Addison Lot Norton Bridge #3754

WIN 27160.00

HYDROLOGY & HYDRAULIC REPORT

PREPARED BY:

TYLin

August 11, 2026

HYDROLOGY REPORT

Upland flow design discharges were provided by the Hydraulics Section of the Maine DOT (October 30, 2023):

Summary

Drainage Area	2.5	mi^2
Q1.1	80	ft^3/s
Q10	320	ft^3/s
Q25	415	ft^3/s
Q50	490	ft^3/s
Q100	570	ft^3/s
Q500	740	ft^3/s

Reported by: Nicholas DiMariano
Date: October 30, 2023

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

Note: Since the structure is tidal as well, these upland flows alone are not the controlling design flows through the structure.

At its current elevation, the Addison roadway is typically impassable due to high water around once a year (based on anecdotes from Maintenance). Looking at storm tide recurrence intervals, that means that at a water level that is near the HAT of 7.75 in Bar Harbor, there is water over the existing road (profile elevation at 8.4). This agrees with the finding that storm surges are 6 to 12" higher at the Addison site than the Bar Harbor tide gage. There are no reported FEMA Flood Insurance Studies for Knowles Brook.

The table below displays the approximate anticipated water levels for the Addison Lot Norton site accounting for a prorated 3.9' sea level rise. (See Table next page.)

Water Level	Year 2025	Year 2050	Year 2100
MLW	-5.57	-4.27	-1.67
MHW	5.00	6.30	8.90
MHHW	5.43	6.73	9.33
Highest Astronomical Tide	7.75	9.05	11.65
Q10 Storm Tide (estimated)	8.75	10.05	12.65
"Q50" (Category 1 Hurricane at MHW – from SLOSH)	**11.50**	12.80	**15.40**
Category 2 Hurricane at MHW – from SLOSH	17.50	18.80	21.40

For more information on these table values, see the Proposed Hydraulic Criteria Memo.

Two time periods will be considered for sea level rise: current conditions and future proposed conditions of the bridge replacement alternative. For the current condition, no modifications were made to the water surface elevations, nor the existing site geometry. The bridge replacement alternative design accounts for anticipated sea level rise through year 2100. All model elevations for this period will be adjusted upward by +3.9 ft to account for sea level rise over the project's lifetime. The existing structure and approaches are inundated with water during current storm surges; therefore, the roadway profile with be raised to accommodate these storm surges along with a predicted +3.9 ft sea level rise. Scour is not evaluated for this structure due to the existing and proposed structures both being closed-bottom culverts.

Time Period	Years From Construction	Sea Level Rise Elevation Adjustment (ft)	Storm Surge High-Water Elevation (ft)
Current	0	+0.0	11.50
Replacement Life Cycle	~75	+3.9	15.40

A set of tidal data from 2006 was collected by a tidal logger stationed in an open tidal region of Pleasant Bay near the Dike Bridge, 1 mile north of the Knowles Brook outlet, which acts as the downstream boundary condition. This data was then compared against the Bar Harbor NOAA gauge which was taken using the MLLW datum. Once adjusted against NAV88 datum, the 2006 Pleasant River dataset aligned very closely with the Bar Harbor data. However, due to issues in the 2006 Pleasant River data, along with the NOAA Bar Harbor data being more complete and having a greater range, tidal data collected from the Bar Harbor logger has been used for the hydraulic model. This also ensures the ability to isolate data, look over longer ranges, and more effectively focus on relevant data. Two date and time ranges were used between cases to focus on storm events and astronomical tides. Each time set were taken at 6-minute intervals between October 26th, 2023 – October 31st, 2023 and December 22nd, 2022 –

December 28th, 2022; The period of data collection varies between each case to ensure that the entire scope of the tidal event is captured. The October 2023 dataset represents highest astronomical high tides, and the December 2022 data set represents the Christmas eve storm verification case. Due to a portion of the tidal data elevations being lower than the lowest point in Knowles Brook, for HEC-RAS modelling purposes, stage hydrograph values were truncated below specific elevations. For cases with Q1.1 upland flow the stage hydrograph values below elevation -2.0 have been truncated, and for cases with Q50 upland flow the stage hydrograph values below elevation 0.0 have been truncated to ensure the model runs properly.

Stage Hydrograph	Stage Hydrograph ID	Minimum Elevation (ft)	Maximum Elevation (ft)
Pleasant Bay Tidal logger (Reference only, NAVD88 Adjusted) (08/01/06 - 09/30/06)	REF	-5.74	6.92
Bar Harbor NOAA Gauge Representative Highest Astronomical Tide Cycle (09/26/23 - 09/31/23)	1A.	-7.015	7.435
Bar Harbor NOAA Gauge Representative Highest Astronomical Tide Cycle (09/26/23 - 09/31/23) offset to Category 1 SLOSH Elevation	1B.	-2.95	11.50
Bar Harbor NOAA Gauge Representative Highest Astronomical Tide Cycle (09/26/23 - 09/31/23) + 3.9' Sea Level Rise	1C.	-3.115	11.335
Bar Harbor NOAA Gauge Representative Highest Astronomical Tide Cycle (09/26/23 - 09/31/23) offset to Category 1 SLOSH Elevation + 3.9' Sea Level Rise	1D.	0.95	15.40
Bar Harbor NOAA Gauge "Storm Surge" Tide Cycle – Christmas Eve Storm Verification	2A	-8.175	8.475

HYDRAULIC REPORT

The U.S. Army Corps of Engineers HEC-RAS computer program (ver. 6.5) was used to perform all the hydraulic calculations and hydraulic modeling. An unsteady flow analysis was performed, as this site is tidally controlled downstream of the structure. The geometric data in the hydraulic model is based upon survey data collected by MaineDOT and NOAA Lidar data. LIDAR data from “NOAA 2021-2022 USGS Lidar: Midcoast Maine” is used to supplement the survey data further upstream and downstream of the structure, along with capturing more of the watershed. Each of the data surfaces were set to the same horizontal and vertical datum (NAVD88), and overlaid on each other, with the survey data taking priority due to its higher resolution.

The three cross-sections downstream of the structure and eleven cross-sections upstream of the structure are based on both the survey data and NOAA Lidar data. The cross-sections both upstream and downstream of the structure are taken at variable distances from each other and focus on areas where the stream profile has unique characteristics. The riverbank lines have been designated as the boundary where Knowles Brook receives typical flow – characterized by a mud and marine clay river bottom with steep saltmarsh banks. The flow paths have been drawn to mark the limits of water inundation of Knowles Brook to capture the entire profile. The figure below displays the layout of Knowles Brook, the proposed and existing roadway, and cross sections analyzed within HECRAS.

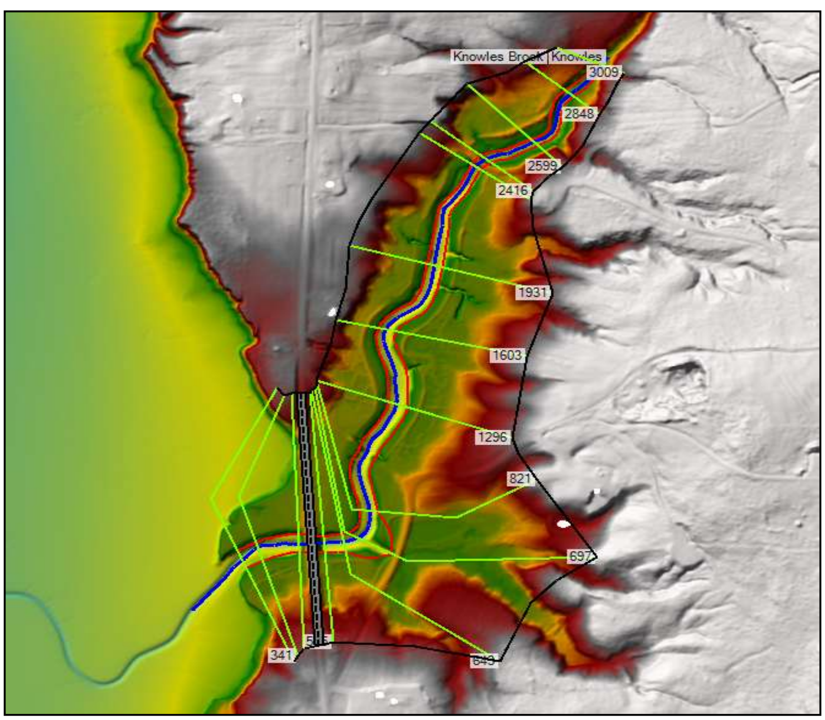

Figure 1 – Knowles Brook HEC-RAS

The three cross-sections on the downstream portion of the bridge highlight the salt marsh flats and where Knowles Brook flows into Pleasant Bay. An area downstream of the bridge, adjacent to the north approach, representing mudflats has been designated as a blocked obstruction in the model. This serves to omit data under a set elevation; in this case the volume of water that is below the elevation of the adjacent salt marshes. On the North and South approach, ineffective flow areas have been established adjacent to the existing raised roadway at a 2:1 ratio from the opening of the modeled culvert. This is to ensure that these areas do not contribute to the flow of Knowles Brook.

At current conditions, the low point of the roadway on East Side Road is measured as elevation 8.00'. The proposed roadway raises the profile of the existing and sets a new low point as 12.51' (See PDR Plan set), raising the low point by 4.50'. With increased proposed overtopping elevation, traffic can pass through during current storm and tidal events, along with proposed sea level rise. The current low chord elevation of the existing pipe culvert is measured approximately at 5.00'. The proposed box culvert alternative and proposed bridge alternative have a low cord elevation of 10.50' and 11.58' respectively – with a top of roadway elevation of 14.50' over the structure centerline. Both new low chord elevations aid in increasing the hydraulic opening compared to the existing pipe culvert.

The eleven cross-sections upstream of the structure highlight the saltmarshes, back eddys and shallow ponds in the floodplain of Knowles Brook. The topographic features in this section are primarily generated from the NOAA Lidar data, with the hydraulic model stretching 3,100-feet upstream to capture the head of tide. The lidar topographical data and survey data was able to capture the entire depth of the stream profile due to Knowles Brook being free from water during low tide events. The upstream side of the north and south approach follow both follow similar ineffective flow areas as described downstream side of the structure, with ineffective flow areas following a 2:1 slope emanating from the culvert opening. A portion of the flood plain upstream of the structure, southeast of Knowles Brook is designated as an ineffective flow area, due to the presence of an elevated roadway blocking any flow into the system.

The roadway and existing culvert were modeled from the original 1994 As-Built plans. A new geometry was created for the proposed structure and roadway. The existing roadway was raised by 4.5-feet at the lowest point to accommodate sea level rise, and a proposed 20' x 16' box culvert was modeled in the same location as the existing pipe culvert. A second proposed alternative of a single span bridge was also modeled in the same location as the existing pipe culvert. The proposed bridge alternative incorporated side slopes up to the abutments at a 2:1 ratio from the existing streambed and has a span length of 65 feet.

16 sets of boundary conditions were included in this study in accordance with the MaineDOT Bridge Design Guide requirements for modelling structures on tidal waterways. Downstream boundary conditions are set as stage hydrographs using tidal data based on Bar Harbor NOAA gauge data. Upstream boundary conditions are set with a flow hydrograph with a constant flow. These cases are evaluated at the current condition as well as a future condition at the end of the life cycle of the proposed replacement alternative to account for potential sea level rise during the life cycle of the replacement structure. The combination of these boundary conditions was used to develop 16 different cases, which are described in the table below. The 65-foot bridge alternative data is not included here for brevity, since it is not the selected alternative.

	HEC-RAS Inputs		
	Upstream Boundary Condition	Downstream Boundary Condition.	
Cases	Eastern River Upland Flow Volume (ft^3/s)	Tidal Max. Elevation (ft)	Tidal Min. Elevation (ft)
Case 1 – Q1.1 Upland Flows, Highest Astronomical Tides, Existing Culvert	80	7.435	-2
Case 2 – Q50 Upland Flows, Highest Astronomical Tides, Existing Culvert	490	7.435	0
Case 3 – Q1.1 Upland Flows, Historic 2022 Storm Tides, Existing Culvert	80	8.475	-2
Case 4 – Q1.1 Upland Flows, Category 1 Hurricane Tides, Existing Culvert	80	9.835	-2
Case 5 – Q1.1 Upland Flows, Highest Astronomical Tides, Proposed Culvert	80	7.435	-2
Case 6 – Q50 Upland Flows, Highest Astronomical Tides, Proposed Culvert	490	7.435	0
Case 7 – Q1.1 Upland Flows, Category 1 Hurricane Tides, Proposed Culvert	80	9.835	-2
Case 8 – Q1.1 Upland Flows, Highest Astronomical Tides + 3.9 ft Sea Level Rise, Proposed Culvert	80	11.335	-2
Case 9 – Q50 Upland Flows, Highest Astronomical Tides + 3.9 ft Sea Level Rise, Proposed Culvert	490	11.335	0
Case 10 – Q1.1 Upland Flows, Category 1 Hurricane Tides + 3.9 ft Sea Level Rise, Proposed Culvert	80	13.735	-0.7150

The design approach for each case are as follows:

- Case 1 models existing conditions of highest astronomical tides with low upland flow, which is used to verify the model. For the upstream boundary condition, a Q1.1 constant flow is used, while for the downstream boundary condition typical highest astronomical tidal cycle was used.
- Case 2 models existing conditions of highest astronomical tides with no coastal storm, and high upland flow. For this case, Q50 Knowles Brook upland flow volume is used for the upstream boundary condition, and a typical highest astronomical tidal cycle on the Pleasant River is used for the downstream boundary condition.
- Case 3 is an additional existing condition validation case that models 2022's "Christmas Eve" storm event with low upland flow. For this case, Q1.1 Knowles Brook constant flow is used as the upstream flow hydrograph, and tidal data taken at the Bar Habor NOAA gauge during the entire storm event is used as the downstream stage hydrograph. This case, in conjunction with photographs taken at the bridge site during the storm event was used to ensure the hydraulic model was functioning correctly, along with providing results for an intermediate storm.
- Case 4 models existing conditions where a Category 1 hurricane (Equivalent to a 50yr storm surge) is set as the downstream stage hydrograph condition, and an upstream boundary condition of constant Q1.1 flow. To achieve data for a Category 1 hurricane, online SLOSH mapping was used to find water depths during a Category 1 hurricane. This was compared against depths generated from NOAA tidal gauge data to find the difference between each scenario. This difference was then applied to offset the tidal data to get a tidal dataset that represented a Category 1 hurricane.
- Case 5 models proposed culvert conditions of highest astronomical tides with low upland flow, which is used to verify the model. For the upstream boundary condition, a Q1.1 constant flow is used, while for the downstream boundary condition typical highest astronomical tidal cycle was used.
- Case 6 models proposed culvert conditions of highest astronomical tides with no coastal storm, and high upland flow. For this case, Q50 Knowles Brook upland flow volume is used for the upstream boundary condition, and a typical highest astronomical tidal cycle on the Pleasant River is used for the downstream boundary condition.
- Case 7 models proposed culvert conditions where a Category 1 hurricane (Equivalent to a 50yr storm surge) is set as the downstream stage hydrograph condition, and an upstream boundary condition of constant Q1.1 flow.
- Case 8 models the proposed culvert conditions with a downstream boundary condition of highest astronomical tides with a +3.9ft sea level rise with an upstream boundary condition of constant Q1.1 flow. The geometry used for this case includes the proposed culvert and elevated approaches.
- Case 9 models the proposed culvert conditions with a downstream boundary condition of highest astronomical tides with a +3.9' sea level rise with an upstream boundary

condition of constant Q50 flow. The geometry used for this case includes the proposed culvert and elevated approaches.

- Case 10 models the proposed culvert conditions with a downstream boundary condition of highest astronomical tides with a storm surge due to a Category 1 Hurricane and considering a +3.9ft sea level rise. To obtain values for a category 1 Hurricane tidal data set, a similar approach to case 4 was taken. A Q1.1 constant flow was used for the upstream boundary condition.

Results:

The results from the hydraulic analysis done in HEC-RAS are shown in the following sixteen tables. All these values were taken at the cross-section at the upstream bridge section (Station 575). Positive flow indicates water flowing out of Knowles Brook into Pleasant Bay, while negative flow indicates water flowing from Pleasant Bay into Knowles Brook.

	Case 1 – Q1.1 Upland Flows, Highest Astronomical Tides, Existing Culvert	
	Minimum	Maximum
Q Total (ft^3/s)	-338.16	732.05
Q Channel (ft^3/s)	-313.59	686.49
Elevation (ft)	-1.4	7.20
Velocity (ft/s)	-0.56	1.31

	Case 2 – Q50 Upland Flows, Highest Astronomical Tides, Existing Culvert	
	Minimum	Maximum
Q (ft^3/s)	-93.39	970.24
Q Channel (ft3/s)	-86.08	887.89
Elevation (ft)	2.29	7.78
Velocity (ft/s)	-.15	1.56

	Case 3 – Q1.1 Upland Flows, Historic 2022 Storm Tides, Existing Culvert	
	Minimum	Maximum
Q (ft^3/s)	-645.05	885.52
Q Channel (ft3/s)	-553.91	821.85
Elevation (ft)	-1.4	8.31
Velocity (ft/s)	-.86	1.52

	Case 4 – Q1.1 Upland Flows, Category 1 Hurricane Tides, Existing Culvert	
	Minimum	Maximum
Q (ft^3/s)	-3886.97	1953.29
Q Channel (ft3/s)	-2390.66	1229.86
Elevation (ft)	-1.4	11.5
Velocity (ft/s)	-3.15	1.57

	Case 5 – Q1.1 Upland Flows, Highest Astronomical Tides, Proposed Culvert	
	Minimum	Maximum
Q (ft^3/s)	-696.48	863.72
Q Channel (ft3/s)	-644	809.44
Elevation (ft)	-1.57	7.42
Velocity (ft/s)	-1.13	1.5

	Case 6 – Q50 Upland Flows, Highest Astronomical Tides, Proposed Culvert	
	Minimum	Maximum
Q (ft^3/s)	-438.22	1233.38
Q Channel (ft3/s)	-404.08	1156.57
Elevation (ft)	1.41	7.49
Velocity (ft/s)	-0.7	2.17

	Case 7 – Q1.1 Upland Flows, Category 1 Hurricane Tides, Proposed Culvert	
	Minimum	Maximum
Q (ft^3/s)	-1592.87	1711.57
Q Channel (ft3/s)	-1281.52	1526.92
Elevation (ft)	-1.57	11.4
Velocity (ft/s)	-1.94	2.63

	Case 8 – Q1.1 Upland Flows, Highest Astronomical Tides + 3.9 ft Sea Level Rise, Proposed Culvert	
	Minimum	Maximum
Q (ft^3/s)	-1555.59	1682.17
Q Channel (ft3/s)	-1276.96	1503.83
Elevation (ft)	-1.57	11.25
Velocity (ft/s)	-1.94	2.6

	Case 9 – Q50 Upland Flows, Highest Astronomical Tides + 3.9 ft Sea Level Rise, Proposed Culvert	
	Minimum	Maximum
Q (ft^3/s)	-1244.06	1952.37
Q Channel (ft3/s)	-1089.91	1714.9
Elevation (ft)	1.41	11.45
Velocity (ft/s)	-1.63	2.88

	Case 10 – Q1.1 Upland Flows, Category 1 Hurricane Tides + 3.9 ft Sea Level Rise, Proposed Culvert	
	Minimum	Maximum
Q (ft^3/s)	-3794.41	2288.43
Q Channel (ft3/s)	-1560.4	1746.43
Elevation (ft)	0.98	15.40
Velocity (ft/s)	-2.30	2.72

The maximum water surface elevation for each case matched the maximum input downstream boundary condition which coincided with a Category 1 Hurricane storm surge event. This confirms that this river is fully tidal controlled with minimal contribution from the upland flows. For the existing condition, the existing low chord elevation of 4.95 ft is 6.545 ft lower than the calculated “storm surge” flows. The existing roadway low point elevation is taken as 7.9 ft, which is 3.495 ft lower than the calculated “Storm surge” flows and therefore overtops. In this existing condition, the existing corrugated aluminum pipe culvert is filled with water and the north approach is inundated with water. For the replacement alternative, the proposed culvert low chord elevation of 10.5 ft is 5.895 ft below the anticipated “Storm surge” flows including the projected effects of sea level rise, but for routine Highest Astronomical Tides the approach roadway will not overtop. The proposed profile raise will alleviate the roadway being flooded during current Category 1 Hurricane Storm Surge Events with a roadway low point of 12.51 ft, which is 1.21 ft lower than case 10, the only event that has a maximum water surface elevation higher than the low point.

During current Q1.1 upland flow and highest astronomical high tide (Case 1) conditions Pleasant Bay and Knowles Brook does exhibit tidal transparency. Downstream of the bridge on Pleasant Bay, the water surface elevation is measured as 7.43 ft, with an upstream water surface elevation of 7.20 ft, signifying a .23 ft offset and satisfying the 3 inch maximum offset requirement of tidal transparency. For the proposed culvert and bridge with Q1.1 upland flow and highest astronomical high tide (Case 5 and Case 11), the system does exhibit tidal transparency with a water surface elevation on both sides of the structure measured at 7.43 ft. Incorporating an additional +3.9 ft sea level rise, the proposed structure maintains tidal transparency with a water surface elevation of 11.33 ft on both sides.

References:

Burdick, David , et al. *Evaluation of Pre Restoration Conditions in the West Branch of the Pleasant River, Maine Final Report*. Department of Natural Resources, US Fish and Wildlife Services, West Branch Study Committee, NOAA Fisheries Service, 10 Feb. 2009.

"SLOSH Maps: Maine's Geologic Hazards: Maine Geological Survey: Maine ACF." *Www.maine.gov*, www.maine.gov/dacf/mgs/hazards/slosh/index.shtml.

"NOAA/NOS/CO-OPS Observed Water Levels at 8413320, Bar Harbor ME." *NOAA Tides & Currents 8413320 Bar Harbor, ME*, NOAA, tidesandcurrents.noaa.gov/waterlevels.html?id=8413320&units=standard&bdate=20221213&edate=20230113&timezone=GMT&datum=MLLW&interval=6&action=.

Summary

		Existing Structure	Recommended Structure
		13'-11" Span Pipe Arch	20' x 16' Box Culvert
Total Area of Waterway Opening	ft^2	97.4	300
Headwater elevation @$Q_{1.1}$	ft	7.2	7.42
Headwater elevation @Q_{50}	ft	11.5	11.5
Headwater elevation @$Q_{1.1}$ + 3.9 ft Sea Level Rise	ft	11.1	11.39
Headwater elevation @Q_{50} + 3.9 ft Sea Level Rise	ft	15.4	15.4
Top Chord	ft	5.17	10.5
Freeboard @$Q_{1.1}$	ft	-2.03	3.08
Freeboard @Q_{50}	ft	-2.61	3.01
Freeboard @$Q_{1.1}$ + 3.9 ft Sea Level Rise	ft	-	-0.75
Freeboard @Q_{50} + 3.9 ft Sea Level Rise	ft	-	-0.95
Outlet Velocity @$Q_{1.1}$ Upland Flow + Spring Tide	ft/s	1.31	1.5
Outlet Velocity @Q_{50} Upland Flow + Spring Tide	ft/s	1.56	2.18
Outlet Velocity @$Q_{1.1}$ Upland Flow + Category 1 Storm Tide	ft/s	1.57	2.64
Outlet Velocity @$Q_{1.1}$ Upland Flow + Spring Tide + 3.9 ft Sea Level Rise	ft/s	-	2.61
Outlet Velocity @Q_{50} Upland Flow + Spring Tide + 3.9 ft Sea Level Rise	ft/s	-	2.88
Outlet Velocity @$Q_{1.1}$ Upland Flow + Category 1 Storm Tide + 3.9 ft Sea Level Rise	ft/s	-	2.73

Reported by: Nicholas DiMariano
Date: October 4, 2024

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

WIN:	27160.00		**Project Name:**		
Town:	Addison		**Stream Name:**	Knowles Brook	
Route No.	East Side Rd		**Bridge Name:**	Lot Norton	
Asset ID:	3754		**Analysis by:**	csh	
Lat:	45.59900	**Long:** -67.73790	**Date:**	10/25/2023	

Peak Flow Calculations by USGS Regression Equations (Lombard/Hodgkins, 2021; Hodgkins, 1999 & Lombard/Hodgkins, 2015)

Enter data in blue cells only!

ver. 2021 Jan 01

	km^2	mi^2	ac	*Enter data in [mi^2]*
A	6.40	2.47	1580.8	Watershed Area *DRNAREA*
W	0.37	0.1	90.4	Wetlands area (by NWI)
P_c	602100	4940483		watershed centroid (E, N; UTM 19N; meters)
County	Washington			*choose county from drop-down menu*

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

Watershed Characteristics from StreamStats

STORAGE	4.93	
STORNWI	5.72	NWI Wetlands %
SANDGRAVF	0.23	sand & gravel aquifer as decimal fraction of watershed A
ELEV	96.9	mean basin elevation (ft)
BSLDEM10M	6.78	mean basin slope (%)
COASTDIST	28.50	distance from the coast (mi)
ELEVMAX	241.4	maximum basin elevation (ft)
LC06WATER	0	percent of drainage basin land cover as open water
PRECIP	50.1	mean annual precipitation
STATSGOA	8.57	mean basin percentage of hydrological soil group A

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

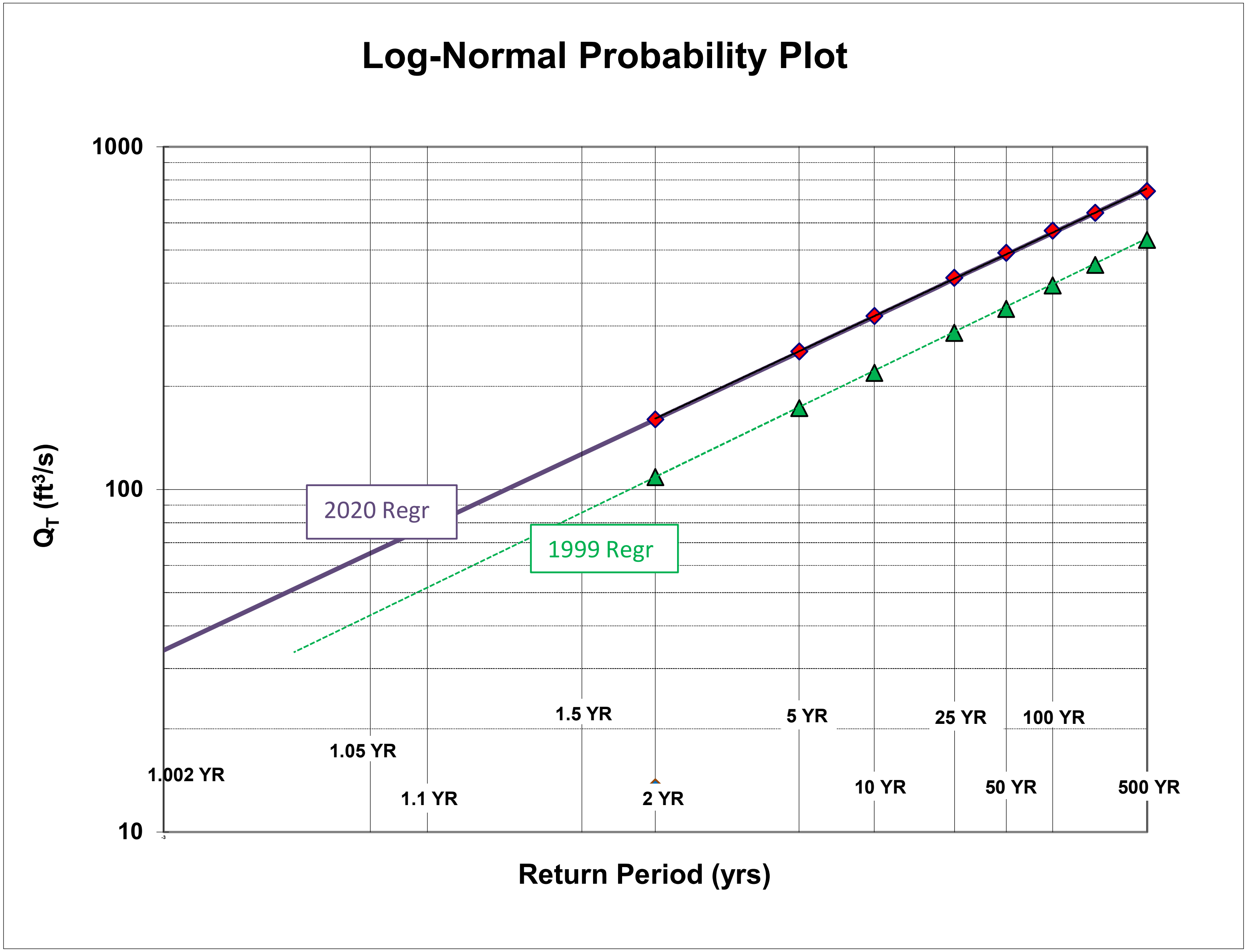
Lombard, P.J. & G.A. Hodgkins, 2015.
Peak flow regression equations for small, ungaged streams:
in Maine: Comparing Map-Based to Field-Based Variables
SIR 2015-4059, USGS, Augusta, ME

Lombard, P.J. & G.A. Hodgkins, 2020.
Estimating Flood Magnitude and Frequency on Gaged and
Ungaged Streams in Maine
SIR 2020-5092, USGS, Augusta, ME.

Ret Pd T (yr)	I24	Q_T (ft^3/s) *1999 / 2015*	Q_T (ft^3/s) *2020*	Q_T (ft^3/s) ***Design***
1.1			78	***80***
2	3.33	109	160	***160***
5	4.10	173	253	***255***
10	4.75	219	321	***320***
25	5.63	287	415	***415***
50	6.30	337	490	***490***
100	7.00	394	569	***570***
200	7.75	453	642	***640***
500	8.83	535	742	***740***

Calculated Bankfull Width: 15.6 **ft**

Instructions:
Enter values in blue cells only, watershed data from StreamStats
Copy I24 values from Stream Stats
Use results under "Design"
Check against gage data and FEMA studies if available
Questions? Check with ENV / Hydrology Section


Log-Normal Probability Plot
1000
100
10
Q_T (ft^3/s)
2020 Regr
1999 Regr
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)

WIN:	27160.00	Project Name:	0
Town:	Addison	Stream Name:	Wilson Stream
Route No.	East Side Rd	Bridge Name:	Bridges
Asset ID:	3754	Analysis by:	csh
Lat:	45.59900 Long: -67.73790	Date:	6/12/2023

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

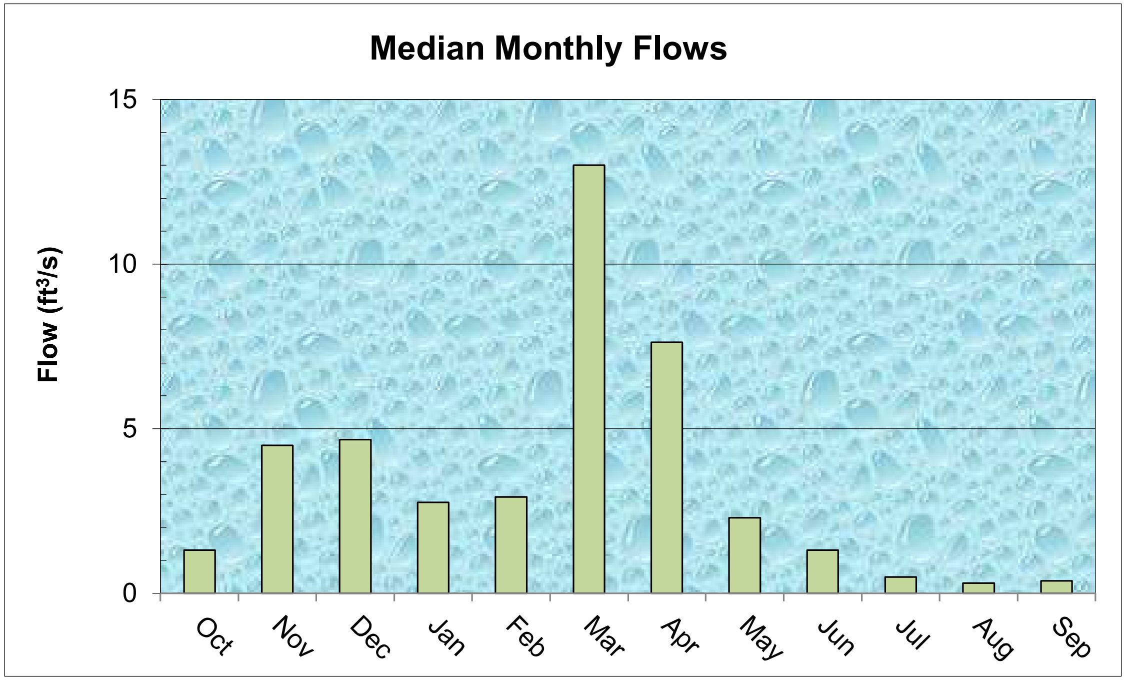
MAINE MONTHLY MEDIAN FLOWS and HYDRAULIC GEOMETRY BY USGS REGRESSION EQUATIONS (2004, 2013, 2015)

	Value	Variable	Explanation
	2.47	*A*	Area (mi^2)
602100	4940483	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
	28.50	*DIST*	Distance from Coastal reference line (mi)
	50.1	*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	**2.76**	0.0783
Feb	**2.92**	0.0829
Mar	**13.00**	0.3685
Apr	**7.63**	0.2161
May	**2.30**	0.0651
Jun	**1.31**	0.0370
Jul	**0.49**	0.0140
Aug	**0.31**	0.0088
Sep	**0.37**	0.0106
Oct	**1.31**	0.0370
Nov	**4.50**	0.1274
Dec	**4.67**	0.1322

Q_{bf}	**13.4**	
ann avg	**6.1**	
ann med	**3.2**	
$Q_{1.002}$	**30.2**	
$Q_{1.01}$	**40.7**	
$Q_{1.05}$	**58.3**	
$Q_{1.1}$	**69.9**	
Q_{bf}	**39.6**	assume v = 4ft/s

W_{bf}	**15.6**	estimated bankfull width (ft)
d_{bf}	**0.8**	estimated bankfull depth (ft)
A_{bf}	**9.9**	estimated bankfull flow area (ft^2)

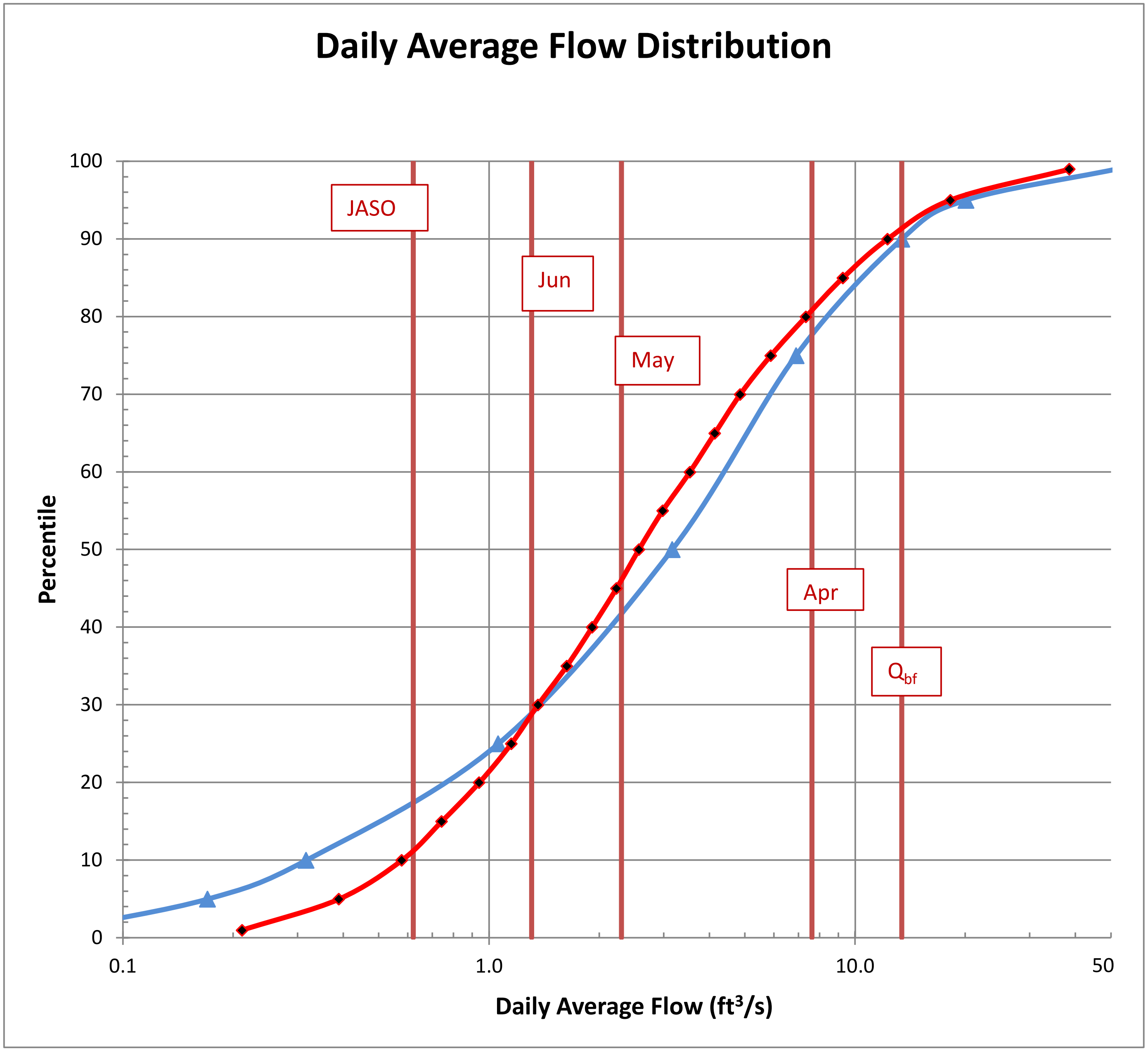


References

Dudley, 2013. FY2013 Progress Report - Phase 1 …, USFWS QRP Project

Dudley, 2004. Estimating Monthly Streamflows … , SIR 2004-5026

Dudley, 2015. Regression Equations for Monthly & Annual Mean..., USGS SIR 2015-5151



Daily Avg Flow Dist

A_{ws} = (mi^2) 2.5

Q (ft^3/s)

Pctl	Median	84th pctl
1.00E-06	0.00	0.00
1	0.21	0.37
5	0.39	0.63
10	0.58	0.87
15	0.74	1.08
20	0.94	1.31
25	1.15	1.54
30	1.36	1.76
35	1.63	2.01
40	1.91	2.31
45	2.23	2.61
50	2.57	3.08
55	2.98	3.58
60	3.54	4.21
65	4.14	4.90
70	4.86	5.72
75	5.89	6.88
80	7.34	8.21
85	9.26	10.52
90	12.27	14.13
95	18.21	21.97
99	38.51	50.70

Q_{bf}	13.4
$Q_{1.002}$	30.2
$Q_{1.1}$	69.9
Q_2	144.8

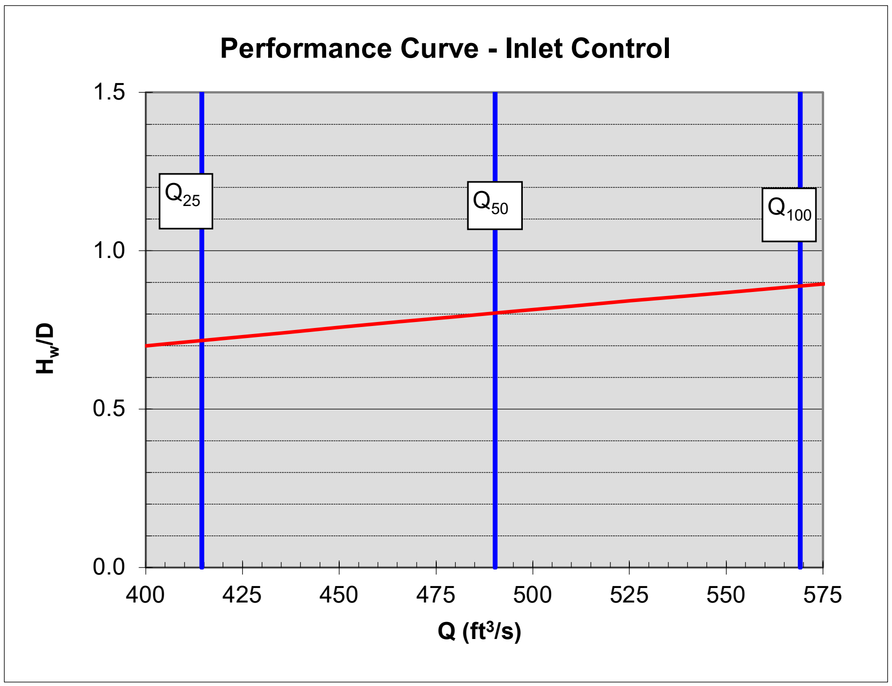
NOTE: ***This page is for preliminary sizing only.***
Final design should be done with HY8 or HDS-5

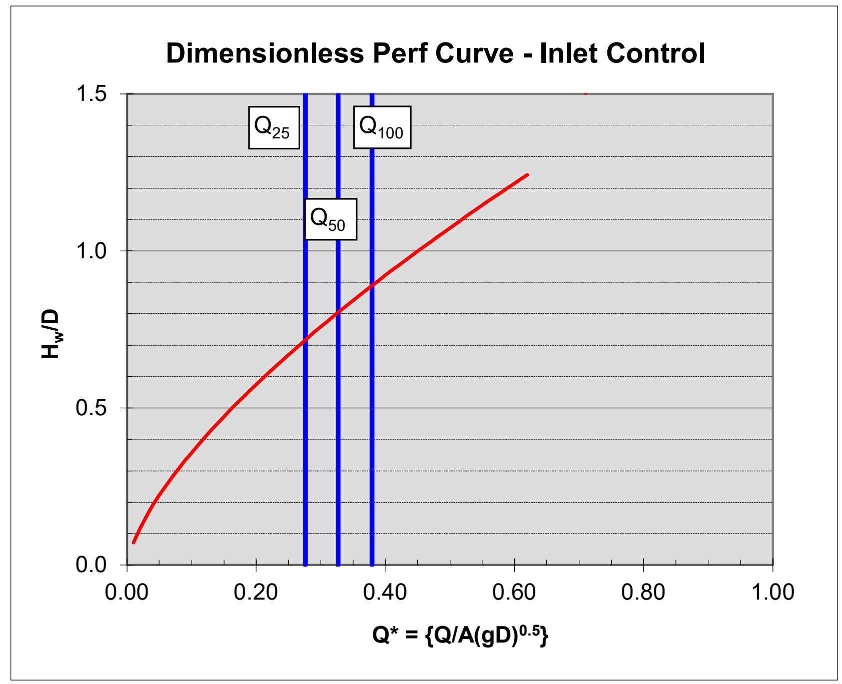
Note:
culvert dimensions are for open flow area; adjust for lost capacity due to embedding / backfilling (min {2' / 25% rise} embedment)
Finish analysis with HY-8

Preliminary Culvert Sizing - Round & Box Culverts

Choose shape and inlet type by pull-down menu in green cells

Shape:	Box					
Inlet Type:	Box 0 ww		Q_{25}	414.5		
D or R (ft)	6	*diam / rise*	Q_{50}	490.3	trial D / R =	9.9
w (ft)	*18*	*box span*	Q_{100}	569.1	trial w: BFW =	15.6
Slope (ft/ft)	0.01					
A (ft^2)	108.00					
g (ft/s^2)	32.2					

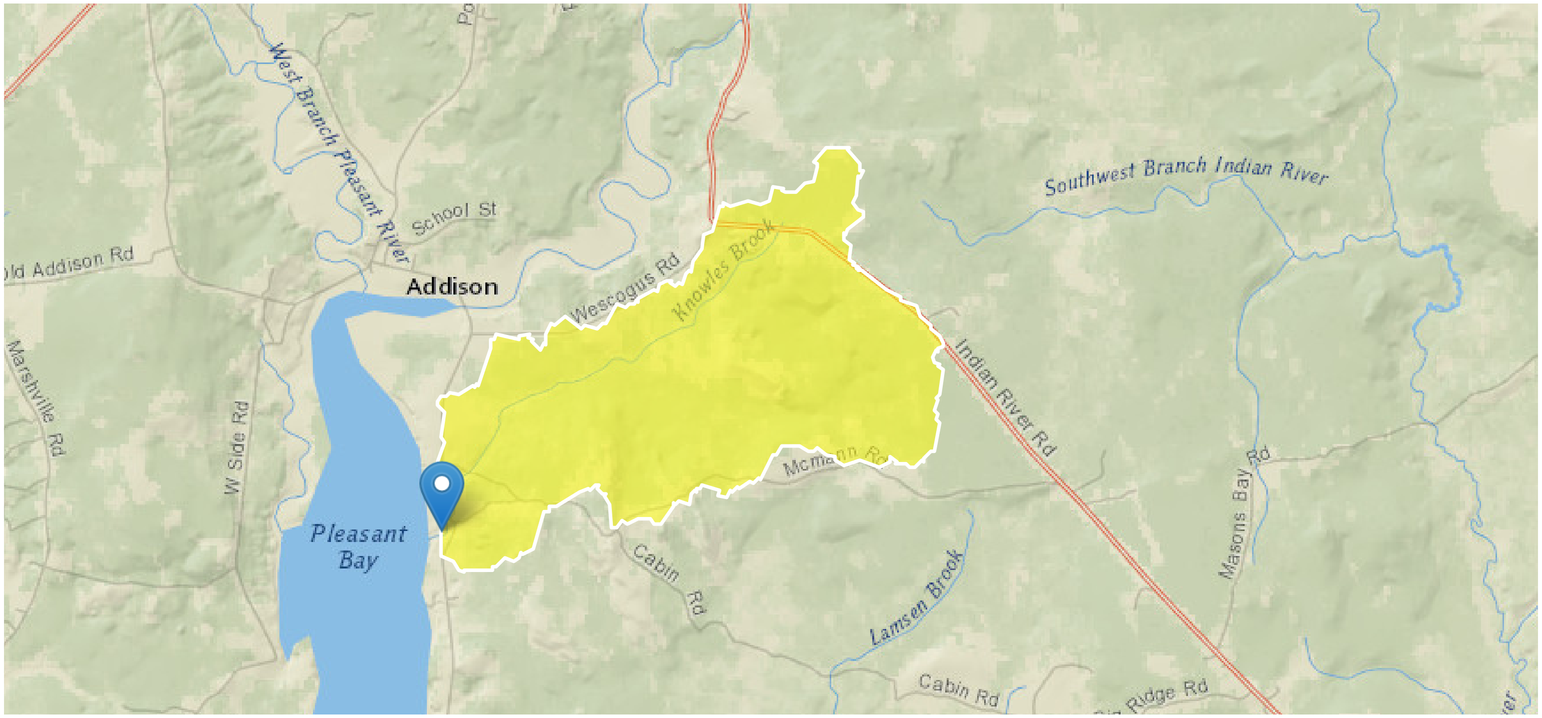




A D D I S O N
Tracy Corners
Indian River Rd
Addison
Addison Pt
Addison Volunteer Fire Department Station 1
Brook
Knowles
River
Upper East Side School
Porcupine Hill
Heath
187

Addison 27160 Lot Norton Bridge #3754

Region ID: ME
Workspace ID: ME20231026102258637000
Clicked Point (Latitude, Longitude): 44.59993, -67.73786
Time: 2023-10-26 06:23:23 -0400



East Side Rd @ Knowles Brook

Collapse All

Basin Characteristics

Parameter Code **Parameter Description** **Value** **Unit**

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BSLDEM10M	Mean basin slope computed from 10 m DEM	6.78	percent
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	602100.54	meters
CENTROIDY	Basin centroid vertical (y) location in state plane units	4940483.16	meters
COASTDIST	Shortest distance from the coastline to the basin centroid	28.5	miles
DRNAREA	Area that drains to a point on a stream	2.47	square miles
ELEV	Mean Basin Elevation	96.9	feet
ELEVMAX	Maximum basin elevation	241.4	feet
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	7	inches
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	4.75	inches
I24H200Y	Maximum 24-hour precipitation that occurs on average once in 200 years	7.75	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	5.63	inches
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	3.33	inches
I24H500Y	Maximum 24-hour precipitation that occurs on average once in 500 years	8.83	inches
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	6.3	inches
I24H5Y	Maximum 24-hour precipitation that occurs on average once in 5 years	4.1	inches
JULAVPRE	Mean July Precipitation	3.49	inches
LC06WATER	Percent of open water, class 11, from NLCD 2006	0	percent
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	23.364	percent
PRDECFEB90	Basin average mean precipitation for December to February from PRISM 1961-1990	13.3	inches
PRECIP	Mean Annual Precipitation	50.1	inches
SANDGRAVAF	Fraction of land surface underlain by sand and gravel aquifers	0.234	dimensionless
SANDGRAVAP	Percentage of land surface underlain by sand and gravel aquifers	23.39	percent

Parameter Code Parameter Description Value Unit

Parameter Code	Parameter Description	Value	Unit
PRECIP	Mean Annual Precipitation	50.1	inches
SANDGRAVAF	Fraction of land surface underlain by sand and gravel aquifers	0.234	dimensionless
SANDGRAVAP	Percentage of land surface underlain by sand and gravel aquifers	23.39	percent
STATSGOA	Percentage of area of Hydrologic Soil Type A from STATSGO	8.57	percent
STORAGE	Percentage of area of storage (lakes ponds reservoirs wetlands)	4.925	percent
STORNWI	Percentage of strorage (combined water bodies and wetlands) from the Nationa Wetlands Inventory	5.72	percent

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Statewide multiparameter peakflows SIR 2020 5092]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.47	square miles	0.26	5680
I24H2Y	24 Hour 2 Year Precipitation	3.33	inches	1.92	4.17
STORAGE	Percent Storage	4.925	percent	0	29.4
I24H5Y	24 Hour 5 Year Precipitation	4.1	inches	2.48	5.38
I24H10Y	24 Hour 10 Year Precipitation	4.75	inches	2.84	6.38
I24H25Y	24 Hour 25 Year Precipitation	5.63	inches	3.3	7.75
I24H50Y	24 Hour 50 Year Precipitation	6.3	inches	3.65	8.79
I24H100Y	24 Hour 100 Year Precipitation	7	inches	3.99	9.88
I24H200Y	24 Hour 200 YearPrecipitation	7.75	inches	5.26	11.1
I24H500Y	24 Hour 500 Year Precipitation	8.83	inches	5.95	13.1

Peak-Flow Statistics Flow Report [Statewide multiparameter peakflows SIR 2020 5092]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	160	ft^3/s	85.4	300	39.1
20-percent AEP flood	253	ft^3/s	137	466	38.1

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	160	ft^3/s	85.4	300	39.1
20-percent AEP flood	253	ft^3/s	137	466	38.1
10-percent AEP flood	321	ft^3/s	172	600	38.9
4-percent AEP flood	415	ft^3/s	219	786	39.9
2-percent AEP flood	490	ft^3/s	255	943	39.7
1-percent AEP flood	569	ft^3/s	297	1090	40.7
0.5-percent AEP flood	642	ft^3/s	325	1270	42.8
0.2-percent AEP flood	742	ft^3/s	370	1490	43.8

Peak-Flow Statistics Citations

Lombard, P.J., and Hodgkins, G.A.,2020, Estimating flood magnitude and frequency on gaged and ungaged streams in Maine: U.S. Geological Survey Scientific Investigations Report 2020–5092, 56 p. (https://doi.org/10.3133/sir20205092)

Annual Flow Statistics

Annual Flow Statistics Parameters [Statewide Annual SIR 2015 5151]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.47	square miles	14.9	1419
SANDGRAVAF	Fraction of Sand and Gravel Aquifers	0.234	dimensionless	0	0.212
ELEV	Mean Basin Elevation	96.9	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	6.1	ft^3/s

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

Statistic	Value	Unit
Mean Annual Flow	6.1	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)

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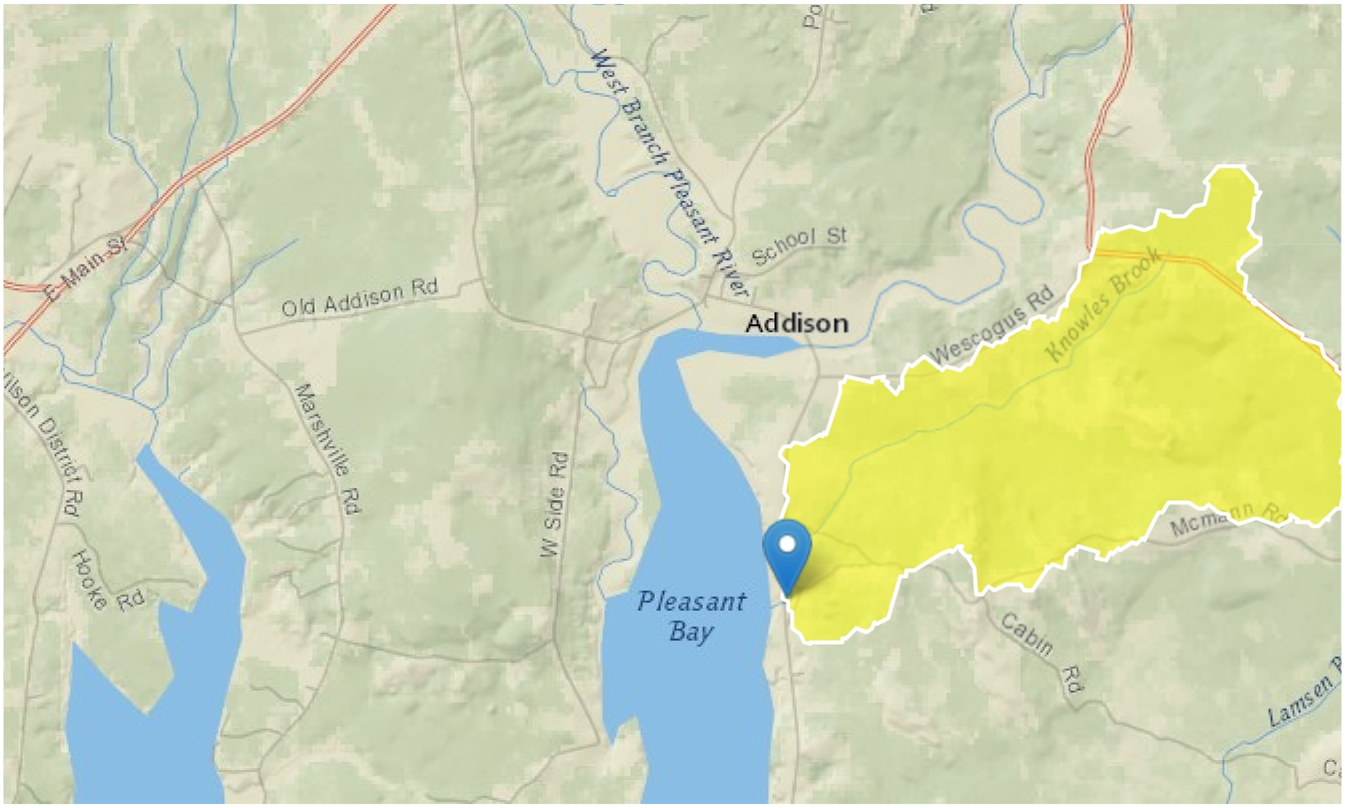
Application Version: 4.18.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

StreamStats Report - Addison Lot Norton

Region ID: ME
Workspace ID: ME20231116195250718000
Clicked Point (Latitude, Longitude): 44.59994, -67.73779
Time: 2023-11-16 14:53:22 -0500



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	2.47	square miles
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	7	inches
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	4.75	inches

Parameter Code	Parameter Description	Value	Unit
I24H200Y	Maximum 24-hour precipitation that occurs on average once in 200 years	7.75	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	5.63	inches
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	3.33	inches
I24H500Y	Maximum 24-hour precipitation that occurs on average once in 500 years	8.83	inches
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	6.3	inches
I24H5Y	Maximum 24-hour precipitation that occurs on average once in 5 years	4.1	inches
STORAGE	Percentage of area of storage (lakes ponds reservoirs wetlands)	4.918	percent

Maximum Probable Flood Statistics

Maximum Probable Flood Statistics Parameters [Crippen Bue Region 1]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.47	square miles	0.1	10000

Maximum Probable Flood Statistics Flow Report [Crippen Bue Region 1]

Statistic	Value	Unit
Maximum Flood Crippen Bue Regional	6800	ft^3/s

Maximum Probable Flood Statistics Citations

Crippen, J.R. and Bue, Conrad D.1977, Maximum Floodflows in the Conterminous United States, Geological Survey Water-Supply Paper 1887, 52p. (https://pubs.usgs.gov/wsp/1887/report.pdf)

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Statewide multiparameter peakflows SIR 2020 5092]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.47	square miles	0.26	5680
I24H2Y	24 Hour 2 Year Precipitation	3.33	inches	1.92	4.17
STORAGE	Percent Storage	4.918	percent	0	29.4
I24H5Y	24 Hour 5 Year Precipitation	4.1	inches	2.48	5.38
I24H10Y	24 Hour 10 Year Precipitation	4.75	inches	2.84	6.38
I24H25Y	24 Hour 25 Year Precipitation	5.63	inches	3.3	7.75
I24H50Y	24 Hour 50 Year Precipitation	6.3	inches	3.65	8.79
I24H100Y	24 Hour 100 Year Precipitation	7	inches	3.99	9.88
I24H200Y	24 Hour 200 YearPrecipitation	7.75	inches	5.26	11.1
I24H500Y	24 Hour 500 Year Precipitation	8.83	inches	5.95	13.1

Peak-Flow Statistics Flow Report [Statewide multiparameter peakflows SIR 2020 5092]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	160	ft^3/s	85.4	300	39.1
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10-percent AEP flood	321	ft^3/s	172	600	38.9
4-percent AEP flood	415	ft^3/s	219	786	39.9
2-percent AEP flood	490	ft^3/s	255	943	39.7

Statistic	Value	Unit	PIL	PIU	ASEp
1-percent AEP flood	569	ft^3/s	297	1090	40.7
0.5-percent AEP flood	642	ft^3/s	325	1270	42.8
0.2-percent AEP flood	743	ft^3/s	371	1490	43.8

Peak-Flow Statistics Citations

Lombard, P.J., and Hodgkins, G.A.,2020, Estimating flood magnitude and frequency on gaged and ungaged streams in Maine: U.S. Geological Survey Scientific Investigations Report 2020–5092, 56 p. (https://doi.org/10.3133/sir20205092)

Bankfull Statistics

Bankfull Statistics Parameters [Central and Coastal Bankfull 2004 5042]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.47	square miles	2.92	298

Bankfull Statistics Parameters [99.3 Percent (2.45 square miles) Appalachian Highlands D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.47	square miles	0.07722	940.1535

Bankfull Statistics Parameters [99.3 Percent (2.45 square miles) New England P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.47	square miles	3.799224	138.999861

Bankfull Statistics Parameters [99.3 Percent (2.45 square miles) USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.47	square miles	0.07722	59927.7393

Bankfull Statistics Disclaimers [Central and Coastal Bankfull 2004 5042]

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

Bankfull Statistics Flow Report [Central and Coastal Bankfull 2004 5042]

Statistic	Value	Unit
Bankfull Streamflow	13.4	ft^3/s
Bankfull Width	12.3	ft
Bankfull Depth	0.808	ft
Bankfull Area	9.9	ft^2

Bankfull Statistics Flow Report [99.3 Percent (2.45 square miles) Appalachian Highlands D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	22.1	ft
Bieger_D_channel_depth	1.45	ft
Bieger_D_channel_cross_sectional_area	32.6	ft^2

Bankfull Statistics Disclaimers [99.3 Percent (2.45 square miles) New England P Bieger 2015]

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

Bankfull Statistics Flow Report [99.3 Percent (2.45 square miles) New England P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	32.5	ft
Bieger_P_channel_depth	1.68	ft
Bieger_P_channel_cross_sectional_area	54.9	ft^2

Bankfull Statistics Flow Report [99.3 Percent (2.45 square miles) USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	17	ft

Statistic	Value	Unit
Bieger_USA_channel_depth	1.46	ft
Bieger_USA_channel_cross_sectional_area	27.8	ft^2

Bankfull Statistics Citations

Dudley, R.W.,2004, Hydraulic-Geometry Relations for Rivers in Coastal and Central Maine: U.S. Geological Survey Scientific Investigations Report 2004-5042, 30 p (http://pubs.usgs.gov/sir/2004/5042/pdf/sir2004-5042.pdf)
Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_campaign=PDFCoverPages)

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Application Version: 4.18.1

StreamStats Services Version: 1.2.22

NSS Services Version: 2.2.1

TYLin

To:	File	**From:**	Daniel Myers (T.Y. Lin International)
Address:	(Via Email)	**Date:**	January 10, 2024
		CC:	

Re: **Addison Lot Norton Bridge WIN 27160.00**
Sea Level Elevation Data

MEMORANDUM

Charlie Hebson provided data from tidal loggers nearby. When the loggers worked properly, they matched up perfectly with the Bar Harbor tide gage, which is approximately 30 miles away, so Charlie recommended we use Bar Harbor dataset. (https://tidesandcurrents.noaa.gov/stationhome.html?id=8413320)

CURRENT DATA:

Per VDatum, the MLLW to NAVD88 translation at this location is approximately -5.945 ft.

Bar Harbor Data Point	Gage Elevation (above MLLW)	Translated NAVD88 Elevation
Highest Observed Tide (Appears to be 1/10/24)	15.70 (Astronomical Prediction was 11.70)	9.755 (5.755 predicted)
Highest Astronomical Tide	13.69	**7.745**
MHHW	11.37	**5.425**
MHW	10.95	**5.005**
MTL	5.66	-0.285
MLW	0.38	-5.565
MLLW	0.00	-5.945

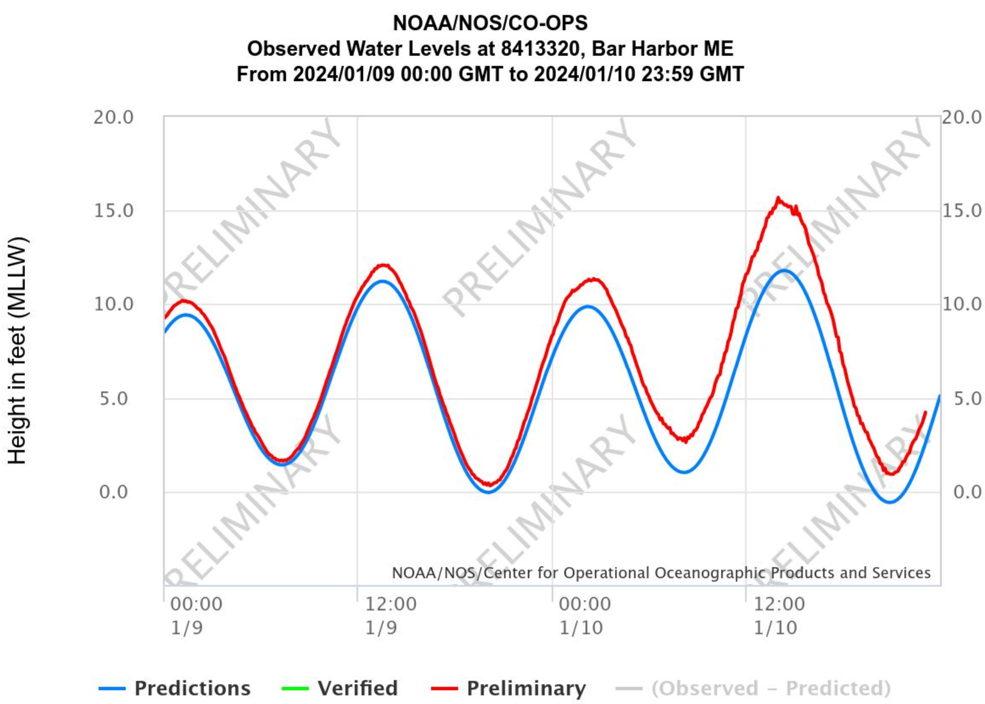
For a typical month, the spring tides get to within around 0.5 feet of the Highest Astronomical Tide (HAT), so around elevation **7.25**.

STORM SURGE DATA:

The existing low point near the Addison Lot Norton bridge was surveyed at **8.4 feet NAVD88** at the crown of the roadway. The edges of the roadway are lower. Given how close this is to the spring tides, it needs only a strong on-shore wind and some waves to wash over the roadway.

TYLin

On 1/10/24, water reached elevation 9.755 at Bar Harbor, which flooded the roadway as shown here:



Note the elevations in the chart are vs. MLLW.

On 12/23/22, water reached elevation 8.475 at Bar Harbor, which led to the flooding shown here (taken 1 hour after high tide):

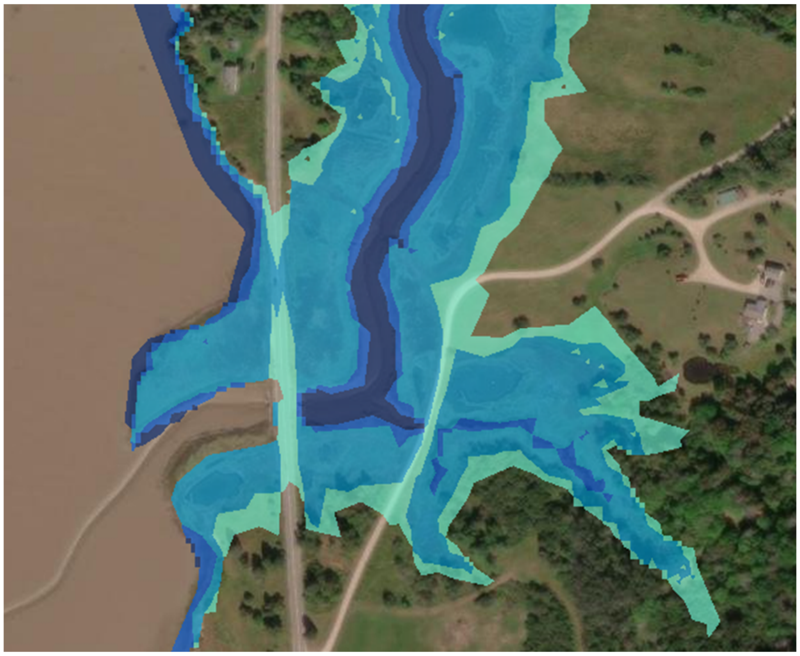
Note that Bar Harbor's tide gage faces away from the ocean (north) while Pleasant Bay faces south, out to sea, so storm surge events likely reach higher water levels at the Addison site than Bar Harbor's gage registered. Based on visual evidence from these 2 events, it appears the storm tides are 6" to 1 foot higher than Bar Harbor.

The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model shows inundation limits for this location for a Category 1 hurricane. A Category 1 hurricane is considered a 50-year event.

> *The layers show areas along the Maine coastline that might potentially be inundated by storm tides (the combination of a predicted tide and storm surge) under scenarios of landfalling Category 1, 2, 3, or 4 storms at mean high tide. (source: https://www.maine.gov/dacf/mgs/hazards/slosh/faq.htm)*

The SLOSH output shows the following for Category 1 storm tide inundation:

TYLin



Based on comparing that output with the survey data, we can approximate the SLOSH category 1 water level as near **11.5 feet** (the water appears to be just over 3 feet deep, and the low point is 8.4). Recall this is for a landfalling hurricane at mean high tide, which is elevation 5.005. Therefore, the **Category 1 storm surge depth is approximately 6.5 feet**.

Category 2 storm surge depth is approximately 12.5 feet, using the same technique for estimation.

STORM TIDE RECURRENCE:

At Portland, ME, the table below shows the recurrence of various storm tides. In Portland MHW is 9.47, MHHW is 9.91, and HAT is 11.97 above MLLW:

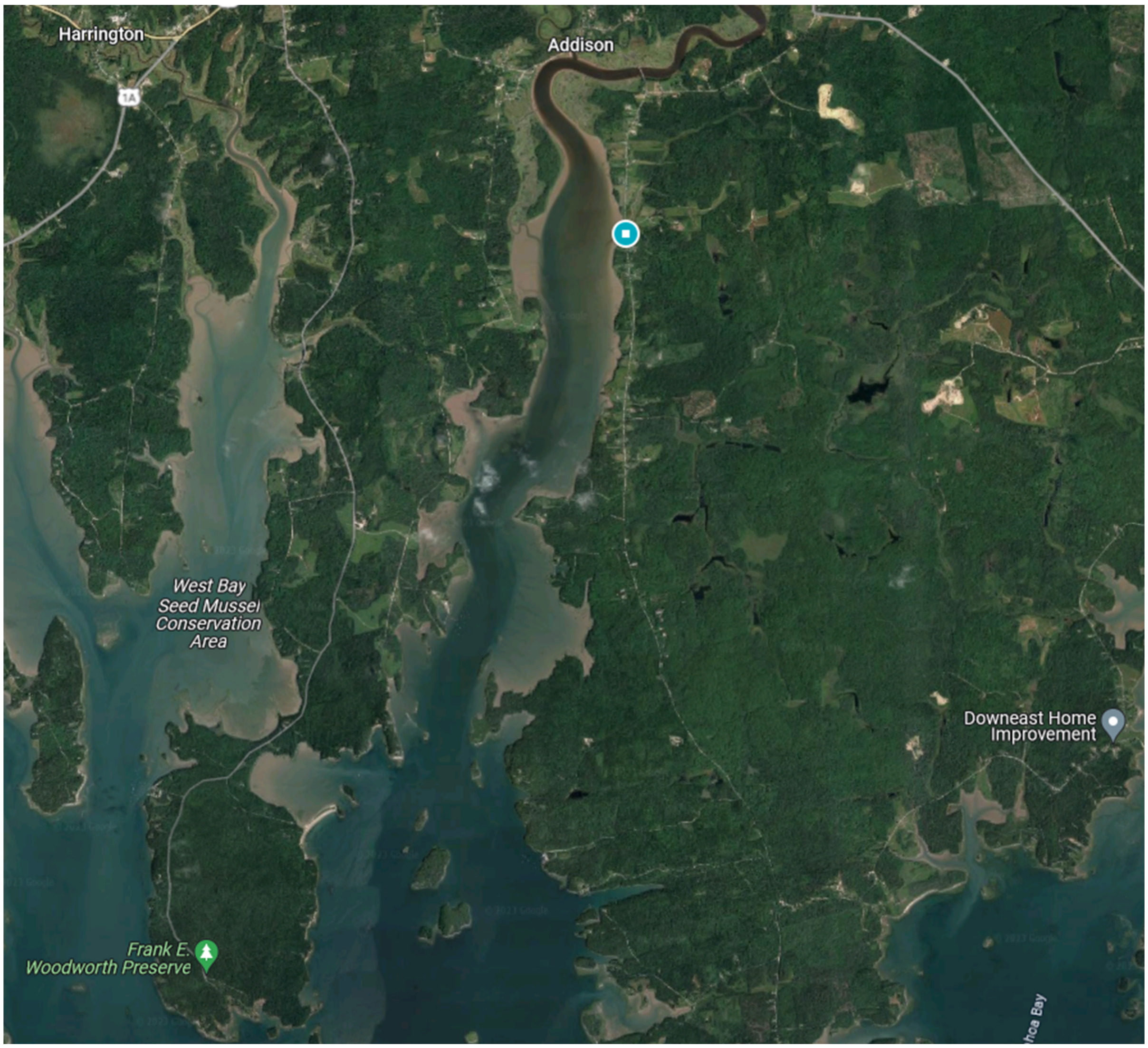
Portland Storm Tide Statistics (1912-2023)		
Recurrence Interval	Annual % Chance	Storm Tide (feet, MLLW)
1	100	11.7
5	20	12.6
10	10	12.9
25	4	13.4
50	2	13.8
100	1	14.1
data through August 2023		

Source: https://www.maine.gov/dacf/mgs/hazards/slr_ss/faq.htm

TYLin

Note that on a short recurrence interval, storm tides are not likely to align with high astronomical tides—hence the 1 year storm tide is very close to the HAT.

Note also that the Portland, ME harbor is not facing out to sea and thus is not highly susceptible to local storm surge effects or wave action (similar to Bar Harbor). Addison's Pleasant Bay is facing south and local storm surge effects are likely to increase the storm tides. Additionally, some wave action is possible on the approach roadway with southwest winds.



SEA LEVEL RISE DATA:

Sea Level Rise is generally estimated at 3.9 feet at year 2100. Quote from: https://www.maine.gov/dacf/mgs/hazards/slr_ss/faq.htm

The sea level rise scenarios were developed by using available long-term sea level rise data from Portland, Bar Harbor, and Eastport tide gauges and the US Army Corps of Engineers Sea-Level Change Curve Calculator and sea level rise scenarios established by NOAA et al. (2017) prepared for the US National Climate Assessment. Scenarios were averaged for all three tide gauges and include low, intermediate low, intermediate, intermediate high, high, and extreme sea level rise at the 50% confidence interval, as shown below.

GAUGE	Scenarios by 2100 (feet, NOAA 2017, 50% CI)					
	Low	Low-Intermediate	Intermediate	Intermediate-High	High	Extreme
PORTLAND	1.1	1.5	3.8	6.0	8.7	10.8
BAR HARBO	1.3	1.7	4.0	6.2	9.0	11.0
EASTPORT	1.2	1.6	3.9	6.0	8.8	10.9
AVERAGE	1.2	1.6	3.9	6.1	8.8	10.9

Notice the range of possible outcomes listed.

DESIGN CRITERIA FOR ADDISON:

The Resiliency Grant application stated a minimum roadway profile elevation of 12.1 feet. This is the lowest elevation that would be acceptable for this project.

From the Bridge Design Guide, Section 2.3.10.2:

Structure Capacity (Tidal)
Culvert-type structures in tidal area - The headwater depth versus structure depth (HW/D) ratio should be approximately equal to or less than 0.9 at Q50 with flow at MHW. The HW/D ratio should be less than 0.9 for twin pipes or pipe arches.

Bridges in tidal area - Bridges on tidal rivers/streams should be designed to protect the bridge structure itself. Most of the surrounding land and the approach roadways may be inundated by relatively frequent tidal storm surges. The minimum design freeboard in these areas is 2 feet above Q10 (based upon MHW) including wave heights. The finished grade of the bridge will be set by considering this requirement, along with navigation clearance, the approach roadways, topography, and good engineering judgment.

There may be instances where a reduction in these requirements will be necessary to minimize high costs, environmental impacts, construction impacts in urban areas, etc. Good engineering judgment should be followed in making these decisions and the reasons should be documented.

At this site, hydraulics modeling of this crossing shows that upland flows on Knowles Brook do not significantly raise water levels—ocean behavior dominates water surface elevation at the site. A Q10 storm tide event in Portland is approximately 3.5 feet above MHW, which would mean +8.5 at the site with current conditions. Note this site appears to flood more frequently than that, meaning storm tides are likely higher in Addison. A more conservative value (accounting for the bay orientation and higher surges the sheltered tide gages received) would be an approximate current Q10 number of +9.5. This would lead to a low-chord elevation of a bridge structure at +11.5, without accounting for sea level rise.

At its current elevation, the Addison roadway is typically impassable due to high water around once a year (based on anecdotes from Maintenance). Looking at storm tide recurrence intervals, that means that at a water level that is near the HAT of 7.75 in Bar Harbor, there is water over the existing road (profile elevation at 8.4). This agrees with the finding that storm surges are 6 to 12" higher at the Addison site than the Bar Harbor tide gage.

Here are the approximate anticipated water levels for the Addison Lot Norton site accounting for a prorated 3.9' sea level rise.

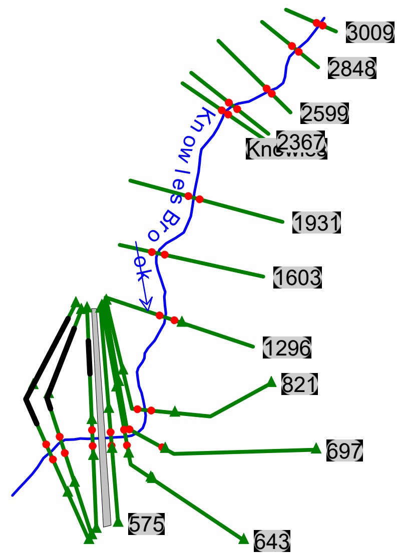
Water Level	Year 2025	Year 2050	Year 2100
MLW	-5.57	-4.27	-1.67
MHW	5.00	6.30	8.90
MHHW	5.43	6.73	9.33
Highest Astronomical Tide	7.75	9.05	11.65
Q10 Storm Tide (estimated)	8.75	10.05	12.65
"Q50" (Category 1 Hurricane at MHW – from SLOSH)	11.50	12.80	15.40
Category 2 Hurricane at MHW – from SLOSH	17.50	18.80	21.40

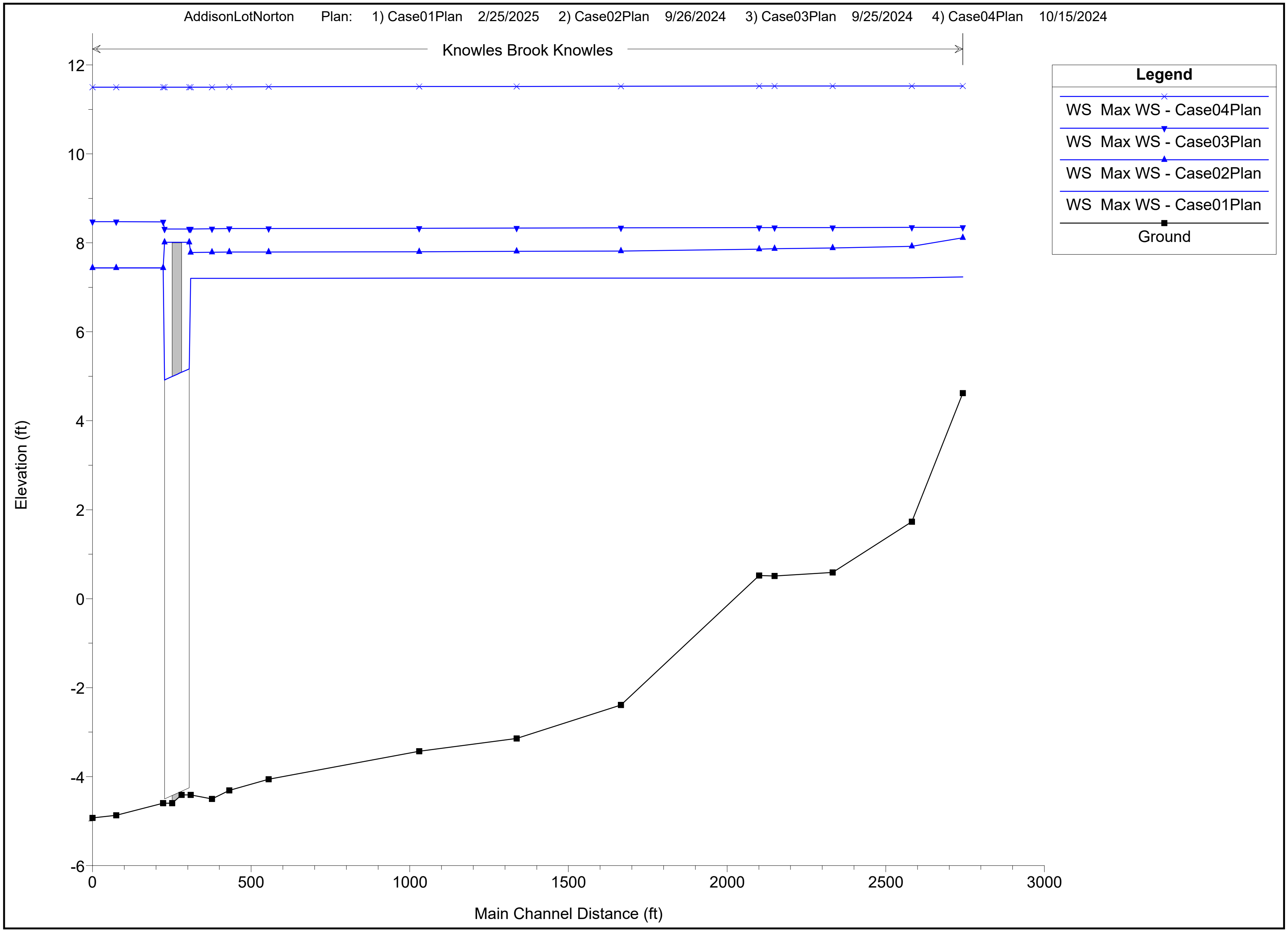
The existing invert of the culvert is at approximately -5.0.

We propose that the **low point of the new roadway be approximately +12.5** (raising the grade approximately 4 feet). This fulfills the resiliency grant criteria and will minimize overtopping the roadway even with sea level rise—it would not be until well into the future (near 2100) where the roadway is overtopping again with any frequency.

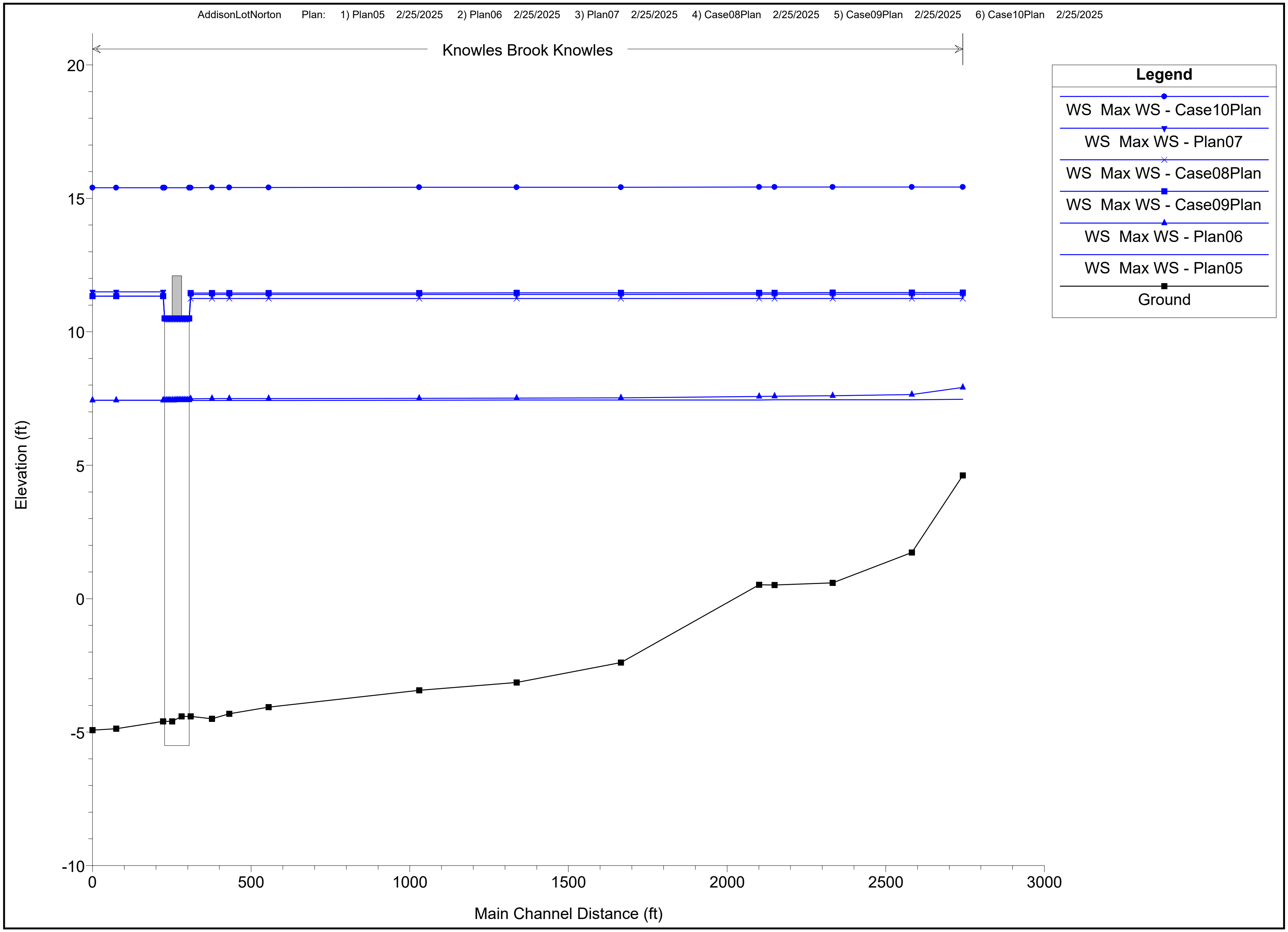
We propose that the grade be higher over the structure. We propose a 16-foot tall box culvert be set with an invert of -5.5, with the top at +10.5. With the thickness of the box and minimum 2’ subgrade and pavement, the **PGL should be approximately +14.0** over the box.

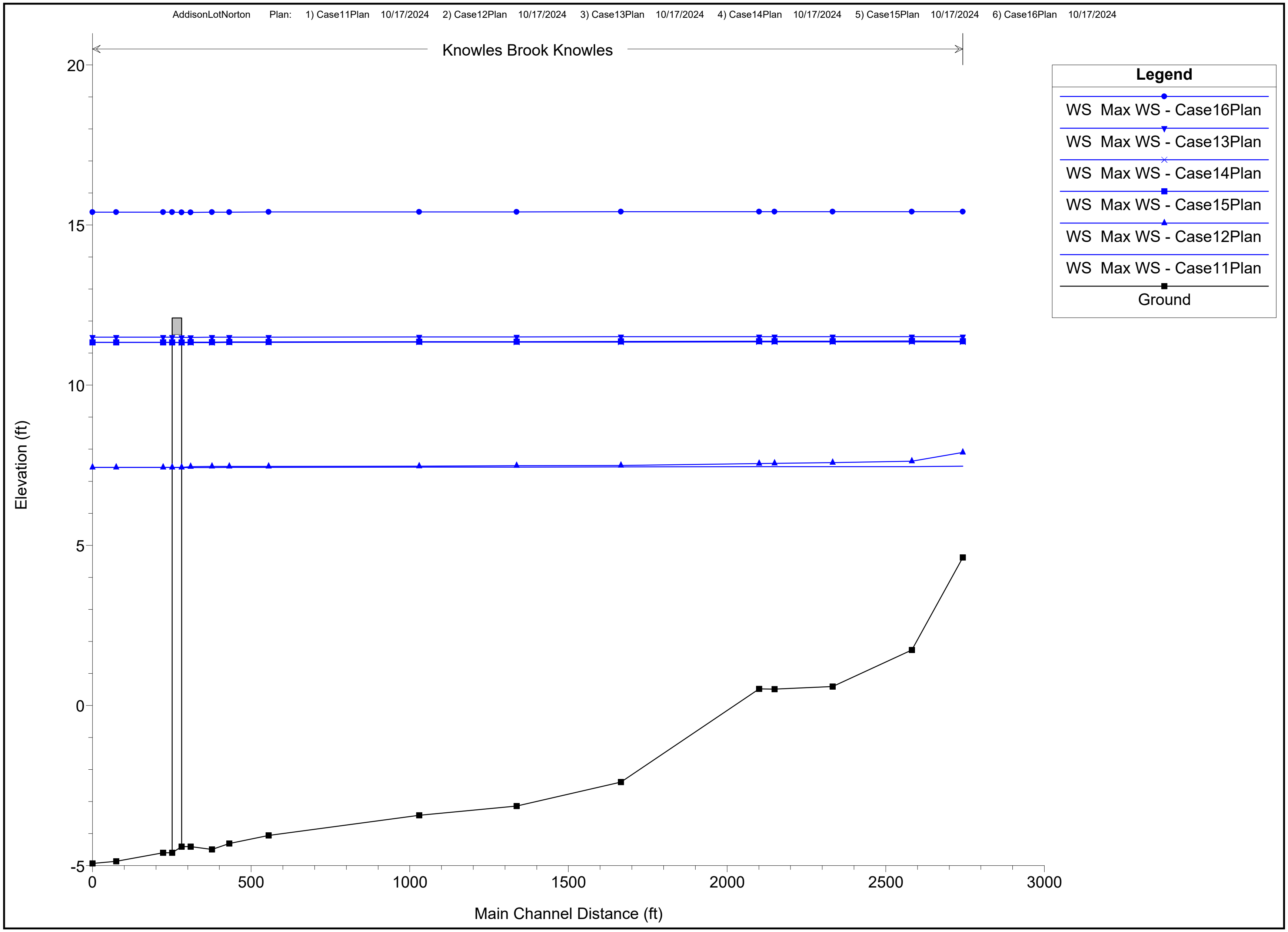
For a span structure, a +14.0 PGL would lead to a low chord elevation around +12 or a little below that. This will meet the current Q10+2’ criteria of 10.75 feet, but will not meet that criteria beyond around 2050 assuming prorated sea level rise. Still, this should be acceptable for this site.

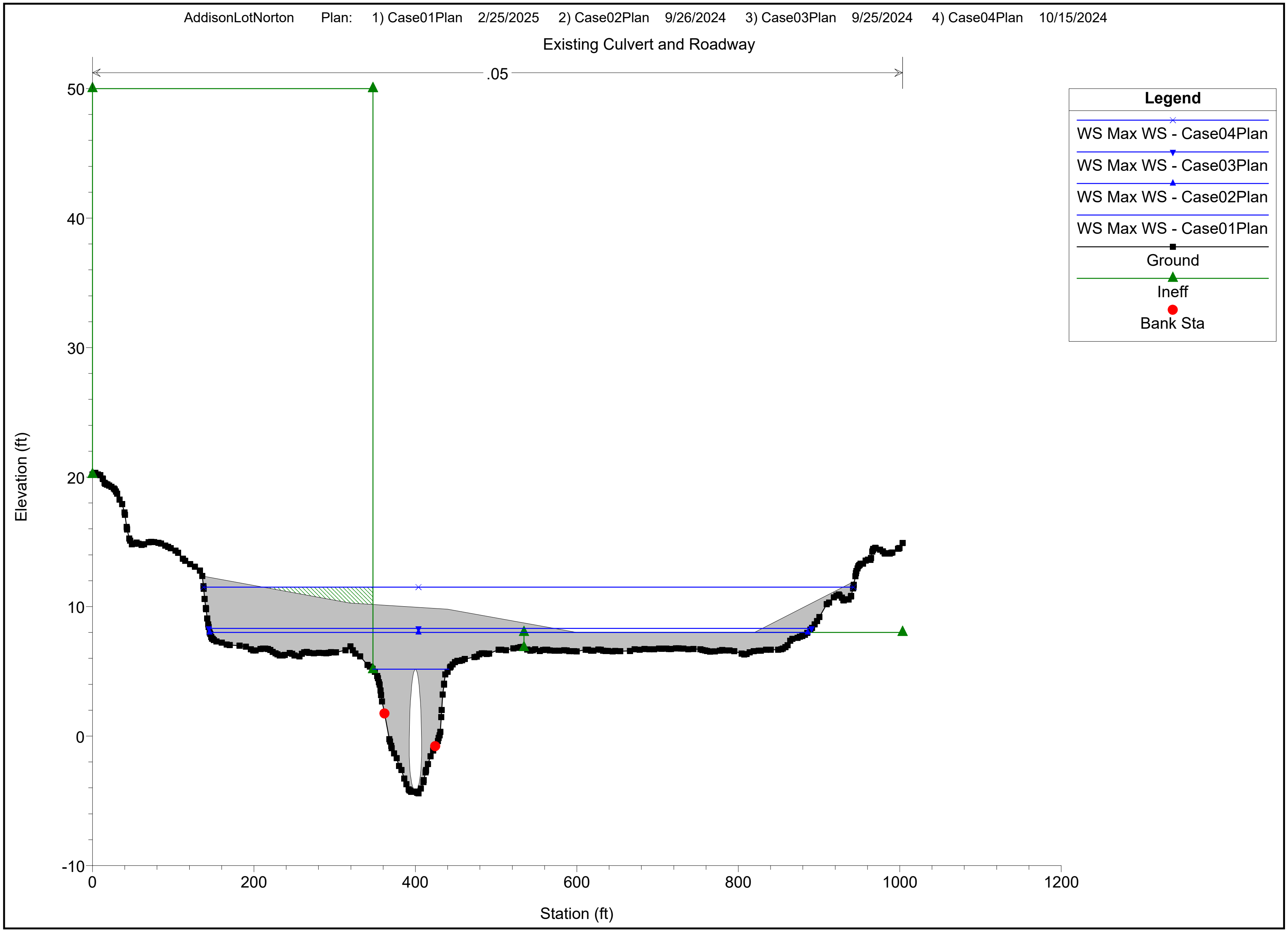

3009
2848
2599
2367
Knowles
Knowles Brook
1931
1603
1296
821
697
575
643



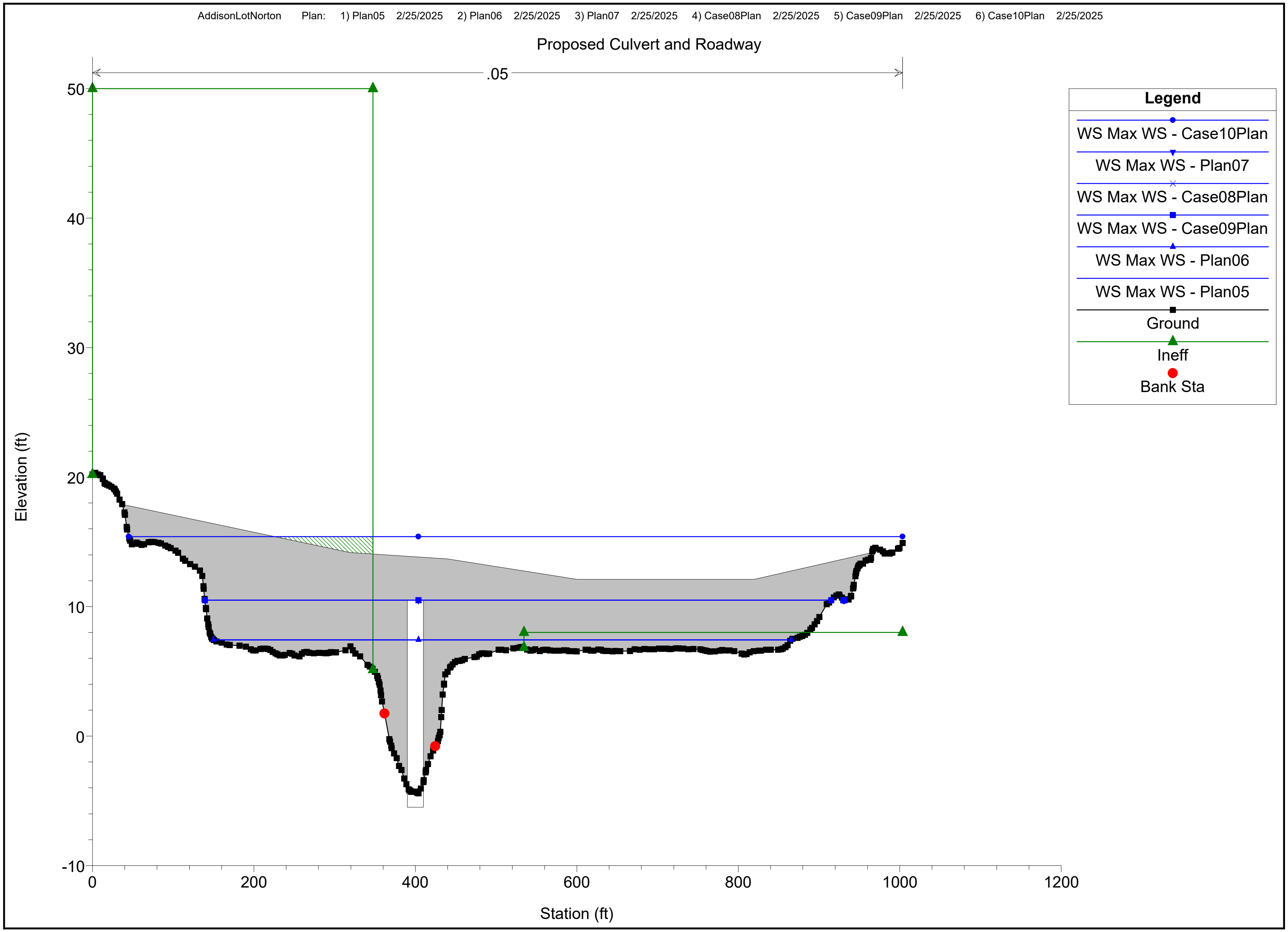
AddisonLotNorton Plan: 1) Case01Plan 2/25/2025 2) Case02Plan 9/26/2024 3) Case03Plan 9/25/2024 4) Case04Plan 10/15/2024
Knowles Brook Knowles
Legend
WS Max WS - Case04Plan
WS Max WS - Case03Plan
WS Max WS - Case02Plan
WS Max WS - Case01Plan
Ground
Elevation (ft)
Main Channel Distance (ft)
12
10
8
6
4
2
0
-2
-4
-6
0
500
1000
1500
2000
2500
3000


AddisonLotNorton Plan: 1) Plan05 2/25/2025 2) Plan06 2/25/2025 3) Plan07 2/25/2025 4) Case08Plan 2/25/2025 5) Case09Plan 2/25/2025 6) Case10Plan 2/25/2025
Knowles Brook Knowles
Legend
WS Max WS - Case10Plan
WS Max WS - Plan07
WS Max WS - Case08Plan
WS Max WS - Case09Plan
WS Max WS - Plan06
WS Max WS - Plan05
Ground
Elevation (ft)
Main Channel Distance (ft)
20
15
10
5
0
-5
-10
0
500
1000
1500
2000
2500
3000

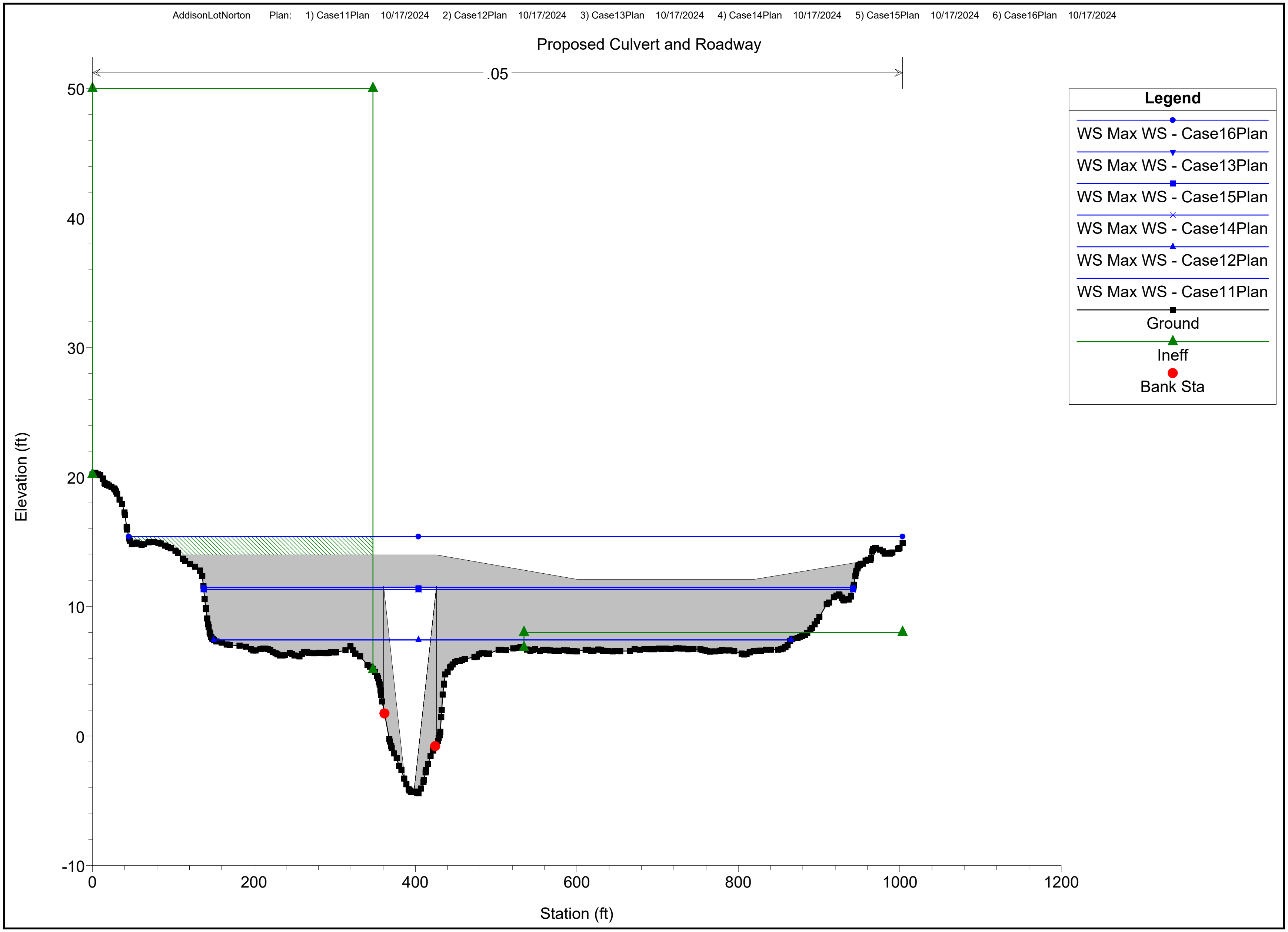

AddisonLotNorton Plan: 1) Case11Plan 10/17/2024 2) Case12Plan 10/17/2024 3) Case13Plan 10/17/2024 4) Case14Plan 10/17/2024 5) Case15Plan 10/17/2024 6) Case16Plan 10/17/2024
Knowles Brook Knowles
Legend
WS Max WS - Case16Plan
WS Max WS - Case13Plan
WS Max WS - Case14Plan
WS Max WS - Case15Plan
WS Max WS - Case12Plan
WS Max WS - Case11Plan
Ground
Elevation (ft)
Main Channel Distance (ft)
20
15
10
5
0
-5
0
500
1000
1500
2000
2500
3000



AddisonLotNorton Plan: 1) Case01Plan 2/25/2025 2) Case02Plan 9/26/2024 3) Case03Plan 9/25/2024 4) Case04Plan 10/15/2024
Existing Culvert and Roadway
.05
Elevation (ft)
Station (ft)
50
40
30
20
10
0
-10
0
200
400
600
800
1000
1200
Legend
WS Max WS - Case04Plan
WS Max WS - Case03Plan
WS Max WS - Case02Plan
WS Max WS - Case01Plan
Ground
Ineff
Bank Sta



AddisonLotNorton Plan: 1) Plan05 2/25/2025 2) Plan06 2/25/2025 3) Plan07 2/25/2025 4) Case08Plan 2/25/2025 5) Case09Plan 2/25/2025 6) Case10Plan 2/25/2025
Proposed Culvert and Roadway
.05
Legend
WS Max WS - Case10Plan
WS Max WS - Plan07
WS Max WS - Case08Plan
WS Max WS - Case09Plan
WS Max WS - Plan06
WS Max WS - Plan05
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
50
40
30
20
10
0
-10
0
200
400
600
800
1000
1200



AddisonLotNorton Plan: 1) Case11Plan 10/17/2024 2) Case12Plan 10/17/2024 3) Case13Plan 10/17/2024 4) Case14Plan 10/17/2024 5) Case15Plan 10/17/2024 6) Case16Plan 10/17/2024
Proposed Culvert and Roadway
.05
Elevation (ft)
Station (ft)
Legend
WS Max WS - Case16Plan
WS Max WS - Case13Plan
WS Max WS - Case15Plan
WS Max WS - Case14Plan
WS Max WS - Case12Plan
WS Max WS - Case11Plan
Ground
Ineff
Bank Sta

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Cl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Knowles	3009	Max WS	Case01Pla	80	4.62	7.23		7.26	0.000428	1.23	67.15	36.91	0.15
Knowles	3009	Max WS	Case02Pla	490	4.62	8.11		8.51	0.004631	5.14	102.26	43.2	0.53
Knowles	3009	Max WS	Case03Pla	80	4.62	8.35		8.36	0.000094	0.77	112.65	45.02	0.08
Knowles	3009	Max WS	Case04Pla	80	4.62	11.53		11.53	0.000007	0.33	302.62	71.17	0.02
Knowles	3009	Max WS	Plan05	80	4.62	7.47		7.49	0.000295	1.1	75.92	38.51	0.13
Knowles	3009	Max WS	Plan06	490	4.62	7.91		8.38	0.00594	5.55	93.79	41.54	0.59
Knowles	3009	Max WS	Plan07	80	4.62	11.4		11.4	0.000007	0.34	293.9	70.6	0.02
Knowles	3009	Max WS	Case08Pla	80	4.62	11.25		11.25	0.000008	0.35	283.12	69.9	0.02
Knowles	3009	Max WS	Case09Pla	490	4.62	11.47		11.52	0.000263	2.04	298.3	70.89	0.14
Knowles	3009	Max WS	Case10Pla	80	4.62	15.42		15.42	0.000001	0.18	683.23	167.56	0.01
Knowles	3009	Max WS	Case11Pla	80	4.62	7.47		7.49	0.000293	1.09	76.15	38.55	0.13
Knowles	3009	Max WS	Case12Pla	490	4.62	7.9		8.37	0.006068	5.58	93.1	41.42	0.6
Knowles	3009	Max WS	Case13Pla	80	4.62	11.51		11.52	0.000007	0.33	301.81	71.12	0.02
Knowles	3009	Max WS	Case14Pla	80	4.62	11.35		11.35	0.000008	0.34	290.09	70.35	0.02
Knowles	3009	Max WS	Case15Pla	490	4.62	11.38		11.43	0.000279	2.08	291.95	70.47	0.15
Knowles	3009	Max WS	Case16Pla	80	4.62	15.42		15.42	0.000001	0.18	682.16	167.49	0.01
Knowles	2848	Max WS	Case01Pla	79.97	1.73	7.21		7.21	0.000015	0.38	251.62	90.76	0.03
Knowles	2848	Max WS	Case02Pla	489.99	1.73	7.92		7.97	0.000305	1.91	320.02	99.68	0.15
Knowles	2848	Max WS	Case03Pla	79.25	1.73	8.35		8.35	0.000006	0.28	363.52	104.58	0.02
Knowles	2848	Max WS	Case04Pla	78.85	1.73	11.53		11.53	0.000001	0.14	823.94	203.18	0.01
Knowles	2848	Max WS	Plan05	79.96	1.73	7.45		7.45	0.000012	0.36	274.23	95.82	0.03
Knowles	2848	Max WS	Plan06	489.98	1.73	7.65		7.71	0.000382	2.06	293.3	97.51	0.17
Knowles	2848	Max WS	Plan07	79.76	1.73	11.4		11.4	0.000001	0.15	799.22	198.99	0.01
Knowles	2848	Max WS	Case08Pla	79.95	1.73	11.25		11.25	0.000001	0.15	769.24	192.26	0.01
Knowles	2848	Max WS	Case09Pla	489.95	1.73	11.47		11.48	0.000033	0.89	812.14	201.03	0.05
Knowles	2848	Max WS	Case10Pla	79.92	1.73	15.42		15.42	0	0.07	1736.31	253.87	0
Knowles	2848	Max WS	Case11Pla	79.39	1.73	7.46		7.46	0.000012	0.35	274.82	95.88	0.03
Knowles	2848	Max WS	Case12Pla	489.89	1.73	7.62		7.68	0.00039	2.08	290.99	97.32	0.17
Knowles	2848	Max WS	Case13Pla	78.85	1.73	11.51		11.51	0.000001	0.14	821.61	202.88	0.01
Knowles	2848	Max WS	Case14Pla	79.9	1.73	11.35		11.35	0.000001	0.15	788.5	196.9	0.01
Knowles	2848	Max WS	Case15Pla	489.19	1.73	11.38		11.39	0.000034	0.9	794.16	198.06	0.05
Knowles	2848	Max WS	Case16Pla	79.34	1.73	15.42		15.42	0	0.07	1734.7	253.82	0
Knowles	2599	Max WS	Case01Pla	79.83	0.59	7.21		7.21	0.000003	0.22	525.97	196.59	0.02
Knowles	2599	Max WS	Case02Pla	489.98	0.59	7.89		7.9	0.00007	1.13	686.11	257.77	0.08
Knowles	2599	Max WS	Case03Pla	75.74	0.59	8.34		8.34	0.000001	0.15	809.76	277.13	0.01
Knowles	2599	Max WS	Case04Pla	74.85	0.59	11.53		11.53	0	0.07	1820.77	330.59	0
Knowles	2599	Max WS	Plan05	79.91	0.59	7.45		7.45	0.000003	0.21	577.88	237.47	0.01
Knowles	2599	Max WS	Plan06	489.32	0.59	7.61		7.62	0.000087	1.22	615.7	245.45	0.08
Knowles	2599	Max WS	Plan07	78.89	0.59	11.4		11.4	0	0.08	1780.31	329.91	0
Knowles	2599	Max WS	Case08Pla	79.74	0.59	11.25		11.25	0	0.08	1729.72	329.21	0
Knowles	2599	Max WS	Case09Pla	489.83	0.59	11.47		11.47	0.000007	0.46	1800.98	330.26	0.03
Knowles	2599	Max WS	Case10Pla	79.63	0.59	15.42		15.42	0	0.04	3158.04	356.42	0
Knowles	2599	Max WS	Case11Pla	76.64	0.59	7.46		7.46	0.000002	0.2	579.36	237.8	0.01
Knowles	2599	Max WS	Case12Pla	489.72	0.59	7.58		7.6	0.000089	1.23	609.61	244.43	0.08
Knowles	2599	Max WS	Case13Pla	74.83	0.59	11.51		11.51	0	0.07	1817.05	330.53	0
Knowles	2599	Max WS	Case14Pla	79.58	0.59	11.35		11.35	0	0.08	1762.35	329.66	0
Knowles	2599	Max WS	Case15Pla	486.41	0.59	11.37		11.38	0.000007	0.47	1771.09	329.78	0.03
Knowles	2599	Max WS	Case16Pla	77.58	0.59	15.42		15.42	0	0.04	3155.82	356.38	0
Knowles	2416	Max WS	Case01Pla	79.73	0.51	7.21		7.21	0.000003	0.22	466.92	132.28	0.02
Knowles	2416	Max WS	Case02Pla	489.55	0.51	7.87		7.88	0.000077	1.16	556.18	139.15	0.08
Knowles	2416	Max WS	Case03Pla	73.7	0.51	8.34		8.34	0.000001	0.16	623.83	144.55	0.01
Knowles	2416	Max WS	Case04Pla	72.39	0.51	11.52		11.52	0	0.09	1284	266.57	0
Knowles	2416	Max WS	Plan05	75.67	0.51	7.45		7.45	0.000002	0.2	498.92	134.53	0.01
Knowles	2416	Max WS	Plan06	489.03	0.51	7.58		7.6	0.000093	1.24	517.29	135.94	0.09
Knowles	2416	Max WS	Plan07	78.35	0.51	11.4		11.4	0	0.1	1251.56	264.94	0.01
Knowles	2416	Max WS	Case08Pla	79.61	0.51	11.25		11.25	0	0.1	1211.04	262.94	0.01
Knowles	2416	Max WS	Case09Pla	489.79	0.51	11.46		11.47	0.000012	0.61	1267.31	265.81	0.03
Knowles	2416	Max WS	Case10Pla	79.39	0.51	15.42		15.42	0	0.05	2407.04	312.34	0
Knowles	2416	Max WS	Case11Pla	74.96	0.51	7.45		7.46	0.000002	0.2	499.74	134.59	0.01
Knowles	2416	Max WS	Case12Pla	486.5	0.51	7.56		7.58	0.000093	1.24	513.88	135.68	0.09
Knowles	2416	Max WS	Case13Pla	72.33	0.51	11.51		11.51	0	0.09	1281.06	266.43	0
Knowles	2416	Max WS	Case14Pla	79.4	0.51	11.35		11.35	0	0.1	1237.08	264.23	0.01
Knowles	2416	Max WS	Case15Pla	484.73	0.51	11.37		11.38	0.000012	0.62	1243.18	264.52	0.03
Knowles	2416	Max WS	Case16Pla	76.44	0.51	15.42		15.42	0	0.05	2405.13	312.28	0

Knowles	2367	Max WS	Case01Pla	79.71	0.52	7.21		7.21	0.000005	0.27	415.08	132.67	0.02
Knowles	2367	Max WS	Case02Pla	489.53	0.52	7.86		7.88	0.000117	1.41	520.02	201.68	0.1
Knowles	2367	Max WS	Case03Pla	73.31	0.52	8.34		8.34	0.000002	0.19	627.69	237.03	0.01
Knowles	2367	Max WS	Case04Pla	71.84	0.52	11.52		11.52	0	0.08	1468.49	287.86	0
Knowles	2367	Max WS	Plan05	75.4	0.52	7.45		7.45	0.000004	0.24	447.65	143.05	0.02
Knowles	2367	Max WS	Plan06	489.42	0.52	7.57		7.6	0.000143	1.52	466.38	160.86	0.11
Knowles	2367	Max WS	Plan07	78.22	0.52	11.4		11.4	0	0.09	1433.58	285.1	0.01
Knowles	2367	Max WS	Case08Pla	79.58	0.52	11.25		11.25	0	0.1	1390.13	281.82	0.01
Knowles	2367	Max WS	Case09Pla	489.78	0.52	11.46		11.47	0.000011	0.57	1450.64	286.45	0.03
Knowles	2367	Max WS	Case10Pla	79.32	0.52	15.42		15.42	0	0.05	2711.36	344.06	0
Knowles	2367	Max WS	Case11Pla	74.65	0.52	7.45		7.45	0.000004	0.24	448.52	143.58	0.02
Knowles	2367	Max WS	Case12Pla	486.33	0.52	7.55		7.58	0.000144	1.52	462.44	151.88	0.11
Knowles	2367	Max WS	Case13Pla	71.78	0.52	11.51		11.51	0	0.08	1465.34	287.61	0
Knowles	2367	Max WS	Case14Pla	79.36	0.52	11.35		11.35	0	0.09	1417.98	283.4	0.01
Knowles	2367	Max WS	Case15Pla	484.36	0.52	11.37		11.37	0.000011	0.57	1424.64	284.35	0.03
Knowles	2367	Max WS	Case16Pla	76.16	0.52	15.42		15.42	0	0.05	2709.27	343.99	0
Knowles	1931	Max WS	Case01Pla	78.92	-2.39	7.21		7.21	0.000001	0.14	922.75	390.8	0.01
Knowles	1931	Max WS	Case02Pla	489.08	-2.39	7.82		7.82	0.000018	0.71	1164.47	400.42	0.04
Knowles	1931	Max WS	Case03Pla	65.17	-2.39	8.34		8.34	0	0.08	1374.59	406.37	0
Knowles	1931	Max WS	Case04Pla	57.78	-2.39	11.52		11.52	0	0.04	2753.63	468.98	0
Knowles	1931	Max WS	Plan05	68.24	-2.39	7.44		7.44	0	0.11	1016.16	396	0.01
Knowles	1931	Max WS	Plan06	488.27	-2.39	7.52		7.53	0.000023	0.77	1047.9	396.98	0.04
Knowles	1931	Max WS	Plan07	79.4	-2.39	11.4		11.4	0	0.05	2698.24	467.37	0
Knowles	1931	Max WS	Case08Pla	78.36	-2.39	11.25		11.25	0	0.05	2626.67	463.04	0
Knowles	1931	Max WS	Case09Pla	488.41	-2.39	11.46		11.46	0.000002	0.32	2724.47	468.23	0.02
Knowles	1931	Max WS	Case10Pla	75.58	-2.39	15.42		15.42	0	0.03	4705.73	545.57	0
Knowles	1931	Max WS	Case11Pla	66.78	-2.39	7.45		7.45	0	0.11	1018.16	396.07	0.01
Knowles	1931	Max WS	Case12Pla	474.29	-2.39	7.5		7.5	0.000022	0.75	1036.91	396.64	0.04
Knowles	1931	Max WS	Case13Pla	56.9	-2.39	11.51		11.51	0	0.04	2749.15	468.86	0
Knowles	1931	Max WS	Case14Pla	55.32	-2.39	11.34		11.34	0	0.04	2671.58	466.14	0
Knowles	1931	Max WS	Case15Pla	474.96	-2.39	11.36		11.36	0.000002	0.31	2680.55	466.55	0.02
Knowles	1931	Max WS	Case16Pla	66.65	-2.39	15.41		15.41	0	0.02	4702.89	545.49	0
Knowles	1603	Max WS	Case01Pla	78.36	-3.14	7.21		7.21	0.000001	0.13	868.46	350.56	0.01
Knowles	1603	Max WS	Case02Pla	488.89	-3.14	7.81		7.81	0.000021	0.71	1098.45	414.27	0.04
Knowles	1603	Max WS	Case03Pla	62.75	-3.14	8.33		8.33	0	0.08	1322.91	439.04	0
Knowles	1603	Max WS	Case04Pla	49.87	-3.14	11.52		11.52	0	0.03	2812.81	494.24	0
Knowles	1603	Max WS	Plan05	64.8	-3.14	7.44		7.44	0	0.1	952.39	371.79	0.01
Knowles	1603	Max WS	Plan06	486.99	-3.14	7.51		7.52	0.000025	0.76	980.35	386.51	0.05
Knowles	1603	Max WS	Plan07	82.81	-3.14	11.4		11.4	0	0.05	2755.8	492.59	0
Knowles	1603	Max WS	Case08Pla	77.39	-3.14	11.25		11.25	0	0.05	2680.07	488.16	0
Knowles	1603	Max WS	Case09Pla	487.15	-3.14	11.46		11.46	0.000002	0.3	2783.03	493.38	0.02
Knowles	1603	Max WS	Case10Pla	72.22	-3.14	15.42		15.42	0	0.02	4833.5	542.57	0
Knowles	1603	Max WS	Case11Pla	63.31	-3.14	7.44		7.44	0	0.1	953.96	372.46	0.01
Knowles	1603	Max WS	Case12Pla	471.04	-3.14	7.48		7.49	0.000024	0.74	969.04	381.55	0.05
Knowles	1603	Max WS	Case13Pla	48.12	-3.14	11.51		11.51	0	0.03	2808.56	494.12	0
Knowles	1603	Max WS	Case14Pla	46.12	-3.14	11.34		11.34	0	0.03	2726.82	491.75	0
Knowles	1603	Max WS	Case15Pla	469.96	-3.14	11.36		11.36	0.000002	0.3	2735.8	492.01	0.01
Knowles	1603	Max WS	Case16Pla	59.97	-3.14	15.41		15.41	0	0.02	4830.99	542.52	0
Knowles	1296	Max WS	Case01Pla	77.6	-3.43	7.2		7.2	0.000001	0.11	864.28	360.29	0.01
Knowles	1296	Max WS	Case02Pla	488.67	-3.43	7.8		7.81	0.000017	0.65	1023.73	387.46	0.04
Knowles	1296	Max WS	Case03Pla	27.5	-3.43	8.33		8.33	0	0.03	1168.38	395.71	0
Knowles	1296	Max WS	Case04Pla	42.41	-3.43	11.51		11.51	0	0.03	2071.14	476.11	0
Knowles	1296	Max WS	Plan05	63.33	-3.43	7.44		7.44	0	0.09	925.13	377.15	0.01
Knowles	1296	Max WS	Plan06	486.5	-3.43	7.51		7.51	0.00002	0.69	943.99	379.95	0.04
Knowles	1296	Max WS	Plan07	82.13	-3.43	11.4		11.4	0	0.06	2037.84	470.91	0
Knowles	1296	Max WS	Case08Pla	87.69	-3.43	11.25		11.25	0	0.06	1991.72	466.38	0
Knowles	1296	Max WS	Case09Pla	486.44	-3.43	11.46		11.46	0.000003	0.34	2053.88	472.57	0.02
Knowles	1296	Max WS	Case10Pla	66.96	-3.43	15.41		15.41	0	0.03	3355.41	585.39	0
Knowles	1296	Max WS	Case11Pla	28.87	-3.43	7.44		7.44	0	0.04	926.04	377.28	0
Knowles	1296	Max WS	Case12Pla	449.56	-3.43	7.47		7.48	0.000017	0.64	935.46	378.68	0.04
Knowles	1296	Max WS	Case13Pla	39.13	-3.43	11.51		11.51	0	0.03	2068.98	475.72	0
Knowles	1296	Max WS	Case14Pla	36.67	-3.43	11.34		11.34	0	0.03	2019.38	469.04	0
Knowles	1296	Max WS	Case15Pla	466.1	-3.43	11.36		11.36	0.000003	0.34	2024.32	469.51	0.02
Knowles	1296	Max WS	Case16Pla	50.94	-3.43	15.41		15.41	0	0.02	3354.1	585.33	0
Knowles	821	Max WS	Case01Pla	76.86	-4.06	7.2		7.2	0.000001	0.11	1028.82	691.21	0.01

Knowles	821	Max WS	Case02Pla	488.49	-4.06	7.79		7.8	0.000014	0.61	1246.11	774.8	0.04
Knowles	821	Max WS	Case03Pla	24.98	-4.06	8.32		8.32	0	0.03	1497.36	805.64	0
Knowles	821	Max WS	Case04Pla	38.59	-4.06	11.51		11.51	0	0.02	3412.4	1005.48	0
Knowles	821	Max WS	Plan05	33.94	-4.06	7.43		7.43	0	0.05	1112.02	737.43	0
Knowles	821	Max WS	Plan06	485.05	-4.06	7.5		7.5	0.000017	0.65	1137.54	752.16	0.04
Knowles	821	Max WS	Plan07	81.43	-4.06	11.4		11.4	0	0.04	3344.46	1003.22	0
Knowles	821	Max WS	Case08Pla	87.99	-4.06	11.25		11.25	0	0.05	3245.65	999.48	0
Knowles	821	Max WS	Case09Pla	485.94	-4.06	11.45		11.46	0.000002	0.26	3378.55	1004.4	0.01
Knowles	821	Max WS	Case10Pla	61.46	-4.06	15.41		15.41	0	0.02	5981.46	1076.18	0
Knowles	821	Max WS	Case11Pla	26.33	-4.06	7.43		7.43	0	0.04	1112.78	738.56	0
Knowles	821	Max WS	Case12Pla	425.66	-4.06	7.46		7.47	0.000014	0.58	1124.63	750.4	0.03
Knowles	821	Max WS	Case13Pla	33	-4.06	11.5		11.5	0	0.02	3408.76	1005.36	0
Knowles	821	Max WS	Case14Pla	30.07	-4.06	11.34		11.34	0	0.02	3302.93	1001.75	0
Knowles	821	Max WS	Case15Pla	411.27	-4.06	11.35		11.35	0.000001	0.23	3313.23	1002.11	0.01
Knowles	821	Max WS	Case16Pla	42.36	-4.06	15.41		15.41	0	0.01	5979.36	1076.14	0
Knowles	697	Max WS	Case01Pla	75.82	-4.31	7.2		7.2	0	0.05	1927.8	1035.71	0
Knowles	697	Max WS	Case02Pla	491.24	-4.31	7.79		7.79	0.000003	0.27	2172.24	1070.44	0.02
Knowles	697	Max WS	Case03Pla	23.17	-4.31	8.32		8.32	0	0.01	2463.85	1105.05	0
Knowles	697	Max WS	Case04Pla	35.71	-4.31	11.51		11.51	0	0.01	4640	1300.75	0
Knowles	697	Max WS	Plan05	32.36	-4.31	7.43		7.43	0	0.02	2020.97	1045.35	0
Knowles	697	Max WS	Plan06	483.98	-4.31	7.5		7.5	0.000003	0.28	2050.59	1052.61	0.02
Knowles	697	Max WS	Plan07	80.04	-4.31	11.4		11.4	0	0.03	4563.97	1294.61	0
Knowles	697	Max WS	Case08Pla	86.63	-4.31	11.25		11.25	0	0.03	4451.21	1285.61	0
Knowles	697	Max WS	Case09Pla	485.26	-4.31	11.45		11.46	0.000001	0.15	4602.82	1297.74	0.01
Knowles	697	Max WS	Case10Pla	52.91	-4.31	15.41		15.41	0	0.01	7596.74	1389.3	0
Knowles	697	Max WS	Case11Pla	-13.7	-4.31	7.43		7.43	0	-0.01	2021.81	1045.58	0
Knowles	697	Max WS	Case12Pla	421.03	-4.31	7.46		7.46	0.000002	0.24	2035.58	1049.25	0.01
Knowles	697	Max WS	Case13Pla	25.73	-4.31	11.5		11.5	0	0.01	4636.31	1300.45	0
Knowles	697	Max WS	Case14Pla	22.03	-4.31	11.34		11.34	0	0.01	4515.55	1290.92	0
Knowles	697	Max WS	Case15Pla	393.36	-4.31	11.35		11.35	0	0.13	4527.44	1291.83	0.01
Knowles	697	Max WS	Case16Pla	29.29	-4.31	15.41		15.41	0	0.01	7594.58	1389.25	0
Knowles	643	Max WS	Case01Pla	62	-4.5	7.2		7.2	0	0.08	1017.1	739.77	0
Knowles	643	Max WS	Case02Pla	479.07	-4.5	7.79		7.79	0.000011	0.56	1201.46	773.77	0.03
Knowles	643	Max WS	Case03Pla	19.43	-4.5	8.32		8.32	0	0.02	1447.38	797.69	0
Knowles	643	Max WS	Case04Pla	-106.93	-4.5	11.5		11.5	0	-0.06	3369.09	946.44	0
Knowles	643	Max WS	Plan05	-20.7	-4.5	7.43		7.43	0	-0.03	1087.54	750.58	0
Knowles	643	Max WS	Plan06	471.41	-4.5	7.5		7.5	0.000013	0.58	1109.18	754.08	0.03
Knowles	643	Max WS	Plan07	75.67	-4.5	11.4		11.4	0	0.04	3305.93	942.77	0
Knowles	643	Max WS	Case08Pla	82.22	-4.5	11.25		11.25	0	0.05	3208.09	937.6	0
Knowles	643	Max WS	Case09Pla	483.55	-4.5	11.45		11.45	0.000002	0.26	3339.2	944.6	0.01
Knowles	643	Max WS	Case10Pla	37.26	-4.5	15.4		15.4	0	0.01	6022.94	1182.68	0
Knowles	643	Max WS	Case11Pla	-28.61	-4.5	7.43		7.43	0	-0.04	1088.19	750.68	0
Knowles	643	Max WS	Case12Pla	366.88	-4.5	7.46		7.46	0.000008	0.46	1097.87	752.06	0.03
Knowles	643	Max WS	Case13Pla	-93.68	-4.5	11.5		11.5	0	-0.05	3366.2	946.26	0
Knowles	643	Max WS	Case14Pla	-94.64	-4.5	11.33		11.33	0	-0.05	3261.35	940.42	0
Knowles	643	Max WS	Case15Pla	363.03	-4.5	11.35		11.35	0.000001	0.2	3271.62	940.96	0.01
Knowles	643	Max WS	Case16Pla	0.17	-4.5	15.4		15.4	0	0	6021.68	1182.61	0
Knowles	575	Max WS	Case01Pla	48.67	-4.41	7.2		7.2	0	0.07	820.6	702.31	0
Knowles	575	Max WS	Case02Pla	477.42	-4.41	7.78		7.79	0.000021	0.63	929.37	734.85	0.03
Knowles	575	Max WS	Case03Pla	156.9	-4.41	8.31		8.31	0.000002	0.2	1138.94	746.43	0.01
Knowles	575	Max WS	Case04Pla	-244.26	-4.41	11.5		11.5	0.000001	-0.14	2939.32	805.2	0.01
Knowles	575	Max WS	Plan05	-24.51	-4.41	7.42		7.42	0	-0.03	862.14	715.22	0
Knowles	575	Max WS	Plan06	467.03	-4.41	7.49		7.5	0.000023	0.65	874.59	717.52	0.04
Knowles	575	Max WS	Plan07	73.66	-4.41	11.4		11.4	0	0.04	2882.36	804.61	0
Knowles	575	Max WS	Case08Pla	80.26	-4.41	11.25		11.25	0	0.05	2790.26	803.7	0
Knowles	575	Max WS	Case09Pla	482.95	-4.41	11.45		11.45	0.000003	0.28	2913.16	804.93	0.01
Knowles	575	Max WS	Case10Pla	-163.11	-4.41	15.4		15.4	0	-0.05	5351.48	958.45	0
Knowles	575	Max WS	Case11Pla	-85.67	-4.41	7.43		7.43	0.000001	-0.12	862.6	715.31	0.01
Knowles	575	Max WS	Case12Pla	315.55	-4.41	7.46	-2.31	7.46	0.000011	0.44	868.11	716.33	0.02
Knowles	575	Max WS	Case13Pla	-201.75	-4.41	11.49		11.49	0	-0.11	2936.87	805.18	0.01
Knowles	575	Max WS	Case14Pla	-103.54	-4.41	11.33		11.33	0	-0.06	2838.43	804.18	0
Knowles	575	Max WS	Case15Pla	231.69	-4.41	11.34	-2.63	11.35	0.000001	0.14	2849.11	804.29	0.01
Knowles	575	Max WS	Case16Pla	-176.23	-4.41	15.4		15.4	0	-0.05	5350.42	958.44	0
Knowles	532			Culvert									
Knowles	489	Max WS	Case01Pla	-235.53	-4.6	7.43		7.44	0.000009	-0.35	789.17	629.67	0.02

Knowles	489	Max WS	Case02Pla	78.56	-4.6	7.44		7.44	0.000001	0.12	789.45	629.71	0.01
Knowles	489	Max WS	Case03Pla	-531.87	-4.6	8.47		8.48	0.000026	-0.66	1143.48	648.18	0.04
Knowles	489	Max WS	Case04Pla	-244.26	-4.6	11.5		11.5	0.000001	-0.13	2822.74	745.21	0.01
Knowles	489	Max WS	Plan05	-111.69	-4.6	7.44		7.44	0.000002	-0.17	789.42	629.71	0.01
Knowles	489	Max WS	Plan06	301.58	-4.6	7.44		7.44	0.000014	0.45	789.44	629.71	0.03
Knowles	489	Max WS	Plan07	-357.72	-4.6	11.5		11.5	0.000002	-0.19	2822.19	745.18	0.01
Knowles	489	Max WS	Case08Pla	-301.13	-4.6	11.33		11.34	0.000001	-0.17	2730.02	739.23	0.01
Knowles	489	Max WS	Case09Pla	50.28	-4.6	11.34		11.34	0	0.03	2730.17	739.24	0
Knowles	489	Max WS	Case10Pla	-163.11	-4.6	15.4		15.4	0	-0.05	5071.31	834.08	0
Knowles	489	Max WS	Case11Pla	-121.23	-4.6	7.43		7.44	0.000002	-0.18	789.31	629.69	0.01
Knowles	489	Max WS	Case12Pla	315.55	-4.6	7.44		7.44	0.000016	0.47	789.45	629.71	0.03
Knowles	489	Max WS	Case13Pla	-201.75	-4.6	11.5		11.5	0.000001	-0.11	2822.55	745.2	0.01
Knowles	489	Max WS	Case14Pla	-197.84	-4.6	11.34		11.34	0.000001	-0.11	2730.32	739.26	0.01
Knowles	489	Max WS	Case15Pla	231.69	-4.6	11.34		11.34	0.000001	0.13	2730.39	739.27	0.01
Knowles	489	Max WS	Case16Pla	-176.23	-4.6	15.4		15.4	0	-0.05	5071.16	834.07	0
Knowles	341	Max WS	Case01Pla	-237.53	-4.87	7.43		7.44	0.000003	-0.28	1283.24	774.16	0.02
Knowles	341	Max WS	Case02Pla	76.58	-4.87	7.44		7.44	0	0.09	1283.39	774.17	0.01
Knowles	341	Max WS	Case03Pla	-533.93	-4.87	8.47		8.48	0.000009	-0.5	1894.81	788.14	0.03
Knowles	341	Max WS	Case04Pla	-246.6	-4.87	11.5		11.5	0	-0.1	4236.39	848.43	0.01
Knowles	341	Max WS	Plan05	-113.65	-4.87	7.44		7.44	0.000001	-0.13	1283.38	774.17	0.01
Knowles	341	Max WS	Plan06	299.61	-4.87	7.44		7.44	0.000005	0.35	1283.38	774.17	0.02
Knowles	341	Max WS	Plan07	-359.91	-4.87	11.5		11.5	0.000001	-0.15	4236.17	848.43	0.01
Knowles	341	Max WS	Case08Pla	-303.32	-4.87	11.34		11.34	0	-0.13	4108.25	846.05	0.01
Knowles	341	Max WS	Case09Pla	48.09	-4.87	11.34		11.34	0	0.02	4108.3	846.05	0
Knowles	341	Max WS	Case10Pla	-165.5	-4.87	15.4		15.4	0	-0.04	7274.22	920.11	0
Knowles	341	Max WS	Case11Pla	-123.23	-4.87	7.43		7.44	0.000001	-0.14	1283.31	774.16	0.01
Knowles	341	Max WS	Case12Pla	313.65	-4.87	7.44		7.44	0.000006	0.37	1283.38	774.17	0.02
Knowles	341	Max WS	Case13Pla	-204.02	-4.87	11.5		11.5	0	-0.09	4236.31	848.43	0
Knowles	341	Max WS	Case14Pla	-200.11	-4.87	11.34		11.34	0	-0.09	4108.37	846.05	0
Knowles	341	Max WS	Case15Pla	229.47	-4.87	11.34		11.34	0	0.1	4108.39	846.05	0.01
Knowles	341	Max WS	Case16Pla	-178.61	-4.87	15.4		15.4	0	-0.04	7274.16	920.11	0
Knowles	266	Max WS	Case01Pla	-239.24	-4.93	7.44	-2.47	7.44	0.000003	-0.26	1536.73	947.13	0.02
Knowles	266	Max WS	Case02Pla	74.88	-4.93	7.44	-3.5	7.44	0	0.08	1536.73	947.13	0
Knowles	266	Max WS	Case03Pla	-535.7	-4.93	8.48	-1.43	8.48	0.000007	-0.46	2278.54	975.32	0.03
Knowles	266	Max WS	Case04Pla	-248.47	-4.93	11.5	-2.43	11.5	0	-0.09	5033.99	992.77	0
Knowles	266	Max WS	Plan05	-115.35	-4.93	7.44	-3.17	7.44	0.000001	-0.13	1536.73	947.13	0.01
Knowles	266	Max WS	Plan06	297.91	-4.93	7.44	-2.22	7.44	0.000004	0.32	1536.73	947.13	0.02
Knowles	266	Max WS	Plan07	-361.75	-4.93	11.5	-1.98	11.5	0	-0.14	5033.99	992.77	0.01
Knowles	266	Max WS	Case08Pla	-305.16	-4.93	11.34	-2.19	11.34	0	-0.12	4883.24	991.54	0.01
Knowles	266	Max WS	Case09Pla	46.25	-4.93	11.34	-3.81	11.34	0	0.02	4883.24	991.54	0
Knowles	266	Max WS	Case10Pla	-167.45	-4.93	15.4	-2.84	15.4	0	-0.03	8607.48	1046.02	0
Knowles	266	Max WS	Case11Pla	-124.94	-4.93	7.44	-3.11	7.44	0.000001	-0.14	1536.73	947.13	0.01
Knowles	266	Max WS	Case12Pla	311.96	-4.93	7.44	-2.16	7.44	0.000005	0.34	1536.73	947.13	0.02
Knowles	266	Max WS	Case13Pla	-205.88	-4.93	11.5	-2.63	11.5	0	-0.08	5033.99	992.77	0
Knowles	266	Max WS	Case14Pla	-201.96	-4.93	11.34	-2.65	11.34	0	-0.08	4883.24	991.54	0
Knowles	266	Max WS	Case15Pla	227.62	-4.93	11.34	-2.52	11.34	0	0.09	4883.24	991.54	0
Knowles	266	Max WS	Case16Pla	-180.56	-4.93	15.4	-2.76	15.4	0	-0.04	8607.48	1046.02	0