Hydrology & Hydraulics Report

Crockett Bridge #2199
over
Muddy River

Naples, Maine

STP-2046(600)
WIN 20466.00

Maine Department of Transportation Bridge Program

HYDROLOGY REPORT

Crockett Bridge (#2199) over the Muddy River carries Maine Route 11 / 114 in Naples, Maine. The Muddy River watershed extends north and west from the bridge location. The basin begins at Adams Pond in Bridgton to the north and at Foster Pond in Bridgton to the west. Both Adams and Foster Ponds outlet into Holt Pond which is approximately 6.6 miles upstream of the bridge. The Muddy River flows from Holt Pond and outlets into Sebago Cove approximately 1.8 miles north-northwest of the bridge location. The final 1.8 miles upstream of the bridge are classified by various sources as either Muddy River or Sebago Cove (or similar). The watershed upstream of the bridge is 17% wetlands. Downstream of the bridge is Sebago Lake, the second largest lake in the State of Maine.

The drainage basin characteristics for this bridge were provided by the Maine Department of Transportation Environmental Office – Hydrology Section. Peak flows were calculated with techniques described in the United States Geological Survey Water-Resources Investigations Report 99-4008 (Hodgkins, 1999).

As will be discussed in the Hydraulic Report, the bridge location experiences a backwater condition from Sebago Lake. Local accounts that "[sometimes the water flows backwards]"reaffirm the presence of a backwater condition at this location. Due to the relatively low riverine flows at this location, Sebago Lake water levels are assumed to represent headwater elevations at the bridge. This assumption is supported in the Hydraulics Report.

SUMMARY

Drainage Area	16	mi^2
Q1.1	165	ft^3/s
Q10	585	ft^3/s
Q50	850	ft^3/s
Q100	975	ft^3/s
Q500	1,275	ft^3/s

Reported by: Gustafson, Garrett A
Date: June 19, 2015

Note: Supporting documentation is provided in Appendix A of this Hydrology & Hydraulics Report.

HYDRAULIC REPORT

Hydraulic analysis of this bridge location consisted of a qualitative study of information from a number of sources including the Naples 1981 Flood Insurance Study (FIS); the Naples 1982 Flood Insurance Rate Map (FIRM); the Federal Energy Regulatory Commission (FERC) License for the operation and maintenance of Eel Weir, the dam at the outlet of Sebago Lake; Portland Water District (PWD) weekly Sebago Lake water level data; United States Geological Survey Gage 01063995, Sebago Lake near North Windham, Maine data; MaineDOT underwater inspection reports; and MaineDOT survey data. Conventional practice of development of a comprehensive quantitative model in Hydrologic Engineering Center's River Analysis System (HEC-RAS) was not conducted for two interrelated reasons: 1) Backwater from Sebago Lake controls the hydraulics of this site, and 2) Good, reliable, Sebago Lake water elevation historic data is readily available.

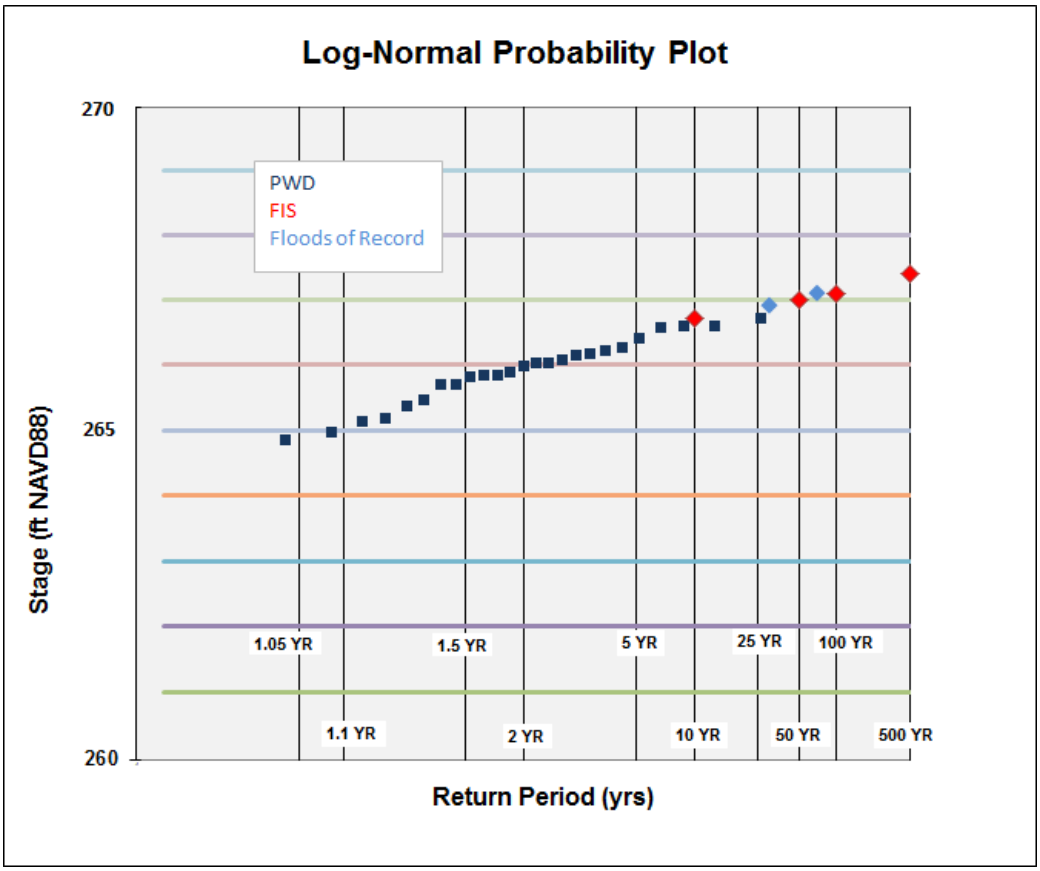
As previously noted, this bridge experiences backwater conditions from Sebago Lake. This conclusion was confirmed by comparing observed water elevations at the bridge location to documented Sebago Lake water elevations for the same dates. Four field measurements were used in the comparison in total: 3 underwater inspection reports which recorded height from curb to water surface and 1 elevation interpolated from waterway shore topography data collected by the MaineDOT Survey Team. The Sebago Lake water elevations were compiled for the corresponding field observation from either USGS gage data, where available, or PWD weekly Sebago Lake water level data. The result of this comparison in each case was that the documented Sebago Lake water level was consistently higher than the observed water elevation at the bridge, ranging from 0.46 feet to 0.89 feet greater. These differences can be attributed to a number of causes including the inherent nominal precision of field measurements, interpolation of survey data, and, in some cases, comparison with weekly, not daily, data. However, the important observation is that in each case the observed bridge location water elevation is not above the documented Sebago Lake water elevation. This data, in conjunction with numerous local accounts and hydraulic literature, including the FIRM which labels the waterway upstream of the bridge as "Sebago Lake," unanimously indicate that the hydraulics at Crockett Bridge are that of a backwater condition from Sebago Lake. The water elevation comparison can be found in Appendix E.

The water elevation of Sebago Lake is controlled by Eel Weir which is owned and operated by S. D. Warren Company. For this reason, the hydraulics of the bridge are dependent on the operation of Eel Weir. On March 23, 2015, the Federal Energy Regulatory Commission (FERC) issued a new license for "operation and maintenance of the Eel Weir Project." This license replaces the original license issued in 1984. Previous operation under the old license

was governed by a Lake Level Management Plan (LLMP) and a 1992 order specifying bypass reach minimum flows. The new license is based on a “flow-based regime” and “under average inflow conditions, S. D. Warren’s proposed operation would increase flood storage and decrease lake levels throughout most of the year when compared to current operation under the LLMP.” This decrease in water elevation and the potential for less moderated water levels is not deemed significant for hydraulics at the bridge due to the enormous storage capacity of Sebago Lake. Additionally, the maximum Sebago Lake water elevation remains unchanged. Therefore, the new FERC license will have no impact hydraulically on the bridge location and historic Sebago Lake water elevation data remains valid for the design of the bridge opening.

The flood of record is considered to have occurred in June 1917. According to the FIS, this flood event yielded a Sebago Lake water elevation of 267.11 NAVD 88. The FIS reported the second largest flood event as having a Sebago Lake water elevation of 266.91 NAVD 88. Other notable flood events in the State of Maine such as the April 1987 flood did not have a significant impact on Sebago Lake. Based on review of the United States Geological Survey report “Flood of April 1987”, this event did not have an appreciable impact on southern Maine. Flows in the Saco and Presumpscot River Basins had calculated recurrence intervals of 35 and 3 years respectively during the April 1987 event.

Final design headwater elevations were developed by combining the floods of record, FIS hydrologic analysis, and 25 years of PWD weekly data. Probabilities of exceedance and recurrence intervals for the PWD data were calculated based on annual maximums and all 3 data sets were combined on the probability plot below.



Vertical datum adjustments were conducted with a datum shift calculated using the National Oceanic and Atmospheric Administration (NOAA) VERTCON program. This program is freely available on the NOAA website, http://www.ngs.noaa.gov/cgi-bin/VERTCON/vert_con.prl. The datum shift at this site is -0.587 feet from NGVD 29 to NAVD 88.

No variation in hydraulic behavior between existing and proposed bridge configurations is considered in this report due to the backwater condition and the large storage capacity of Sebago Lake.

SUMMARY

		Existing Structure	Recommended Structure
		20' Span CIP rigid frame	80' Single Span w/ Integral Abuts.
Total Area of Waterway Opening	ft^2	406	903
Headwater elevation @ $Q_{1.1}$**	ft	265.13	
Headwater elevation @ Q_{10}	ft	266.71	
Headwater elevation @ Q_{25}**	ft	266.91	
Headwater elevation @ Q_{50}	ft	267.01	
Headwater elevation @ Q_{100}	ft	267.11	
Headwater elevation @ Q_{500}	ft	267.41	
Freeboard @ Q_{50}	ft	6.82	5.58
Freeboard @ Q_{100}	ft	6.72	5.48
Flood Of Record (June 1917) Elevation 267.11 ft			

Reported by: Gustafson, Garrett A
Date: June 19, 2015

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

Note: Supporting documentation is provided in Appendix A of this Hydrology & Hydraulics Report.

Scour

Quantitative scour analysis was not conducted for this project. The basis for this decision was the low discharge velocities related to the backwater condition and large storage capacity of Sebago Lake in addition to the extensive history of stable scour conditions at this location. A qualitative assessment of the bridge scour susceptibly follows.

The only record of potentially scour-related issues at this bridge is the slumping of the south approach bank along the western, upstream side, first noted in 1996, 66 years after the bridge was constructed. No changes to this condition have been noted since; a summary of the bridge inspection notes can be found in Appendix C. This is not considered significant because the approach embankment was constructed with a 2.5 foot layer of riprap at a 1H : 1V slope; failure of such a slope could be considered expected particularly in comparison to the current standard of 3 feet of rip rap at a 1.75H : 1V slope. Existing bridge plans can be found in Appendix D of this report.

Underwater inspections dating back to 1991 note no scour, footing exposure, or undermining. These inspections describe the channel as “somewhat bowl shaped with [a] heavy layer of head size stones on the downstream side” and describe the streambed itself as having a “fist to head size rock layer on gravel and sand bottom.” Since 1991 subsequent underwater inspections in 1994, 1999, 2004, 2009, and 2013 have noted no changes in condition. The latest underwater inspection report can be found in Appendix C of this report.

This bridge is not considered scour susceptible. Based on the hydraulic and scour history of the bridge site, plain riprap countermeasures are proposed in front of the proposed integral abutments and along the approach embankments. Current embankment details are considered to be a significant improvement over the existing condition.

Project Name:	Naples Crockett Bridge	**PIN:**	20466
Stream Name:	Mudy River	**Town:**	Naples
Bridge Name:	Crockett Bridge	**Bridge No.**	2199
Route No.	ME 11/114	**USGS Quad:**	
Analysis by:	CSH	**Date:**	3/7/2014

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	41.65	16.08	10291.2	Watershed Area
W	7.12	2.75	1759.6	Wetlands area (by NWI)
P_c	367014.8	4868794		watershed centroid (E, N; UTM 19N; meters)
County	Cumberland NW			*choose county from drop-down menu*
pptA	43.4			mean annual precipitation (inches; by look-up)
SG	0.00			sand & gravel aquifer as decimal fraction of watershed A

A (km^2)	41.65	**Conf Lvl**	0.67
W (%)	17.10		

Worksheet prepared by:

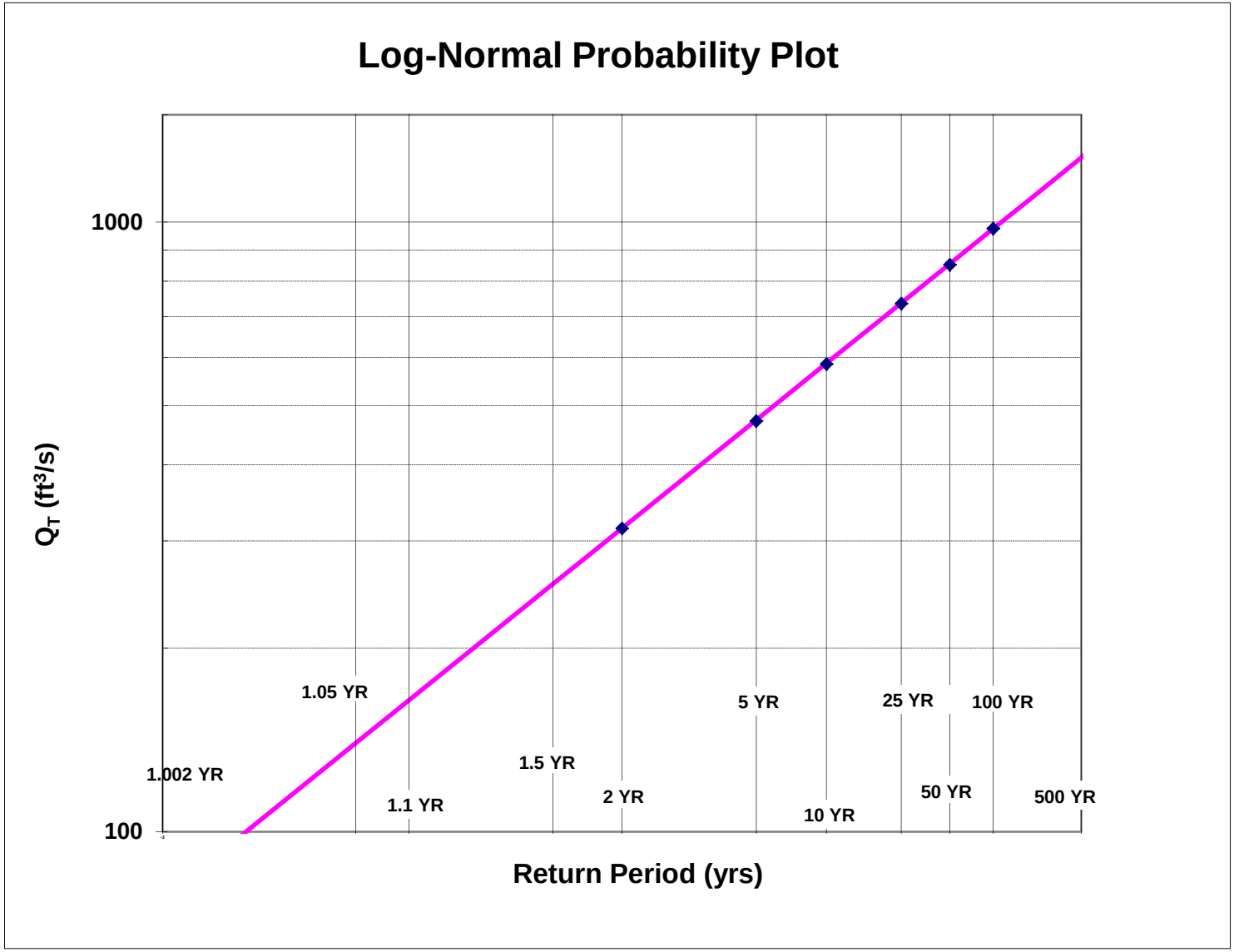
Charles S. Hebson, PE
Environmental Office
Maine Dept. Transportation
Augusta, ME 04333-0016
207-557-1052
Charles.Hebson@maine.gov

Ret Pd T (yr)	Peak Flow Estimate Lower	Q_T (m^3/s)	Upper	Q_T (ft^3/s)
1.1		4.66		164.4
2	6.37	8.91	12.47	314.7
5	9.53	13.37	18.75	472.1
10	11.69	16.58	23.51	585.5
25	14.49	20.84	29.97	735.8
50	16.57	24.12	35.10	851.7
100	18.77	27.65	40.73	976.4
500	23.76	36.14	54.97	1276.2

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

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


Log-Normal Probability Plot
1000
100
Q_T (ft³/s)
1.002 YR
1.05 YR
1.1 YR
1.5 YR
2 YR
5 YR
10 YR
25 YR
50 YR
100 YR
500 YR
Return Period (yrs)

Project Name:	Naples Crockett Bridge	**PIN:**	20466
Stream Name:	Mudy River	**Town:**	Naples
Bridge Name:	Crockett Bridge	**Bridge No.**	2199
Route No.	ME 11/114	**USGS Quad:**	
Analysis by:	CSH	**Date:**	12/1/2008

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

MAINE MONTHLY MEDIAN FLOWS BY USGS REGRESSION EQUATIONS (2004)

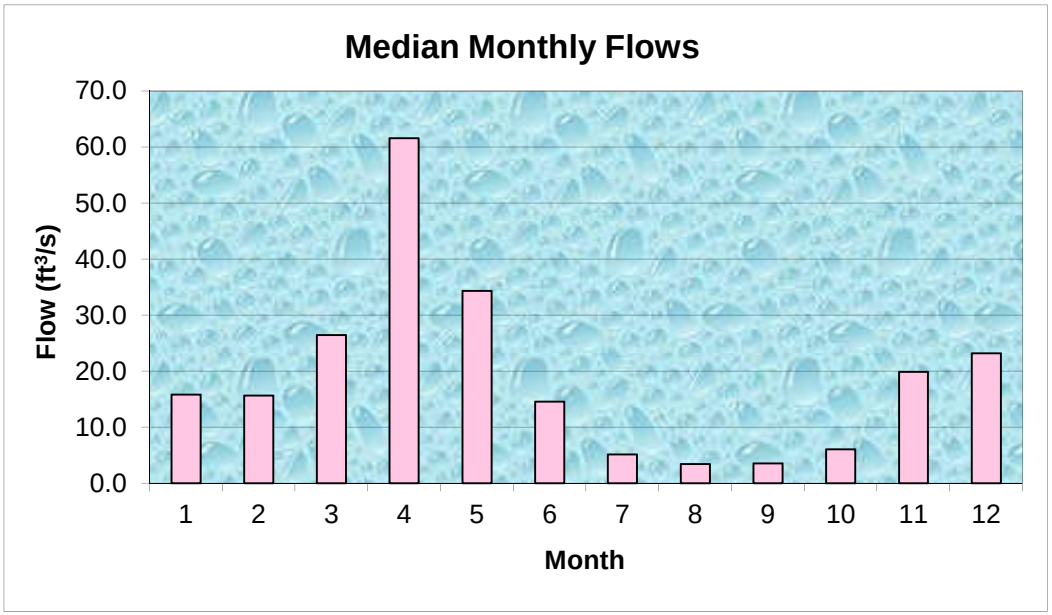
Worksheet prepared by:
Charles S. Hebson, PE
Chief Hydrologist
Maine Dept. Transportation
Augusta, ME 04333-0016
207-624-3073
Charles.Hebson@maine.gov

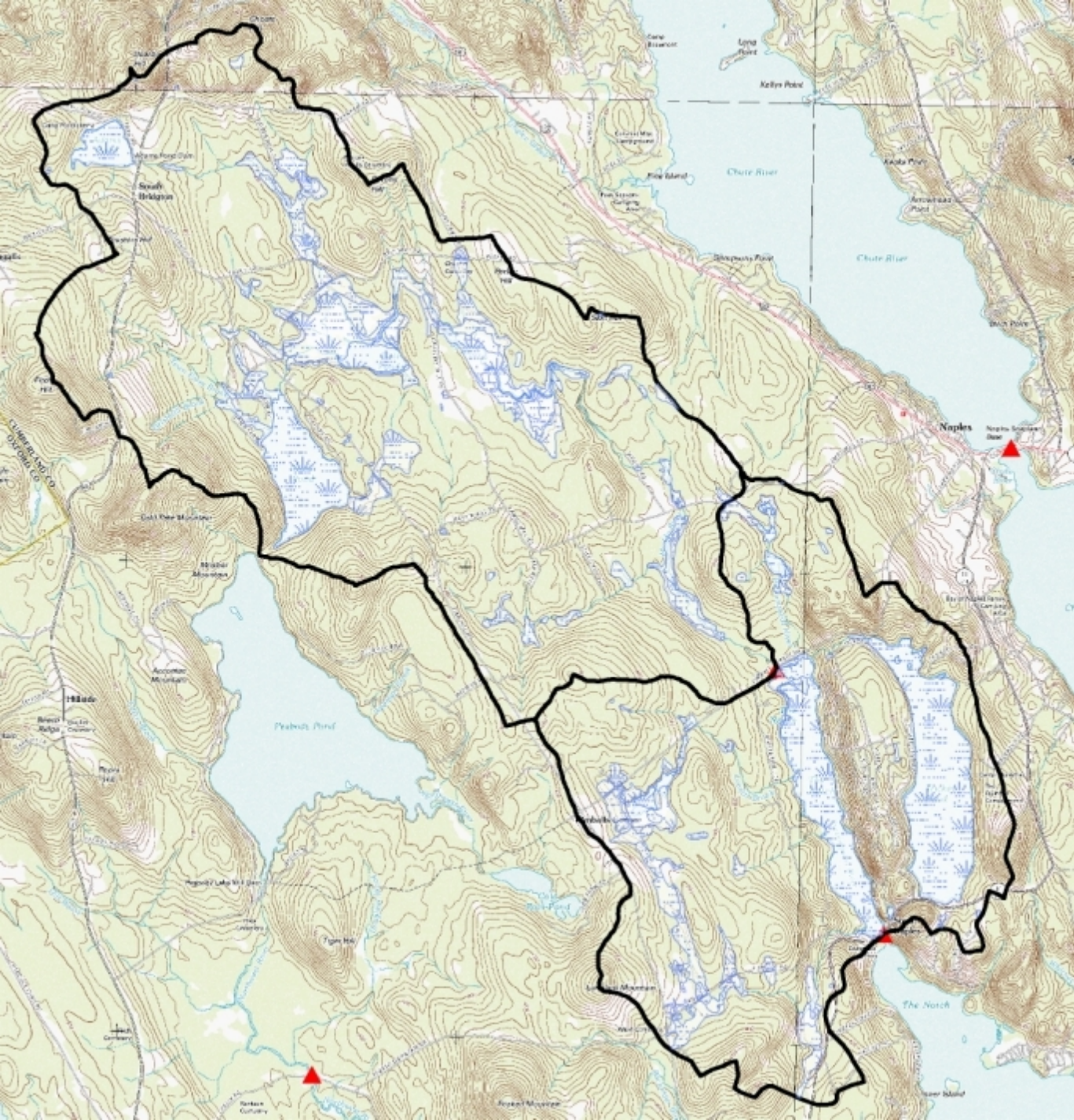
	Value	Variable	Explanation
	16.080	*A*	Area (mi^2)
367014.8	4868794	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
	62.04	*DIST*	Distance from Coastal reference line (mi)
	43.4	*pptA*	Mean Annual Precipitation (inches)
	0.00	*SG*	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q_{median} (ft3/s)	(m^3/s)
Jan	**15.84**	0.4490
Feb	**15.63**	0.4431
Mar	**26.42**	0.7488
Apr	**61.60**	1.7456
May	**34.31**	0.9724
Jun	**14.58**	0.4131
Jul	**5.11**	0.1448
Aug	**3.41**	0.0967
Sep	**3.52**	0.0997
Oct	**6.06**	0.1718
Nov	**19.87**	0.5631
Dec	**23.22**	0.6580

Q_{bf}	**95.9**
ann avg	**32.1**
ann med	**16.2**
$Q_{1.002}$	**77.5**
$Q_{1.01}$	101.2
$Q_{1.05}$	139.7

W_{bf}	32.3	
d_{bf}	2.5	
Q_{bf}	325.3	assume v = 4ft/s





Kellys Point
Chute River
Chute River
Naples
Peabody Pond
The Notch

A summary of drainage area-peak discharge relationships for the streams studied by detailed methods is shown in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
SONGO RIVER					
5,000 feet above Sebago Lake	292.0	6,300	10,000	11,500	15,200
CROOKED RIVER					
540 feet above confluence with the Songo River	151.5	6,100	9,500	11,000	14,800

For Sebago Lake, the Bay of Naples, and Long Lake hydrologic analyses were carried out to establish peak elevation-frequency for floods of the selected recurrence intervals.

Water-surface elevations for the selected recurrence intervals on Sebago Lake were furnished by the USGS. The USGS determined the water-surface elevations by using 40 years (1920-1960) of gaging station information from the Sebago Lake dam gage.

Water-surface elevations for the Bay of Naples, Long Lake, and the Songo River above Songo Lock were computed through the use of a log-Pearson Type III analysis (Reference 11) on 40 years of records, 1920-1960, from the Songo Lock gaging station.

A summary of peak elevation frequency relationships is shown in Table 2, "Summary of Elevations."

TABLE 2 - SUMMARY OF ELEVATIONS

FLOODING SOURCE AND LOCATION	PEAK ELEVATIONS (feet) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
BAY OF NAPLES	273.2	274.0	274.4	275.1
LONG LAKE	273.2	274.0	274.4	275.1
SEBAGO LAKE	267.3	267.6	267.7	268.0

NGVD 29

Portland Water District Sebago Lake Weekly Water Elevation Data

Week	Year																									
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	264.92	264.12	264.03	262.57	262.02	263.30	262.67	263.17	264.71	262.47	261.58	262.80	262.57	260.80	262.96	263.67	263.11	263.07	262.77	261.31	264.37	263.39	263.43	263.06	263.12	261.00	263.23
2	264.52	263.97	263.72	262.72	261.80	263.17	262.46	263.00	263.92	262.27	261.23	262.72	262.51	260.72	263.03	263.24	262.96	263.00	263.07	261.31	264.11	263.35	263.18	262.96	263.08	261.03	263.05
3	264.42	263.77	263.70	262.92	261.75	263.17	262.51	262.83	263.37	262.39	261.07	262.72	262.38	260.73	262.93	263.25	262.87	263.35	263.17	261.64	263.74	263.34	262.91	262.93	263.05	261.26	263.03
4	264.22	263.62	263.67	262.92	261.74	263.10	262.95	262.97	263.05	262.36	261.07	262.58	262.24	260.68	262.80	263.19	262.69	263.83	263.12	261.76	263.64	263.47	262.82	262.95	263.02	261.61	263.14
5	263.97	263.77	263.52	262.72	261.72	263.02	262.94	263.54	263.09	262.29	261.22	262.49	262.13	260.67	262.68	263.13	262.47	263.96	262.99	261.78	263.47	263.61	262.89	263.13	262.88	261.73	263.09
6	263.72	263.62	263.32	262.70	261.62	262.87	262.97	263.60	263.08	262.21	261.52	262.42	262.09	260.65	262.67	263.16	262.34		262.88	261.93		263.54	262.98	263.12	262.91	261.84	263.03
7	263.62	263.52	263.02	262.54	261.65	262.87	262.87	263.73	262.89	262.09	261.72	262.30	261.93	260.67	262.52	263.24	262.42	264.41	262.82	262.19	263.04	263.42	262.93	263.10	262.98	261.92	262.89
8	263.52	263.52	262.82	262.55	261.72	262.42	262.73	263.70	262.76	262.20	261.92	262.34	261.75	260.60	262.34	263.21	262.41	264.35	262.75	262.48	262.88	263.29	262.87	263.10	262.97	262.14	262.75
9	263.32	263.42	262.50	262.52	261.64	262.25	262.72	264.12	262.67	262.54	262.06	262.24	261.62	260.65	262.22	263.23	262.34	264.18	262.62	262.73	262.91	264.83	262.96	263.16	263.05	262.26	262.65
10	263.12	263.32	262.42	262.44	261.67	262.12	262.69	264.20	262.77	262.94	262.42	262.26	261.54	260.84	262.10	263.16	262.32	263.93	262.64	262.90	262.81	265.12	263.28	263.25	263.14	262.30	262.55
11	262.92	263.22	262.52	262.52	261.67	262.16	262.75	264.25	263.07	263.91	263.33	262.39	261.38	261.00	261.88	263.21		263.99	262.61	263.29	262.76	265.49	264.02	263.43	263.25	262.34	262.58
12	262.72	263.62	262.72	263.00	261.52	262.35	262.95	264.12	263.17	264.67	263.80	262.70	261.06	261.17	261.63	263.22	262.17	263.94	262.92	263.39	262.74	265.74	264.60	263.75	263.63	262.48	262.53
13	263.02	264.02	263.02	263.06	261.67	262.60	263.40	264.00	263.25	265.09	264.37	263.00	261.29	261.40	261.71	263.18	262.49	263.85	263.25	263.50	262.82	266.29	264.76	263.89	263.78	262.61	262.53
14	263.52	264.32	263.52	263.92	262.12	263.27	263.83	263.92	263.62	265.52	265.24	263.60	261.40	261.76	262.38	263.39	264.19	263.91	263.69	263.61	263.30	266.24	265.08	263.92	264.19	262.98	262.87
15	264.52	265.02	263.92	264.22	264.02	264.04	263.80	264.20	264.23	266.14	265.85	264.52	261.58	262.16	262.90	264.08	265.43	264.00	264.10	263.98	264.46	265.81	265.55	263.87	264.61	263.78	263.38
16	265.22	265.72	264.12	264.37	265.57	265.10	263.97	264.62	264.79	266.15	265.95	265.42	262.55	262.85	263.29	264.49	265.99	264.03	265.85	264.82	265.29	265.78	266.36	263.79	265.08	265.03	264.21
17	265.52	265.82	264.82	264.52	266.42	265.57	264.04	265.40	265.78	265.92	265.67	265.85	263.60	263.56	263.66	265.14	267.02	264.02	266.73	265.66	265.88	265.58	266.14	264.11	265.28	265.50	264.82
18	265.82	265.82	265.12	265.02	266.36	265.93	264.09	265.82	265.90	266.00	265.66	266.42	264.42	264.15	263.97	265.46	267.31	264.13	266.50	266.53	266.28	265.56	266.20	264.32	265.33	265.73	265.01
19	266.59	265.82	265.52	265.22	266.30	266.10	264.04	266.00	265.88	266.14	265.65	266.73	264.72	264.59	264.27	265.85	266.70	264.21	266.41	266.57	266.24	265.58	266.34	264.54	265.33	265.96	265.08
20	267.16	266.32	265.62	265.27	266.20	266.30	264.24	266.30	265.92	266.55	265.75	266.80	264.77	265.16	264.52	265.96	266.22	265.04	266.47	266.34	266.36	265.60	266.53	264.89	265.44	266.03	265.11
21	266.62	266.57	265.67	265.27	265.97	266.29	264.47	266.20	266.05	266.52	265.70	266.28	264.76	265.68	264.68	266.08	266.57	265.87	266.35	266.27	266.22	265.57	267.00	265.17	265.52	266.32	265.04
22	266.47	266.62	265.70	265.27	265.82	266.12	264.52	265.79	265.95	266.25	265.82	266.32	264.86	265.86	264.96	266.46	266.50	266.16	266.21	266.16	266.16	265.48	266.73	265.46	266.00	266.49	
23	266.62	266.47	265.77	265.27	265.85	265.92	264.47	265.80	265.93	266.07	265.77	266.44	265.32	265.95	265.19	266.76	266.36	266.65	266.51	266.07	266.41	265.60	266.46	267.18	266.16	266.63	
24	266.82	266.34	265.62	265.72	265.84	265.80	264.47	265.85	265.91	265.98	265.70	266.35	265.49	266.05	265.34	266.44	266.51	266.85	266.50	266.04	266.36	265.57	266.14	267.15	266.47	266.52	
25	266.75	266.07	265.52	265.72	265.70	265.62	264.49	265.83	265.90	267.20	265.56	266.22	265.56	266.43	265.43	266.17	266.21	266.34	266.34	266.00	266.66	265.50	265.87	266.29	266.47	266.47	
26	266.62	266.05	265.42	265.67	265.57	265.43	264.32	265.86	265.99	267.00	265.39	266.14	265.48	266.23	265.44	265.99	265.90	266.21	265.85	266.12	266.62	265.49	265.91	265.79	266.37	266.08	
27	266.20	266.02	265.12	265.47	265.38	265.17	264.19	265.79	265.81	266.55	265.26	266.00	265.32	265.99	265.29	265.90	265.65	265.98	265.62	266.24	266.41	265.30	265.80	265.51	265.87	265.89	
28	266.06	265.92	264.92	265.27	265.22	264.97	264.02	265.59	265.70	266.06	265.19	265.82	265.25	265.62	265.15	265.68	265.44	265.67	265.61	265.92	266.29	265.28	265.65	265.23	265.65	265.90	
29	265.82	265.67	264.72	265.12	264.93	264.92	263.97	265.87	265.70	265.58	264.93	265.59	265.23	265.25	264.97	265.56	265.33	265.50	265.39	265.59	265.83	265.10	265.36	265.15	265.47	265.68	
30	265.62	265.72	264.57	265.04	264.76	264.81	263.79	265.52	265.16	265.48	264.71	265.50	265.07	265.20	264.85	265.51	265.13	265.34	265.23	265.41	265.54	265.04	265.17	265.02	265.45	265.29	
31	265.37	265.42	264.32	264.77	264.70	264.53	263.75	264.87	265.11	265.35	264.62	265.42	264.86	265.04	264.70	265.34	264.98	265.13	265.03	265.48	265.32	264.80	264.99	264.94	265.29	265.37	
32	265.32	265.32	264.22	264.64	264.50	264.32	263.67	264.47	264.87	265.05	264.36	265.24	264.74	264.86	264.74	265.10	264.75	265.02	264.85	265.62	265.04	264.58	264.85	264.86	264.96	265.30	
33	265.12	265.37	264.32	264.50	264.32	264.00	263.32	264.29	264.67	264.95	264.21	265.15	264.64	264.60	264.85	264.88	264.61	264.79	264.64	265.58	264.99	264.33	264.80	265.16	265.18	264.99	
34	264.75	265.22	264.72	264.26	264.20	264.01	263.08	264.04	264.52	264.79	264.21	265.12	264.12	264.37	264.75	265.04	264.35	264.45	264.39	265.04	264.80	264.16	264.68	265.39	264.78	265.12	
35	264.52	264.92	264.57	264.02	263.87	263.80	262.80	263.82	264.52	264.60	264.06	264.62	263.84	264.11	264.51	264.87	264.21	264.15	264.19	264.47	264.89	264.04	264.93	265.27	264.51	264.67	
36	264.22	264.52	264.02	263.82	263.74	263.62	262.50	263.62	264.44	264.41	263.80	264.49	263.73	263.96	264.26	264.64	264.05	263.96	263.94	264.26	264.77	263.95	265.01	265.12	264.72	264.34	
37	263.97	264.22	263.72	263.65	263.55	263.44	262.27	263.52	264.35	264.19	263.59	264.20	263.47	263.80	264.16	264.34	263.79	263.76	263.85	264.76	264.30	263.73	264.76	265.03	264.14	264.04	
38	263.82	263.92	263.57	263.47	263.30	263.23	262.18	263.48	264.24	263.97	263.74	263.97	263.24	263.67	264.06	264.20	263.66	263.69	263.62	264.34	264.02	263.51	264.32	264.88	263.99	263.72	
39	263.72	263.82	263.62	263.39	263.38	263.41	262.05	263.19	263.90	263.70	265.00	263.79	263.16	263.57	264.02	264.11	263.42	263.49	263.39	263.71	263.72	263.38	263.94	264.74	263.54	263.43	
40	263.72	263.82	263.67	262.90	263.02	263.22	261.97	263.04	263.65	263.54	265.10	263.60	262.97	263.36	263.76	263.84	263.21	263.34	263.11	264.09	263.57	263.21	263.93	264.76	263.22	263.25	
41	263.52	263.62	263.62	262.90	262.97	262.97	262.00	262.96	263.33	263.28	264.92	263.35	262.75	263.18	263.44	263.46	263.81	262.93	262.80	263.60	263.48	262.91	263.52	264.71	263.10	263.02	
42	263.52	263.82	263.39	262.82	262.87	262.77	261.95	262.76	263.02	263.83	264.71	263.30	262.67	263.05	263.23	263.12	264.52	263.07	262.67	263.25	263.24	262.84	263.32	264.65	262.92	262.80	
43	263.72	264.12	263.12	262.77	262.80	262.71	262.15	264.75	262.72	263.97	264.46	263.00	262.50	262.88	263.22	262.99	264.93	263.18	262.49	263.05	262.85	262.64	263.12	264.77	262.61	262.90	
44	263.97	264.32	262.77	262.92	262.92	262.72	262.47	265.75	262.54	263.57	264.62	262.92	262.27	262.71	263.33	262.69	264.92	263.78	262.25	263.04	262.85	262.57	262.98	264.83	262.18	262.85	
45	264.22	264.37	262.52	263.02	263.00	262.72	262.61	266.25	262.95	263.25	264.67	262.80	262.12	262.67	263.41	262.52	264.91	263.94	262.26	262.99	262.76	262.83	262.89	264.78	262.03	262.62	
46	264.52	264.67	262.32	263.12	263.02	262.72	263.52	266.40	263.09	262.92	264.62	262.47	261.62	262.80	262.85	262.46	264.92	264.42	262.02	262.99	262.65	263.02	263.09	264.55	261.77	262.52	
47	264.75	264.67	262.35	263.19	263.13	262.72	264.15	265.80	263.14	262.77	264.56	262.68	261.22	262.92	262.77	262.35	264.94	264.36	261.90	263.19	262.99	263.23	263.05	263.93	261.56	262.42	
48	264.72	264.70	262.62	263.22	263.10	262.87	264.20	264.70	263.03	262.52	264.24	262.51	260.88	263.01	262.87	262.33	264.54	264.26	261.72	263.46	263.02	263.05	263.01	263.28	261.50	262.40	
49	264.62	264.82	262.72	263.00	263.16	262.87	264.20	264.74	262.89	262.24	263.37	262.30	260.88	262.93	262.95	262.83	264.55	263.13	261.50	263.96	263.25	263.16	263.15	263.09	261.50	262.47	
50	264.42	264.52	262.72	262.72	263.29	262.85	263.92	265.04	262.87	262.21	262.99	262.12	260.86	262.81	262.83	263.38	263.88	262.55	261.17	263.89	262.98	263.63	263.31	262.72	261.24	262.60	
51	264.42	264.20	262.72	262.49	263.55	262.70	263.95	265.20	262.62	261.94	262.90	262.47	260.92	262.88	263.19	263.55	263.23	262.41	260.92	264.27	262.92	263.87	263.12	262.52	260.96	262.97	
52	264.12	264.37	262.52	262.27	263.34	262.87	263.35	265.24	262.49	261.77	262.91	262.50	260.94	262.94	263.17		263.08	262.67	261.00	264.41	263.21	263.70	263.02	262.97	260.99	263.13	
Max	267.16	266.62	265.77	265.72	266.42	266.30	264.52	266.40	266.05	267.20	265.95	266.80	265.56	266.43	265.44	266.76	267.31	266.85	266.73	266.57	266.66	266.29	267.00	267.18	266.47	266.63	
Rank	4	12	22	23	16	18	26	17	20	2	21	7	24	15	25	8	1	6	9	13	10	19	5	3	14	11	

Source: http://www.pwd.org/lake/level.php?mode=table&year=1989

Note: Elevations assumed to be referenced to NGVD29 datum

Portland Water District Recurrence Interval Analysis

n = 25
i = Rank
P = i / (n + 1)
RI = 1 / P

Rank (i)	Max Headwater Elevation	Probability of Exceedance (P)	Recurrence Interval (RI)
1	267.31	3.8%	26.0
2	267.2	7.7%	13.0
3	267.18	11.5%	8.7
4	267.16	15.4%	6.5
5	267	19.2%	5.2
6	266.85	23.1%	4.3
7	266.8	26.9%	3.7
8	266.76	30.8%	3.3
9	266.73	34.6%	2.9
10	266.66	38.5%	2.6
11	266.63	42.3%	2.4
12	266.62	46.2%	2.2
13	266.57	50.0%	2.0
14	266.47	53.8%	1.9
15	266.43	57.7%	1.7
16	266.42	61.5%	1.6
17	266.4	65.4%	1.5
18	266.3	69.2%	1.4
19	266.29	73.1%	1.4
20	266.05	76.9%	1.3
21	265.95	80.8%	1.2
22	265.77	84.6%	1.2
23	265.72	88.5%	1.1
24	265.56	92.3%	1.1
25	265.44	96.2%	1.0

NOTE: Data for 2015 omitted as the year is not complete

Crockett Bridge to Sebago Lake Water Elevation Comparison

Date	Measurement Type	Recorded Measurement	Water Elevation at Bridge	Documented Sebago Lake Elevation			Difference between Sebago Lake and Crockett Bridge water elevation
				NGVD29	NAVD88	Source	
			FT	FT	FT		FT
6/17/2014	Survey	EL 265	265	266.48	265.89	USGS Gage 01063995	0.89
5/19/2009	Underwater Inspection Team Measurement	Water 11.5 feet below curb	265.2	266.25	265.66	USGS Gage 01063995	0.46
7/29/1999	Underwater Inspection Team Measurement	Water 13.3 feet below curb	263.4	264.71	264.12	Portland Water District weekly data	0.72
7/28/1994	Underwater Inspection Team Measurement	Water 13.25 feet below curb	263.45	264.81	264.22	Portland Water District weekly data	0.77

Datum adjustment: NAVD88 = NGVD29 - 0.5873 feet
Curb elevation at midspan: 276.70

Questions concerning the VERTCON process may be mailed to NGS

Latitude: 43 55 36

Longitude: 070 36 52.62

NAVD 88 height:

Datum shift(NAVD 88 minus NGVD 29): -0.179 meter

= -0.5873 feet

EL NAVD88 = EL NGVD29 - 0.5873 ft