	1 year	71.40	71.40	0.00	1
545.97	2 year	143.10	143.10	0.00	1
546.65	5 year	222.20	222.20	0.00	1
547.06	10 year	274.50	274.50	0.00	1
547.68	25 year	360.40	360.40	0.00	1
548.03	50 year	412.80	412.80	0.00	1
548.48	100 year	483.60	483.60	0.00	1
548.59	200 year	501.30	501.30	0.00	1
549.44	500 year	639.90	639.90	0.00	1
553.90	Overtopping	1269.50	1269.50	0.00	Overtopping

Table 2 - Culvert Summary Table : 8' x 22' Conc

rete Box

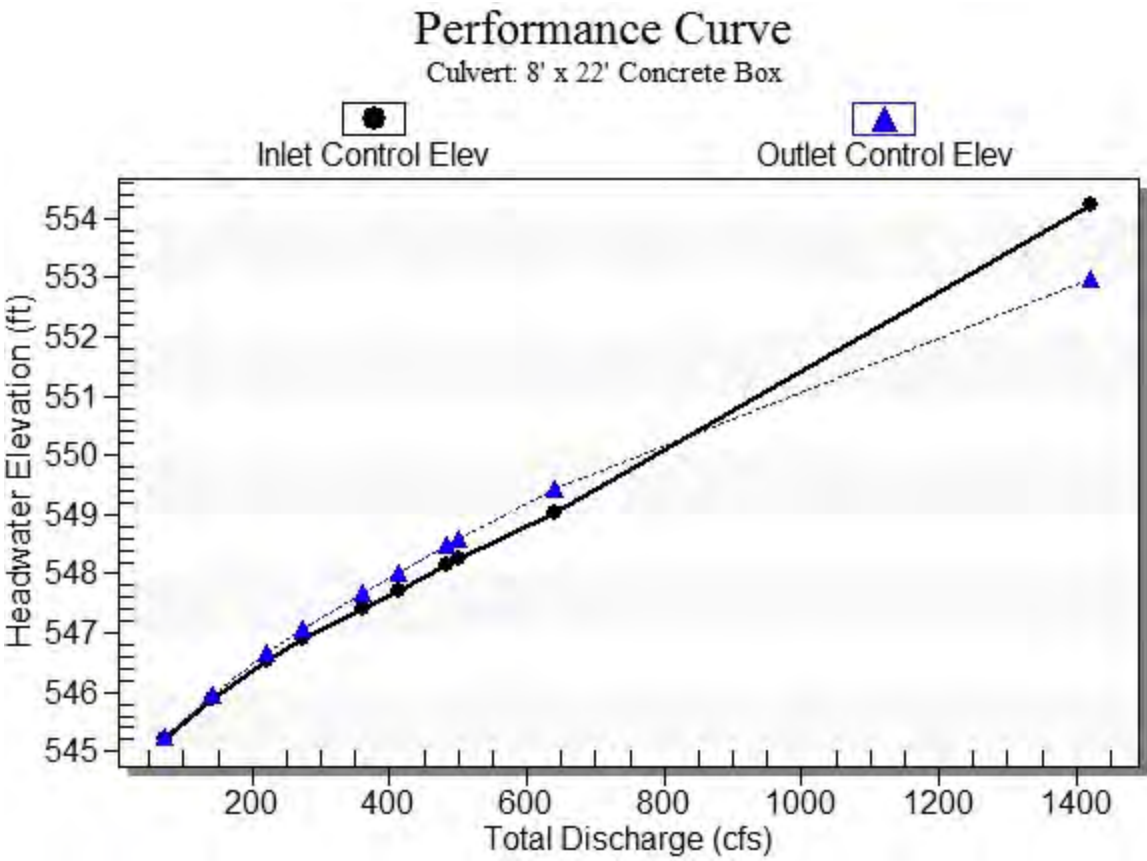
Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1 year	71.40	71.40	545.24	1.208	1.236	3-M1t	0.791	0.682	1.053	1.053	3.083	2.813
2 year	143.10	143.10	545.97	1.880	1.969	3-M1t	1.228	1.090	1.583	1.583	4.108	3.591
5 year	222.20	222.20	546.65	2.515	2.652	3-M1t	1.604	1.476	2.044	2.044	4.941	4.166
10 year	274.50	274.50	547.06	2.897	3.057	3-M1t	1.832	1.696	2.309	2.309	5.404	4.467
25 year	360.40	360.40	547.68	3.416	3.678	3-M1t	2.165	2.034	2.697	2.697	6.074	4.878
50 year	412.80	412.80	548.03	3.722	4.026	3-M1t	2.346	2.226	2.913	2.913	6.441	5.092
100 year	483.60	483.60	548.48	4.136	4.480	3-M1t	2.591	2.472	3.185	3.185	6.901	5.352
200 year	501.30	501.30	548.59	4.239	4.595	3-M1t	2.653	2.532	3.250	3.250	7.011	5.412
500 year	639.90	639.90	549.44	5.036	5.439	3-M1t	3.061	2.976	3.725	3.725	7.809	5.834

Straight Culvert

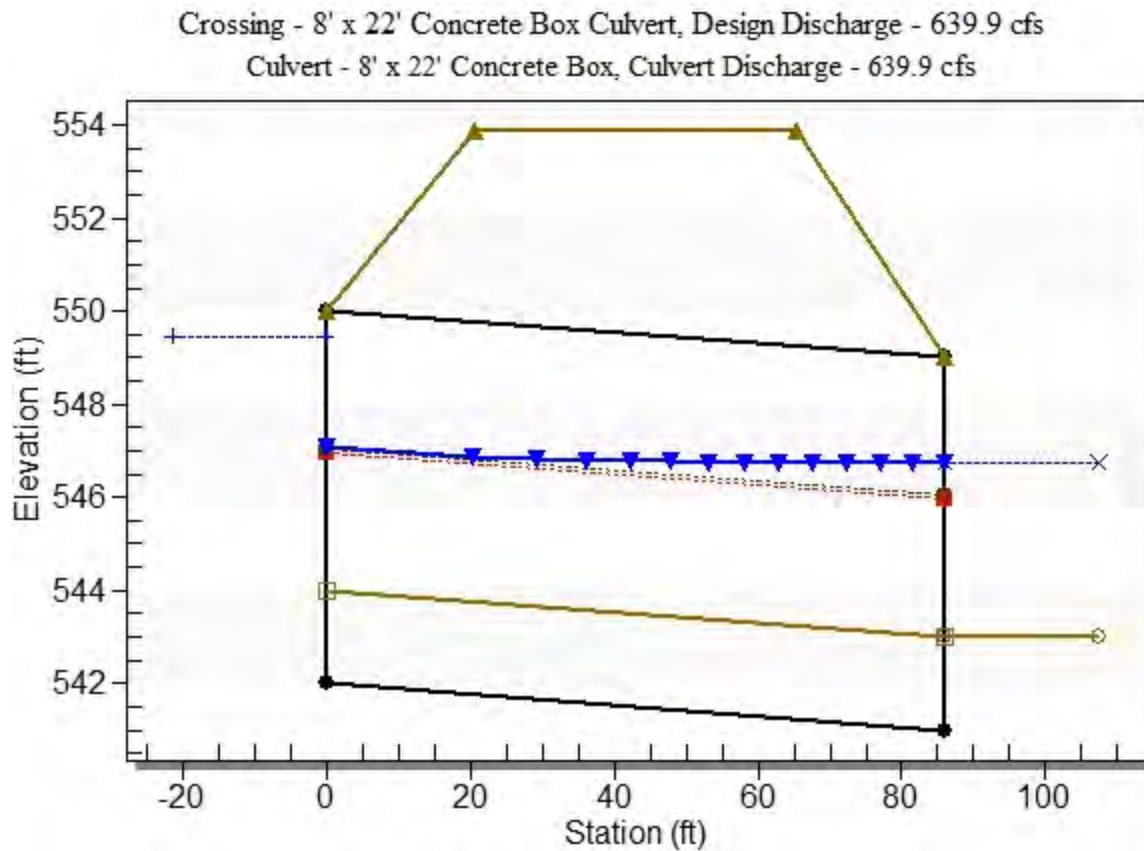
Inlet Elevation (invert): 544.00 ft, Outlet Elevation (invert): 543.00 ft

Culvert Length: 86.01 ft, Culvert Slope: 0.0116

Culvert Performance Curve Plot: 8' x 22' Concrete Box



Water Surface Profile Plot for Culvert: 8' x 22' Concrete Box



Site Data - 8' x 22' Concrete Box

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 542.00 ft

Outlet Station: 86.00 ft

Outlet Elevation: 541.00 ft

Number of Barrels: 1

Culvert Data Summary - 8' x 22' Concrete Box

Barrel Shape: Concrete Box

Barrel Span: 22.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 24.00 in

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

Manning's n: 0.0350 (bottom)

Culvert Type: Straight

Inlet Configuration: Mitered to Conform to Slope

Table 3 - Downstream Channel Rating Curve (Crossing: 8' x 22' Concrete Box Culvert)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
71.40	544.05	1.05	2.81	0.31	0.50
143.10	544.58	1.58	3.59	0.46	0.53
222.20	545.04	2.04	4.17	0.60	0.55
274.50	545.31	2.31	4.47	0.68	0.56
360.40	545.70	2.70	4.88	0.79	0.57
412.80	545.91	2.91	5.09	0.85	0.58
483.60	546.19	3.19	5.35	0.93	0.58
501.30	546.25	3.25	5.41	0.95	0.59
639.90	546.72	3.72	5.83	1.09	0.60

Tailwater Channel Data - 8' x 22' Concrete Box Culvert

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 22.00 ft

Side Slope (H:V): 2.00 (2:1)

Channel Slope: 0.0047

Channel Manning's n: 0.0350

Channel Invert Elevation: 543.00 ft

Roadway Data for Crossing: 8' x 22' Concrete Box Culvert

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 200.00 ft

Crest Elevation: 553.90 ft

Roadway Surface: Paved

Roadway Top Width: 45.00 ft