Preliminary Assessment of Water Withdrawal Thresholds at Selected Surface-Water Withdrawal Points

Prepared by the
Maine Geological Survey, Department of Conservation
for the
Maine Department of Environmental Protection

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Executive Summary

- This report provides an initial assessment of the impact of imposing seasonal withdrawal thresholds on pumping water from small to medium sized streams and rivers in Maine.
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- A dataset of 90 surface-water extraction/withdrawal points (74 Public Water Supplies; 14 Agricultural) on small to medium sized rivers and streams in Maine, was compiled from data provided by the Department of Agriculture, Drinking Water Program of the Department of Human Services, and data collected in the first year of the State's water use data collection program.

- The watersheds above each withdrawal point were delineated using ESRI's ArcMap software. First, a GIS dataset of 14 digit HUC (Hydrologic Unit Code) drainage basins from the USGS were imported, and then watershed divide lines were added/drawn to split these basin polygons at the withdrawal point. The areas of these new polygons were then calculated and converted to square miles.

- Nine (9) withdrawal points were selected covering a range of drainage basin size from 0.93 sq mi. to 64 sq mi., and geographically distributed so as to allow for the use of both Statewide and regional equations that have been developed by the U.S. Geological Survey (USGS) for estimating August median flow.

- A statewide equation for basin areas above 10 sq mi. has been developed from an analysis of existing continuous long-term stream-gaging records, and regional equations for Aroostook County and Washington County (Downeast Basins) have been developed from specific low-flow studies conducted in these regions.

- Statewide (Dudley, 2003) $Q_{aug} = 0.152 * A^{1.12} * 10^{(1.31*SG)}$

  Regional Aroostook Co. (Lombard et al, 2003) $Q_{aug} = 0.061 * A^{1.28} * 10^{(0.00059*ELEV)}$

  Regional Washington Co. (Lombard, 2004, in review) $Q_{aug} = 0.148 * A^{1.18466} * 10^{(0.00409*SG)}$

  Q_{aug} = estimated August median flow
  A = drainage basin area
  SG = fraction of sand and gravel underlying the basin
  ELEV = mean basin elevation above sea level in feet

?? The graph on page 9 (Comparison of +1-standard error for estimated August median flows versus drainage basin area) compares the above three (3) equations and also plots a combined +1 standard error for the three equations. Also a graph (dotted line) is drawn to show the relationship between flow and drainage basin area if flow were directly proportional to drainage basin area. Divergence between this line and the estimated August median flow is important in understanding the results of the threshold assessment.

The estimated median flow falls off faster as a function of drainage basin area than the dotted line. This means that the seasonal thresholds estimated from the USGS equations fall more rapidly as a function of drainage basin area than the estimated daily flows based on a USGS base hydrograph. This will have the effect of ***increasing*** the predicted number of days when pumping may be allowed in very small basins where the daily flows are estimated from a USGS gage with a larger contributing area using the ratio of the drainage basin areas and ***decreasing*** the predicted number of days when pumping may be allowed in larger basins where the daily flows are estimated from a USGS gage with a smaller contributing area using the ratio of the drainage basin areas.

?? The tables on pages 10 and 11 summarize the estimated August median flow data (first graph) and the seasonal withdrawal threshold data (second graph) for the 9 selected withdrawal points. The seasonal withdrawal thresholds were calculated using time intervals and multipliers supplied by the Department of Environmental Protection (DEP).

?? Actual flow data at the 9 withdrawal points is not available, so a synthetic hydrograph was generated for each point for the 2001, 2002, and 2003 water years by scaling the flow at the most appropriate USGS gaging station by the ratio of the withdrawal point drainage basin area to the USGS gage contributing drainage basin area.

$$Q_{\text{withdrawal point}} = Q_{\text{USGS gage}} * (A_{\text{withdrawal point}})/(A_{\text{USGS gage}})$$

?? Table on page 12 summarizes these calculations. The most extreme multiplier occurred with Grower 50. Extreme multipliers occur when the gage basin areas are significantly different from the withdrawal points drainage area, and could lead to significant error in assessing the number of days the flow was above or below the seasonal threshold.

?? Synthetic hydrographs were generated for the 9 withdrawal points and the seasonal thresholds were plotted on the hydrographs showing the number of days when the estimated daily flow was above or below the seasonal threshold.

?? Tables and charts summarizing all of this data follow the text. There are 3 graphs for each withdrawal point or USGS gaging station, one each for year 2001, 2002, and 2003. These years represent dry (2001), intermediate (2002), and normal (2003) precipitation.

?? Seasonal thresholds based on both the estimated August median (lower line) and the estimated August median +1 standard error (upper line) are shown superimposed on the daily flow at the USGS gaging stations and the synthetic hydrographs of daily flows calculated for each grower. The shaded periods represent times when the calculated daily flow falls below the seasonal threshold.

?? Dudley (2003) equation not recommended for use in basins less than 10 sq mi in area.

Introduction:

This draft report provides an initial assessment of the impact of imposing seasonal withdrawal thresholds on pumping water from medium and small sized rivers and streams in Maine.

Tasks:

Based on the May 21, 2004, draft task statement prepared by the Department of Environmental Protection (DEP), the Maine Geological Survey (MGS) will:

?? select water users to analyze for the impact of a proposed withdrawal threshold on the ability to utilize the surface water resource

?? delineate and determine the size of the watershed above the water user's withdrawal point

?? estimate a relevant measure of summer low flow for use as a summer seasonal withdrawal threshold. Calculate other seasonal withdrawal thresholds based on the summer seasonal withdrawal threshold.

?? summarize the results of the assessment

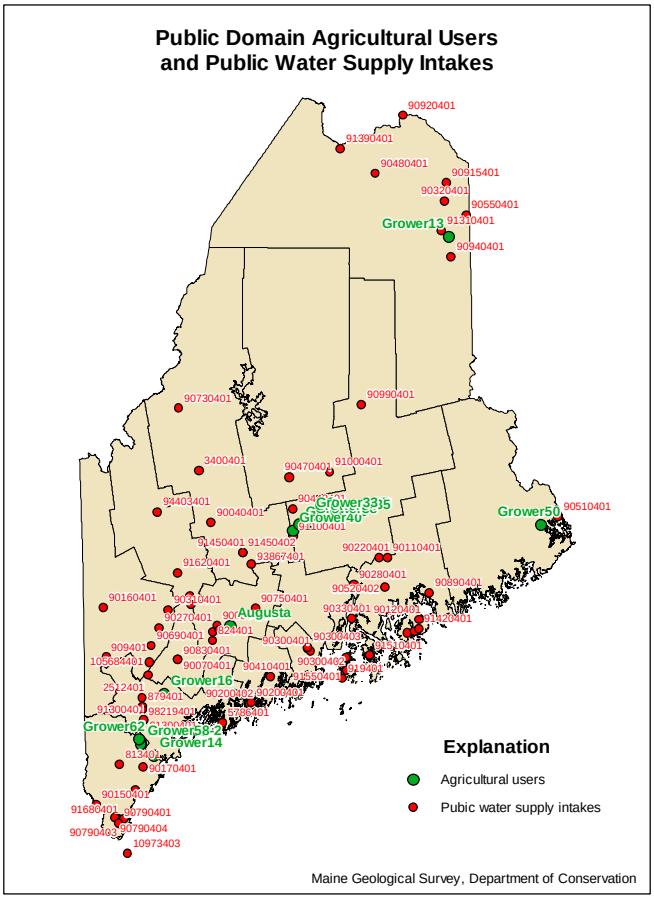
Methodology:

A set of water user withdrawal points on medium and small sized rivers and streams was developed from the public domain agricultural water use data provided by the Department of Agriculture, public water supply intakes provided by the Drinking Water Program in the Department of Human Services, and data collected in the first year of the State's water use data collection program.

The top figure on the next page shows the withdrawal points identified. All the withdrawal points came from either the public domain agricultural users (14 points) or the public water supply intakes (76 points) data sets.

For this initial assessment, only 9 withdrawal points, 6 from the public domain agricultural water use data set and 3 from the public water supply intake dataset, were selected for analysis. These 9 users covered a range in drainage basin size from 0.93 sq mi to 64 sq mi, and were geographically distributed throughout the State to allow use of both Statewide and regional equations that have been developed by the U.S. Geological Survey (USGS) for estimating August median flow.

These nine withdrawal points are shown in the bottom figure on the next page.


Public Domain Agricultural Users
and Public Water Supply Intakes
90920401
91390401
90480401
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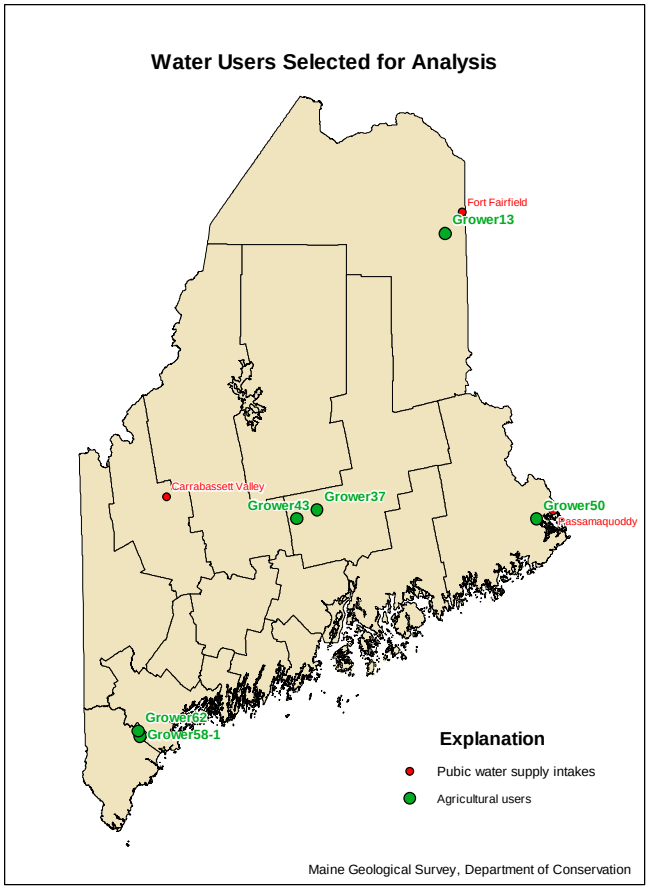
Grower13
91310401
90940401
90730401
90990401
3400401
90470401
91000401
93403401
90040401
Grower33
Grower40
93100401
Grower50
90510401
91450401
91450402
93867401
90220401
90110401
91620401
90280401
90890401
90160401
90310401
90750401
90520402
Augusta
90330401
90120401
91120401
90270401
90690401
90300401
909401
90830401
105584401
90070401
90410401
Grower16
2512401
90200402
90200401
91300401
98219401
Grower62
Grower58-2
Grower14
90170401
90150401
91680401
90790401
90790404
10973403
Explanation
Agricultural users
Pubic water supply intakes
Maine Geological Survey, Department of Conservation


Water Users Selected for Analysis
Fort Fairfield
Grower13
Carrabassett Valley
Grower43
Grower37
Grower50
Passamaquoddy
Grower62
Grower58-1
Explanation
Pubic water supply intakes
Agricultural users
Maine Geological Survey, Department of Conservation

The watersheds above each withdrawal point in the full datasets were delineated in ESRI's ArcGIS software. A GIS dataset of existing drainage divides for drainage basins delineated by the USGS was obtained from Maine Office of GIS (MEGIS). Because the withdrawal points selected for initial analysis were not generally at the confluence of streams (typical points used to define basins in the USGS/MEGIS GIS dataset), additional watershed divide lines were added to split a basin polygon at the withdrawal points. Any additional upstream basin polygons in the USGS/MEGIS above the withdrawal point were then added to basin polygon at the withdrawal point to create a single watershed polygon above the withdrawal point.

The drainage area of this single watershed polygon was calculated in ArcGIS and converted to square miles. The table gives the drainage basin area obtained for the 9 withdrawal points selected for initial analysis:

Water user	Area (sq m)	Area (sq mi)
Grower 13	7343521	2.84
Grower 37	165762725	64.0
Grower 43	28546394	11.0
Grower 50	2402658	0.93
Grower 58-1	4522441	1.75
Grower 62	10705003	4.13
Carrabassett Valley	29607775	11.43
Passamaquoddy	48010310	18.54
Fort Fairfield	73910003	28.54

Based on these drainage basin areas, the August median flow for each withdrawal point was estimated using equations developed by the USGS. At the present time, a statewide equation for basins above 10 sq mi has been developed from an analysis of existing continuous long-term stream gaging records, and regional equations for Aroostook County and Washington County (Downeast Basins) have been developed from specific low-flow studies conducted in these regions.

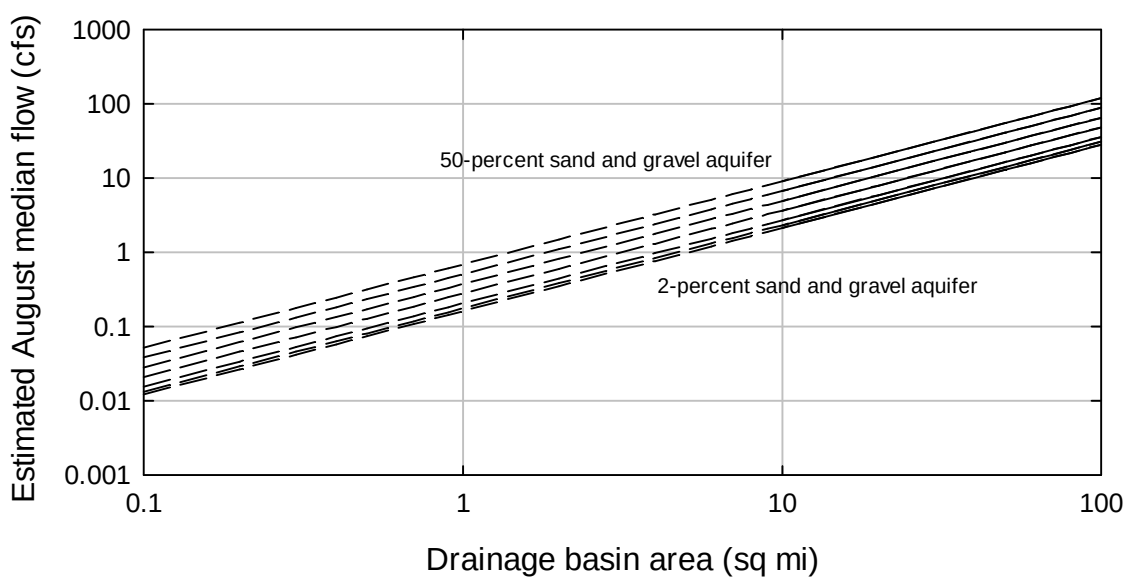
The statewide equation (Dudley, 2003) is

$$Q_{aug} = 0.152 * A^{1.12} * 10^{(1.31*SG)}$$

Where Q_{aug} is the estimated August median flow at the site, A is the drainage basin area in square miles, and SG is the fraction of sand and gravel aquifer underlying the basin. The 1-sigma average standard error of prediction for the estimate is from –28.6 to +40-percent. There is a 68-percent probability that the true August median flow will lie within the range of the standard error of prediction.

The figure below shows the relationship between drainage area, fraction of sand and gravel aquifer underlying the basin, and estimated Augusta median flow for a range of drainage basin area and percent sand and gravel aquifer. The dashed lines below 10 sq mi drainage basin area are below the recommended limit for the application of the equation.

Statewide August median flow as a function of drainage basin area and fraction of sand and gravel aquifer (Dudley, 2003)



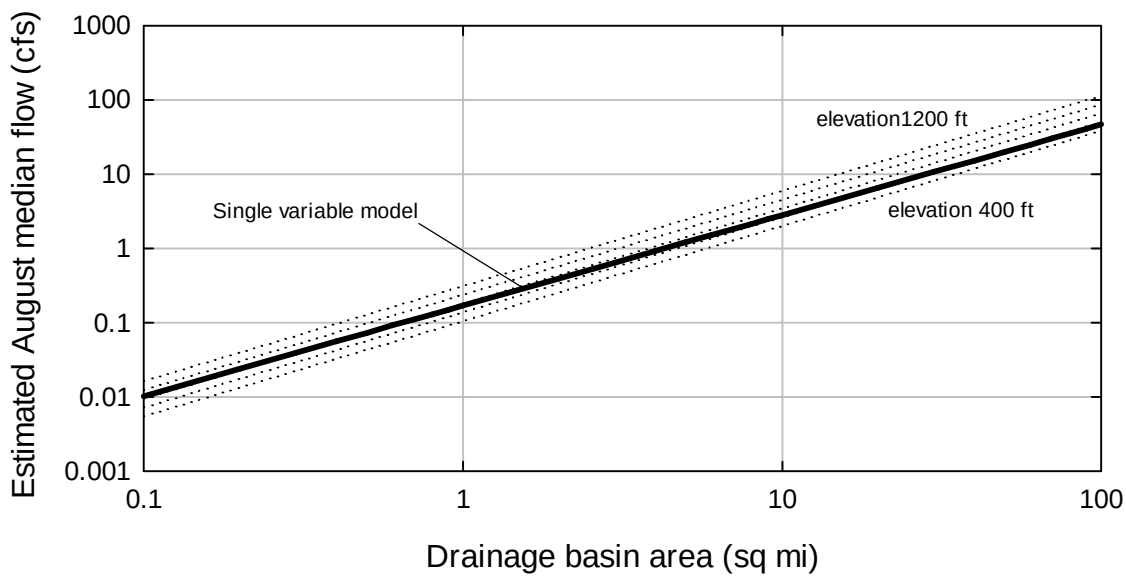
The regional equation for Aroostook County (Lombard and others, 2003) is

$$Q_{aug} = 0.061 * A^{1.28} * 10^{(0.00059*ELEV)}$$

Where Q_{aug} is the estimated August median flow at the site, A is the drainage basin area in square miles, and ELEV is the mean basin elevation above sea level in feet. The 1-sigma average standard error of prediction for the estimate is from –38 to +62-percent. There is a 68-percent probability that the true August median flow will lie within the range of the standard error of prediction.

The figure below shows the relationship between drainage area, mean basin elevation in feet, and estimated Augusta median flow for a range of drainage basin area and mean basin elevation. The heavy line is the single-variable model that includes just the drainage basin area as a variable. The 1-sigma standard error for the single-variable model is from –40 to +67-percent.

Aroostook County single variable model compared to two-variable model (Lombard and others, 2003)



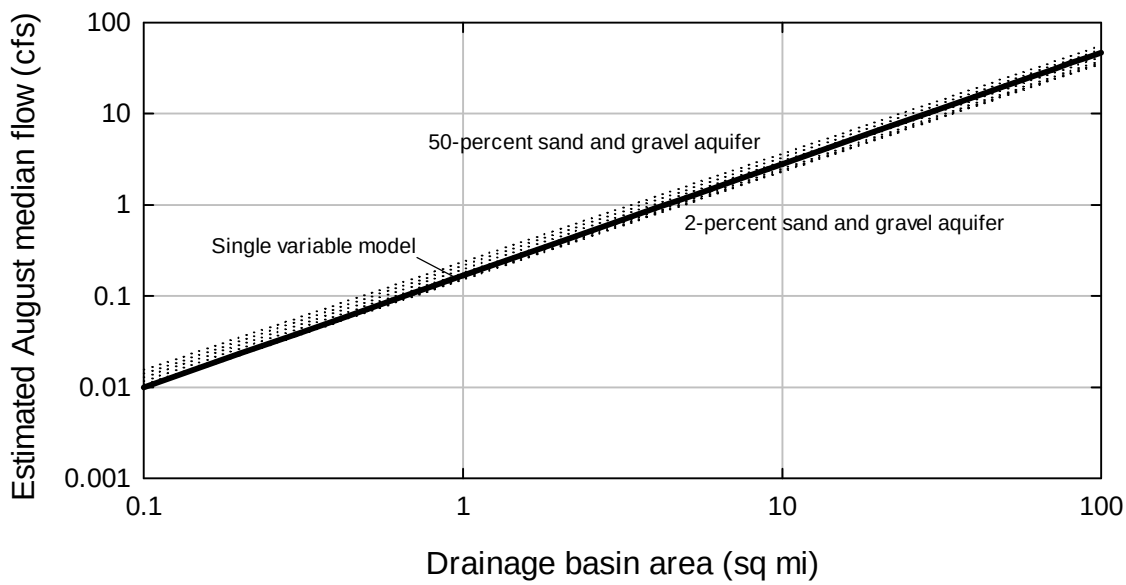
The regional equation for Washington County (Lombard, 2004, in review) is

$$Q_{aug} = 0.148 * A^{1.18466} * 10^{(0.00409*SG)}$$

Where Q_{aug} is the estimated August median flow at the site, A is the drainage basin area in square miles, and SG is the percent of sand and gravel aquifer underlying the basin. The 1-sigma average standard error of prediction for the estimate is from –27 to +38-percent. There is a 68-percent probability that the true August median flow will lie within the range of the standard error of prediction.

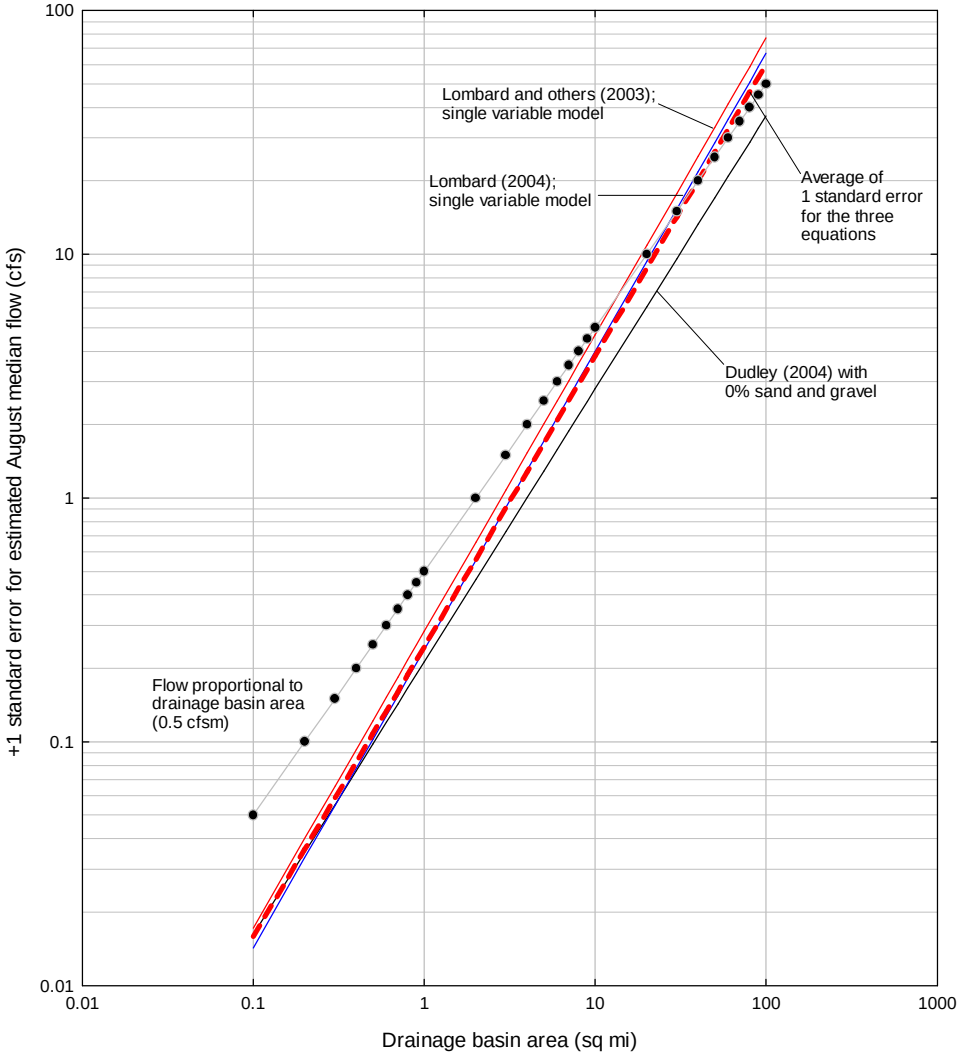
The figure below shows the relationship between drainage area, fraction of sand and gravel aquifer underlying the basin, and estimated Augusta median flow for a range of drainage basin area and percent sand and gravel aquifer. The heavy line is the single-variable model that includes just the drainage basin area as a variable. The 1-sigma standard error for the single-variable model is from –30 to +43-percent.

Downeast Basins single variable model compared to two-variable model (Lombard, 2004, in review)



The figure below compares the +1 standard error of the estimated August median flow for the statewide equation with 0-percent sand and gravel aquifer (Dudley, 2003) and the single-variable (drainage basin area only equations) for Aroostook County (Lombard and others, 2003) and the Downeast Basins (Lombard, 2004, in review). Note that the statewide equation is not recommended for use below 10 sq mi drainage basin area.

Comparison of +1-standard error for estimated August median flows versus drainage basin area



The +1 standard error values tend to converge at smaller values of drainage basin area (again, that the statewide equation is not recommended for use below 10 sq mi drainage basin area). The heavy dashed line is the average of the 3 values of +1 standard error of the estimated August median flow.

The dotted line in the figure is the 0.5 cfsm line, the current US Fish and Wildlife northeast region aquatic base flow standard. Note that for small drainage basins, the estimated August median flow +1 standard error is significantly lower that 0.5 cfsm. For larger drainage basins, the statewide equation of Dudley (2003) still yields values below the 0.5 cfsm value (with 0-percent sand and gravel aquifer in the basin), but the values from the regional equations are close to or slightly above the 0.5 cfsm value.

This dotted line also shows the relationship between flow and drainage basin area if flow were directly proportional to drainage basin area. The divergence between the +1 standard error values for the estimated August median flow (and therefore the estimated August median flow) and this dotted line is important in understanding the results of the threshold assessment and is discussed in more detail below.

The table below lists the estimated August median flows and +1 standard error for the estimated August median flow for the 9 withdrawal points selected for initial analysis.

Water user	**Equation used**	**2nd variable**	**Q_{aug} (cfs)**	**Q_{aug} + 1 standard error (cfs)**
Grower 13	Lombard and others (2003)	ELEV = 650 ft	0.56	0.91
Grower 37	Dudley (2003)	SG = 0 percent	16.0	22.4
Grower 43	Dudley (2003)	SG = 0 percent	2.23	3.12
Grower 50	Lombard (2004), in review	SG = 0 percent	0.14	0.19
Grower 58-1	Dudley (2003)	SG = 0 percent	0.28	0.40
Grower 62	Dudley (2003)	SG = 0 percent	0.74	1.04
Carrabassett Valley	Dudley (2003)	SG = 0 percent	2.33	3.26
Passamaquoddy	Lombard (2004), in review	SG = 0 percent	4.71	6.49
Fort Fairfield	Lombard and others (2003)	ELEV = 650 ft	6.45	9.08

The next table lists the seasonal withdrawal thresholds based on the following multiplier factors supplied by the DEP:

July 1 to September 15	estimated August median flow
September 16 to March 15	multiply estimated August median flow by two
March 16 to May 15	multiply estimated August median flow by four
May 16 to June 30	multiply estimated August median flow by two

		Season			
Water user		**7/1 to 9/15**	**9/16 to 3/15**	**3/16 to 5/15**	**5/15 to 6/30**
Grower 13	Q_{aug} (cfs)	0.56	1.12	2.24	1.12
	Q_{aug} +1 SE (cfs)	0.91	1.82	3.64	1.82
Grower 37	Q_{aug} (cfs)	16.0	32.0	64.0	32.0
	Q_{aug} +1 SE (cfs)	22.4	44.8	89.6	44.8
Grower 43	Q_{aug} (cfs)	2.23	4.46	8.92	4.46
	Q_{aug} +1 SE (cfs)	3.12	6.24	12.48	6.24
Grower 50	Q_{aug} (cfs)	0.14	0.28	0.56	0.28
	Q_{aug} +1 SE (cfs)	0.19	0.38	0.76	0.38
Grower 58-1	Q_{aug} (cfs)	0.28	0.56	1.12	0.56
	Q_{aug} +1 SE (cfs)	0.40	0.80	1.60	0.80
Grower 62	Q_{aug} (cfs)	0.74	1.48	2.96	1.44
	Q_{aug} +1 SE (cfs)	1.04	2.08	4.16	2.08
Carrabassett valley	Q_{aug} (cfs)	2.33	4.66	9.32	4.66
	Q_{aug} +1 SE (cfs)	3.26	6.52	13.04	6.52
Passamaquoddy	Q_{aug} (cfs)	4.71	9.42	18.84	9.42
	Q_{aug} +1 SE (cfs)	6.49	12.98	25.96	12.98
Fort Fairfield	Q_{aug} (cfs)	6.45	12.90	25.80	12.90
	Q_{aug} +1 SE (cfs)	9.08	18.16	36.32	18.16

Since actual flow data at the 9 withdrawal points is not available, a synthetic hydrograph was generated for each withdrawal point for the 2001, 2002, and 2003 water years by scaling the flow at the most appropriate USGS gaging station by the ratio of the withdrawal point drainage basin area to the USGS gage contributing drainage basin area.

That is

$$Q_{\text{withdrawal point}} = Q_{\text{USGS gage}} * (A_{\text{withdrawal point}}) / (A_{\text{USGS gage}})$$

where Q = flow in cfs and A = drainage basin area in square miles.

For Growers 37 and 43 (central Maine) and the Carrabasset Valley public water supply intake, the USGS gage on Kingsbury Stream near Abbot Village was used for the base hydrograph. For Growers 58-1 and 62 (southern Maine), the gage on Stony Brook at East Sebago was used for the base hydrograph. For Grower 50 and the Passamaquoddy public water supply intake (Downeast Basins), the gage on Old Stream at Wesley was used for the base hydrograph. For Grower 13 and the Fort Fairfield public water supply intake (Aroostook County), the gage on Williams Brook at Phair was used for the base hydrograph.

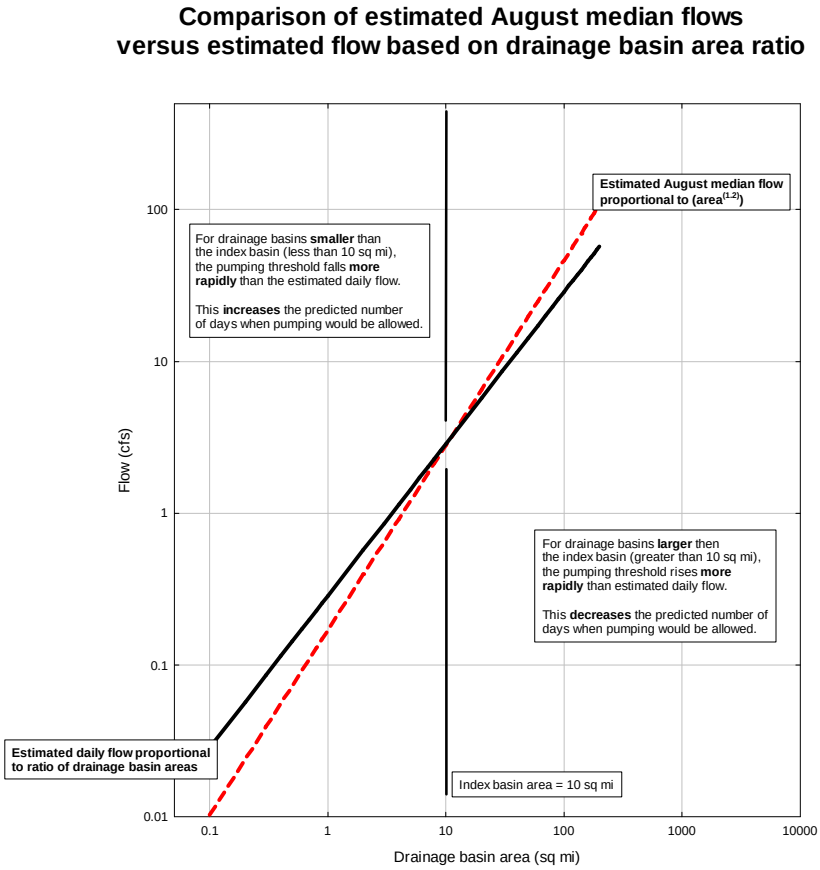
The table below compares the contributing drainage basin ares of the USGS gage to the contributing drainage basin at the withdrawal point.

USGS gage	Drainage basin area (sq mi)	Water User	Drainage basin area (sq mi)
Kingsbury Stream near Abbot Village	94.5	Grower 37	64.0
		Grower 43	11.0
		Carrabassett Valley	11.43
Stony Brook at East Sebago	0.81	Grower 58-1	1.75
		Grower 62	4.13
Old Stream at Wesley	29.1	Grower 50	0.93
		Passamaquoddy	18.54
Williams Brook at Phair	3.82	Grower 13	2.84
		Fort Fairfield	28.54

The most extreme multiplier factor that was applied to the USGS gage data was 0.032 to scale the flow on Old Stream at Wesley to flow at the withdrawal site for Grower 50. This is obviously a significant factor, and if the assumption that flow is directly proportional to drainage basin area is incorrect, it would be a potential source of significant error in assessing the number of days the flow was above or below the seasonal threshold. However, at the present time this is the best method for estimating daily flow at the withdrawal points.

One systematic feature of the method used in estimating daily flows at the withdrawal points should be discussed. The figure comparing +1 standard error for estimated August median flows on page 9 includes a dotted line showing the relationship between flow and drainage basin area if flow were directly proportional to drainage basin area (the assumption used in estimating daily flows at the withdrawal points). Note that the estimated median flow falls off faster as a function of decreasing drainage basin area than the dotted line. This means that the seasonal thresholds estimated from the USGS equations ***fall more rapidly*** as a function of ***decreasing drainage basin area*** than the estimated daily flows based on a USGS base hydrograph. Conversely, the estimated median flow increases more rapidly as a function of increasing drainage area than the dotted line. This means that the seasonal thresholds estimated from the USGS equations ***increase*** more rapidly as a function of ***increasing drainage basin area*** than the estimated daily flows based on a USGS base hydrograph.

This is illustrated in the graph below. The dotted line for the estimated August median flow is proportional to (area$^{(1.2)}$), while the solid line for the estimated daily flow is directly proportional to the drainage basin area. In this example, the estimated daily flow was set to match the estimated August median at a basin area of 10 sq mi and a flow of approximately 3 cfs. This allows for examining the effect of both decreasing and increasing drainage basin area on the estimated Augusta median flow and the estimated daily flow.



For the case where the area of the drainage basin above the withdrawal point is less than the area of the drainage basin of the USGS base gage, the estimated August median flow (and therefore the seasonal withdrawal threshold) ***falls*** more rapidly than the estimated daily flow. This will result in an ***increase*** in the predicted number of days when pumping would be allowed.

This effect can be seen for Grower 43. The area of the basin above the withdrawal point is only 0.93 sq mi. Daily flows at the withdrawal point are based on the USGS base gage on Kingsbury Stream near Abbot Village, where the area above the gage is 94.5 sq mi. At the base gage 109 days of pumping are allowed in water year 2001 (table on page 17), but the synthetic hydrograph for Grower 43 allows 143 days. The same inflated number of pumping days must affect the results for Grower 50 as well.

Conversely, for the case where the area of the drainage basin above the withdrawal point is greater than the area of the drainage basin of the USGS base gage, the estimated August median flow (and therefore the seasonal withdrawal threshold) ***rises*** more rapidly than the estimated daily flow. This will result in a ***decrease*** in the predicted number of days when pumping would be allowed.

The Fort Fairfield public water supply intake has a drainage basin area is approximately 10 times larger than the drainage basin area of Williams Brook at Phair. The predicted number of days when pumping would be allowed based on the hydrograph at Williams Brook is 87 days in water year 2001 (table on page 17), but only 41 based on the synthetic hydrograph for Fort Fairfield.

As a result, caution must be used in interpreting the number of days when pumping would be allowed and would not be allowed and the figures showing when pumping would and would not be allowed ***if the USGS base gage has a drainage basin area very different from the withdrawal point***.

Once synthetic hydrographs for the withdrawal points were generated, the seasonal thresholds were plotted on the hydrographs and the number of days when the estimated daily flow was above or below the seasonal threshold was calculated.

Results:

The tables on pages 15 and 17 provides a summary of the results for the 9 withdrawal points selected for the initial assessment. Season thresholds for the 4 USGS gaging stations used as base hydrographs were also estimated from the USGS equations, and they were also analyzed for days when pumping would be allowed and days when pumping would not be allowed.

The first table lists days when pumping would be allowed and pumping would not be allowed assuming the ***estimated August median + 1 standard error*** is the base summer threshold. The second table uses just the ***August median*** as the base summer threshold, and consequently shows a greater number of days when pumping would be allowed.

The table is graphically summarized in a series of bar charts for the withdrawal points in central Maine, southern Maine, and eastern and northern Maine.

Following the summary bar charts, a series of figures graphically illustrates when pumping would and would not be allowed. There are 3 graphs for each withdrawal point or USGS gaging station – one each for water year 2001, 2002, and 2003. Seasonal thresholds based on both the estimated August median (lower line) and estimated August median + 1 standard error (upper line) are shown superimposed on the daily flow at the USGS base gaging stations and the synthetic hydrograph of daily flows calculated for each grower. The shaded areas show times when the calculated daily flow falls below the seasonal threshold. The dark gray areas show times when the estimated flow was below

the estimated August median flow; the light gray areas show times when the estimated flow was below the estimated Augusta median +1 standard error.

Water year 2001 should be considered an example of a dry year, with water year 2003 approaching a normal year. Water year 2002 is intermediate between these two, with a very dry beginning.

Again, it must be noted that the statewide equation from Dudley (2003) is not recommended for use in basins less that 10 sq mi in area, so the thresholds estimated for Stony Brook at East Sebago and Growers 58-1 and 62 have more error than stated in Dudley (2003) and, more importantly, may be systematically higher or lower than the "true" threshold.

Summary

Estimating daily flows based in drainage basin proportionality ***overestimates*** daily flows ***in basins smaller*** than the USGS base gage drainage basin relative to Statewide and regional equation for August median flow.

Estimating daily flows based in drainage basin proportionality ***underestimates*** daily flows ***in basins larger*** than the USGS base gage drainage basin relative to Statewide and regional equation for August median flow.

Statewide and regional equations for August median flow have large standard errors (between -27- and +62- percent). The percent standard error is larger for +1 standard error.

Estimating daily flows based on strict drainage basin proportionality has the potential to introduce large errors into the analysis of predicted days when pumping would and would not be allowed when the USGS base gage drainage basin and the withdrawal site drainage basin are not closely matched.

The Statewide equation for estimating August median flow (Dudley, 2003) should not be used for basins with area less than 10 square miles.

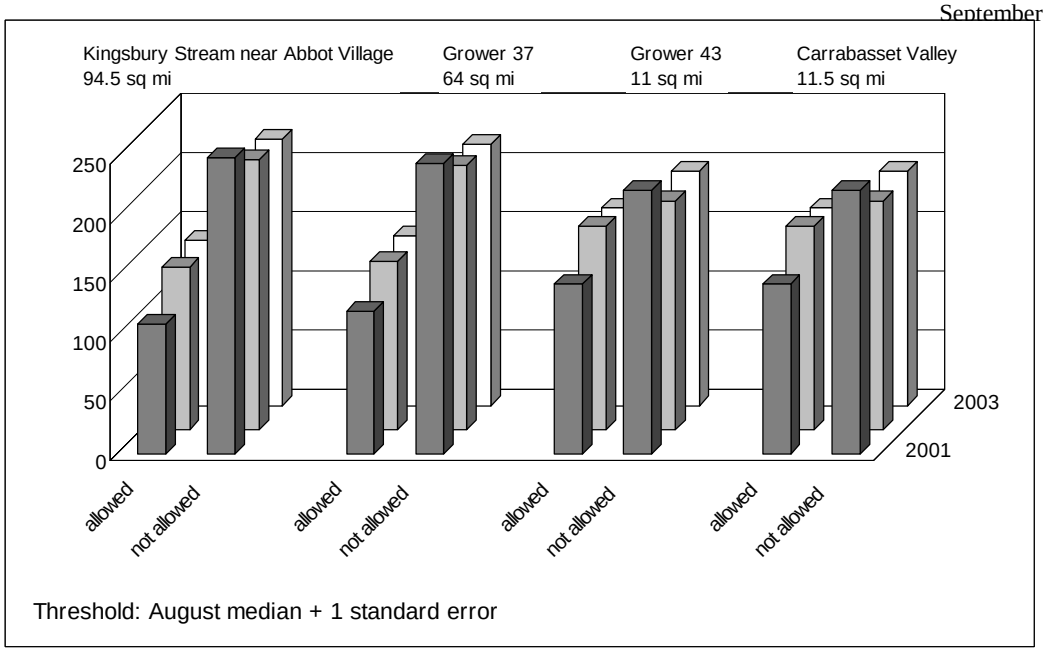
Grower or USGS gaging station	Area (sq mi)	Water year					
		2001		2002		2003	
		days pumping allowed	days pumping not allowed	days pumping allowed	days pumping not allowed	days pumping allowed	days pumping not allowed
Kingsbury Stream near Abbot Village	94.5	109	256	137	228	140	225
Grower 37	64.0	120	245	142	223	144	221
Grower 43	11.0	143	222	172	193	167	198
Carrabassett Valley	11.4	143	222	172	193	167	198
Stony Brook at East Sebago	0.81	274	91	160	205	326	39
Grower 58-1	1.75	268	97	152	213	318	47
Grower 62	4.13	259	106	150	215	310	55
Old Stream at Wesley	29.1	90	275	131	234	209	156
Grower 50	0.93	259	106	192	173	281	84
Pasamaquoddy	18.5	109	256	142	223	224	141
Williams Brook at Phair	3.82	87	278	135	230	170	195
Grower 13	2.84	92	273	141	224	187	178
Fort Fairfield	28.5	41	324	63	302	85	279

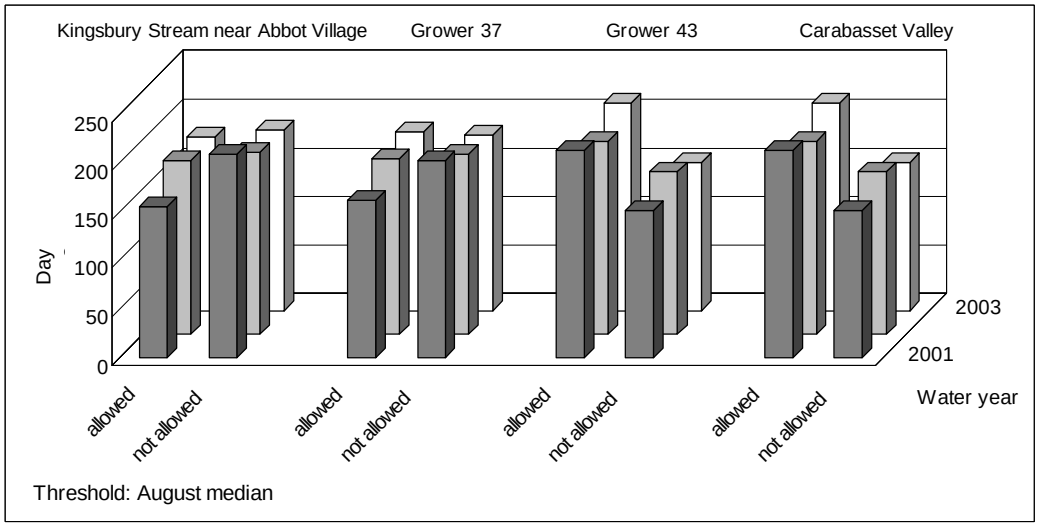
Days pumping/no pumping for summer threshold equal to estimated August median + 1 standard error.

Grower or USGS gaging station	Area (sq mi)	Water year					
		2001		2002		2003	
		days pumping allowed	days pumping not allowed	days pumping allowed	days pumping not allowed	days pumping allowed	days pumping not allowed
Kingsbury Stream near Abbot Village	94.5	155	210	178	187	179	186
Grower 37	64.0	162	203	180	185	184	181
Grower 43	11.0	214	151	198	167	213	152
Carrabassett Valley	11.4	214	151	198	167	213	152
Stony Brook at East Sebago	0.81	291	74	199	166	349	16
Grower 58-1	1.75	291	74	187	178	343	22
Grower 62	4.13	287	78	169	196	336	29
Old Stream at Wesley	29.1	163	202	157	208	248	117
Grower 50	0.93	277	88	225	140	293	72
Passamaquoddy	18.5	197	168	164	201	248	117
Williams Brook at Phair	3.82	142	223	167	198	245	120
Grower 13	2.84	151	214	172	193	252	113
Fort Fairfield	28.5	75	290	125	240	158	207

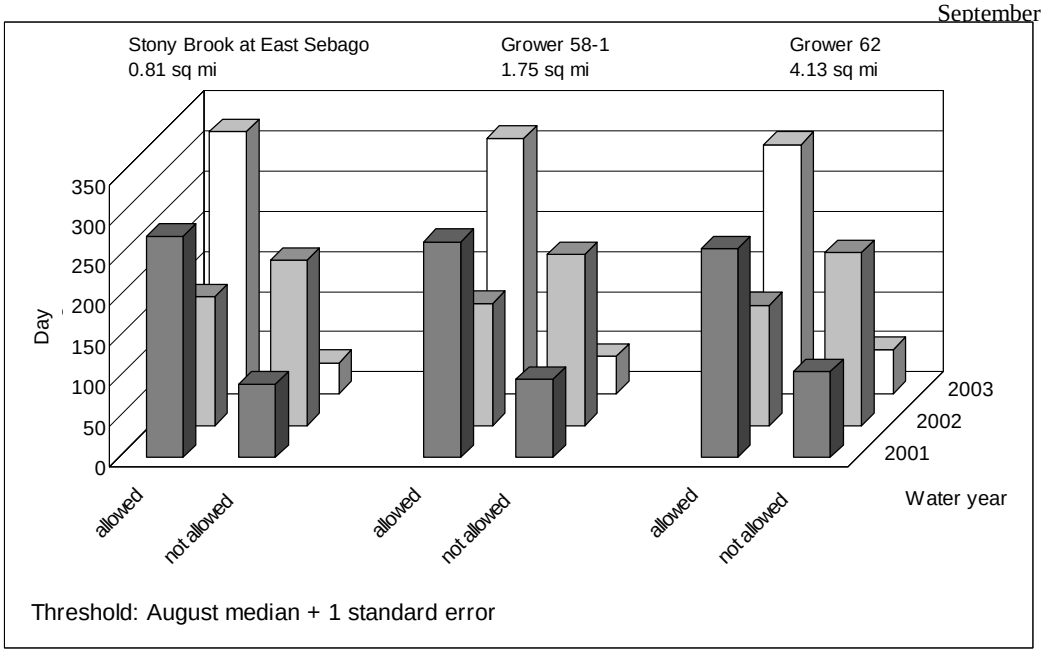
Days pumping/no pumping for summer threshold equal to estimated August median

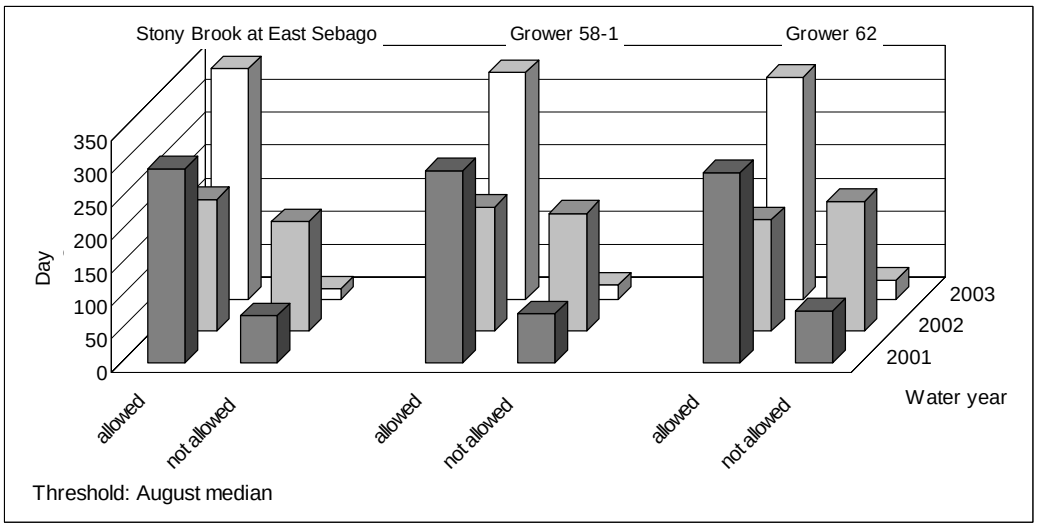
.



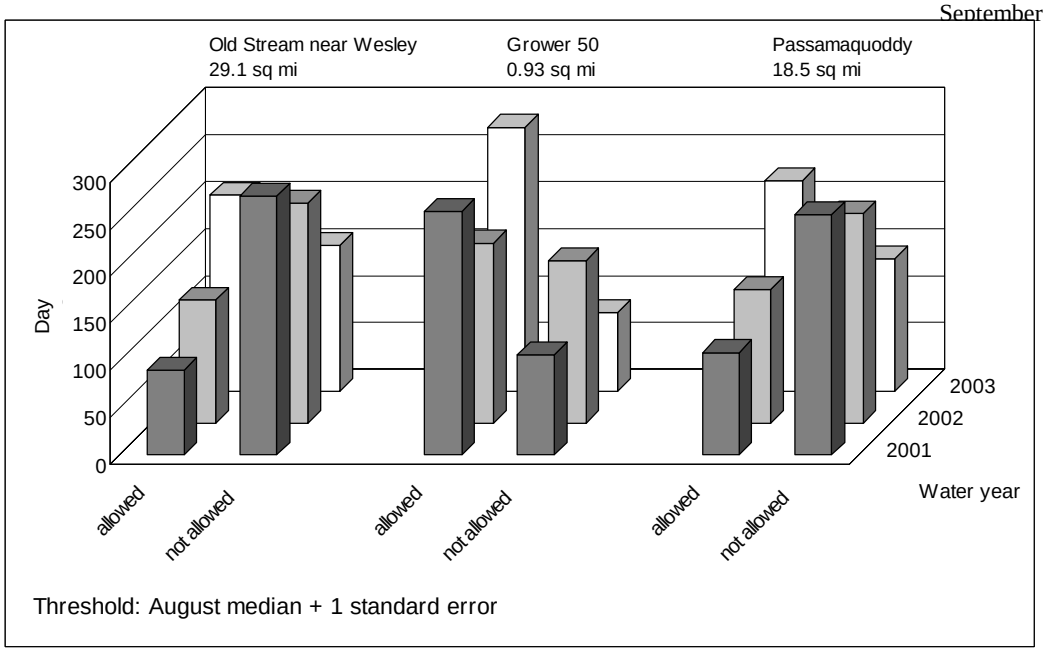


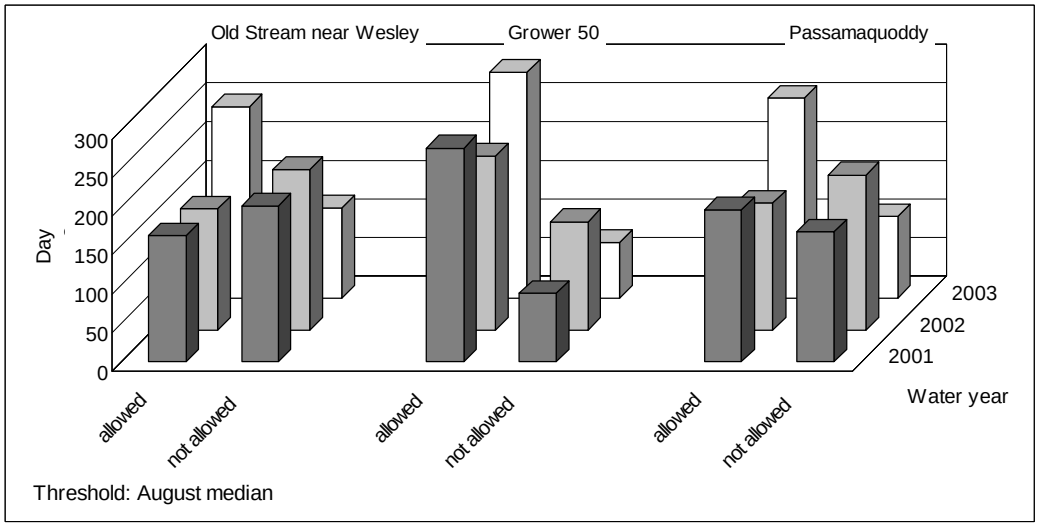
Summary of days when pumping allowed and pumping not allowed for withdrawal points in central Maine.



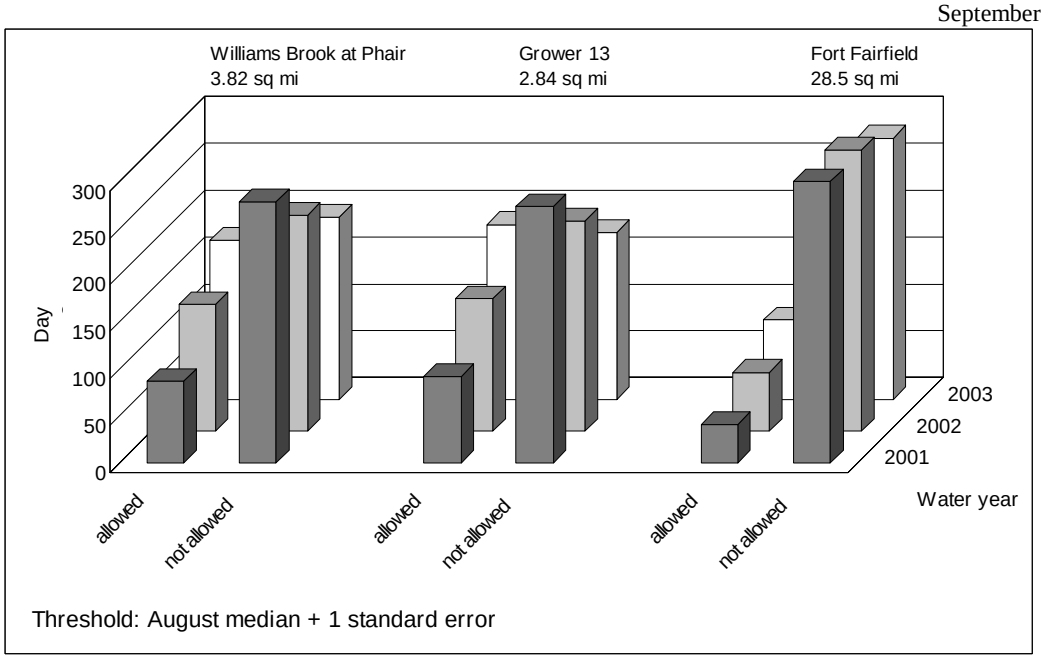


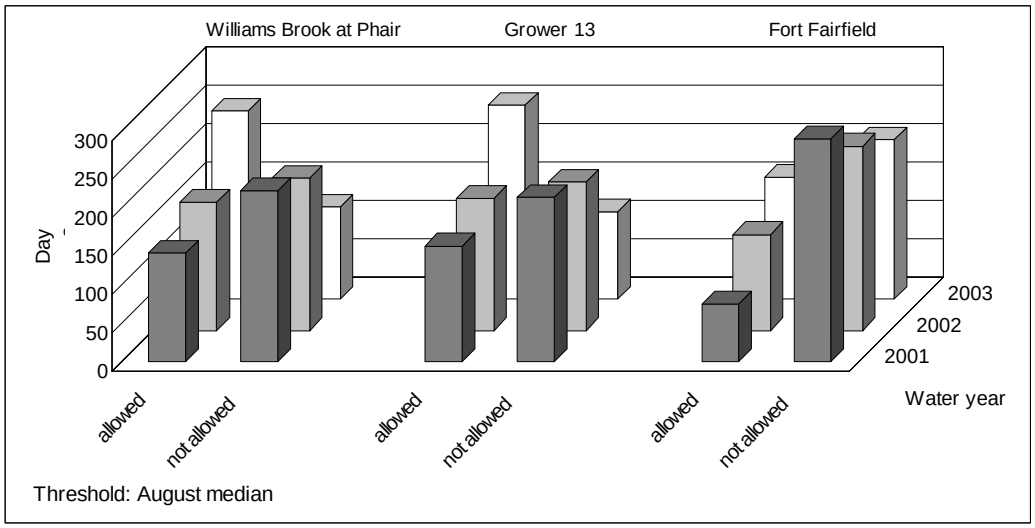
Summary of days when pumping allowed and pumping not allowed for withdrawal points in southern Maine.





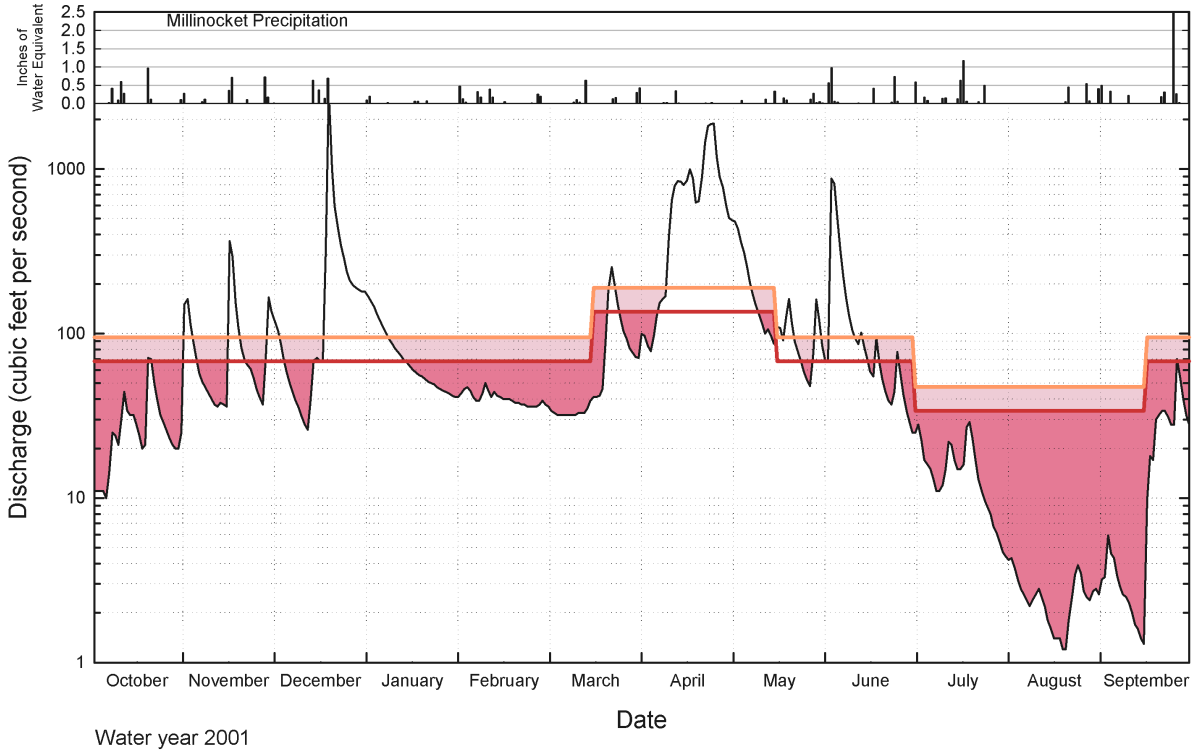
Summary of days when pumping allowed and pumping not allowed for withdrawal points in eastern Maine.





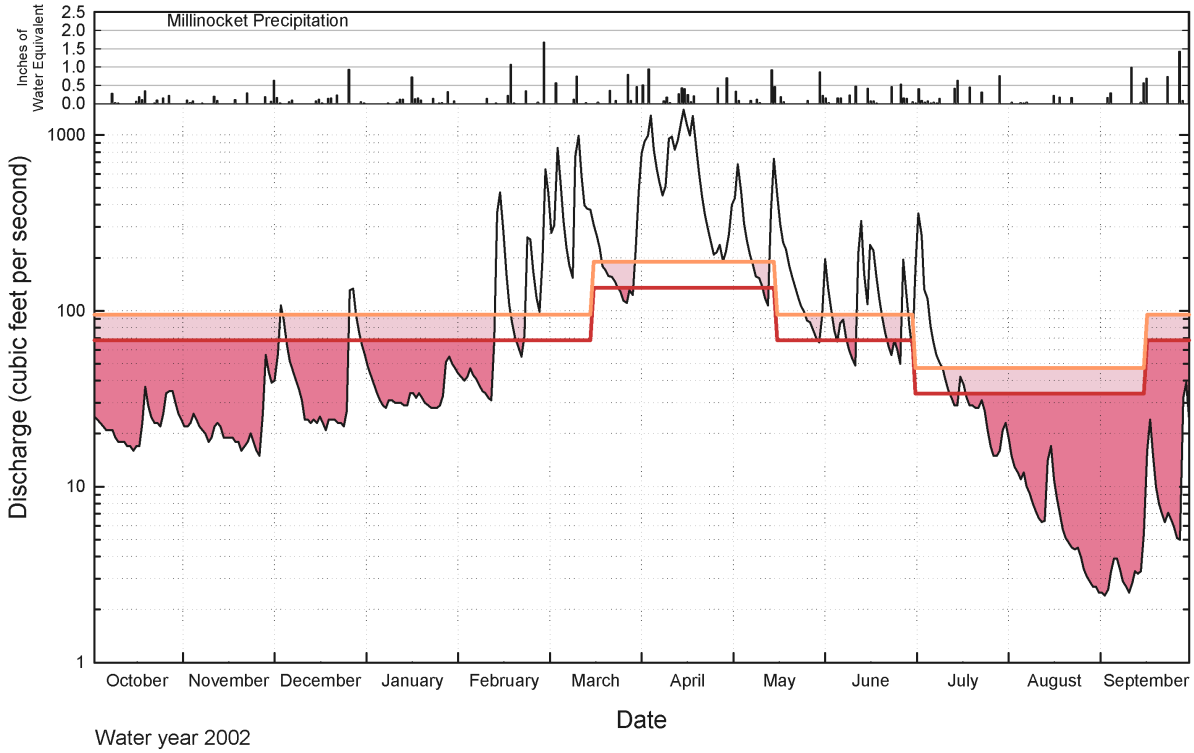
Summary of days when pumping allowed and pumping not allowed for withdrawal points in northern Maine.

Kingsbury Stream near Abbot Village



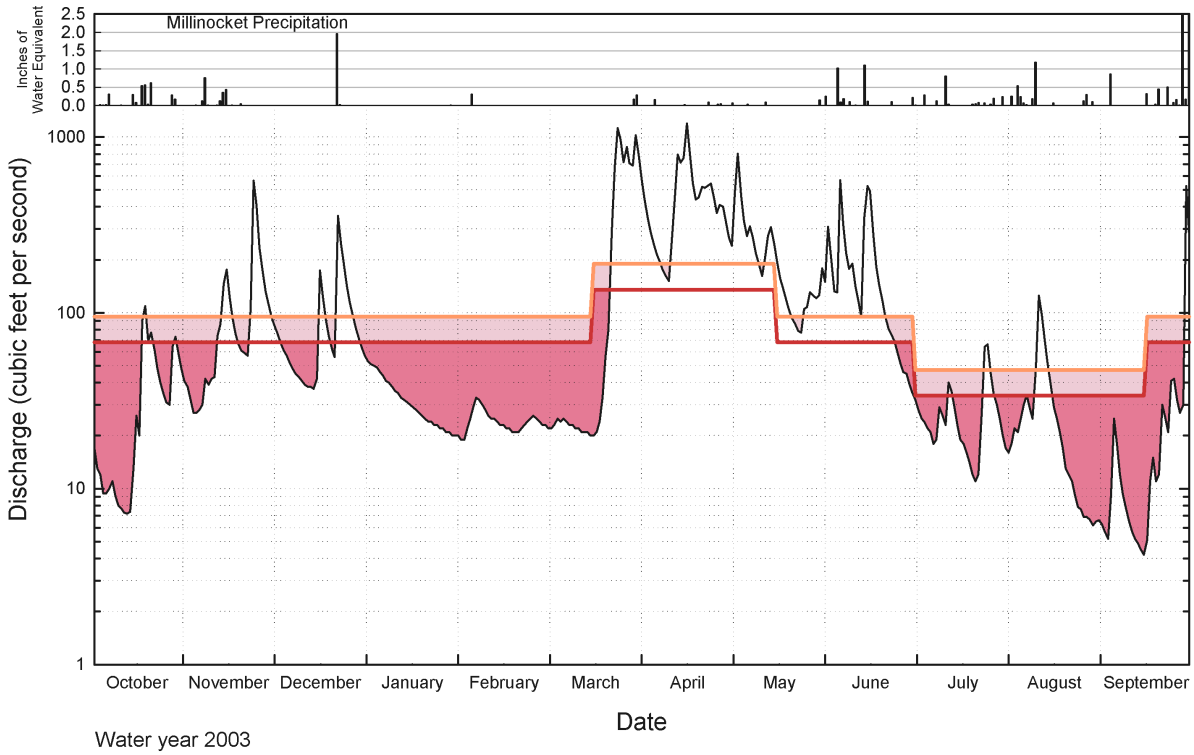
Water year 2001
Drainage area: 94.5 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)

Kingsbury Stream near Abbot Village



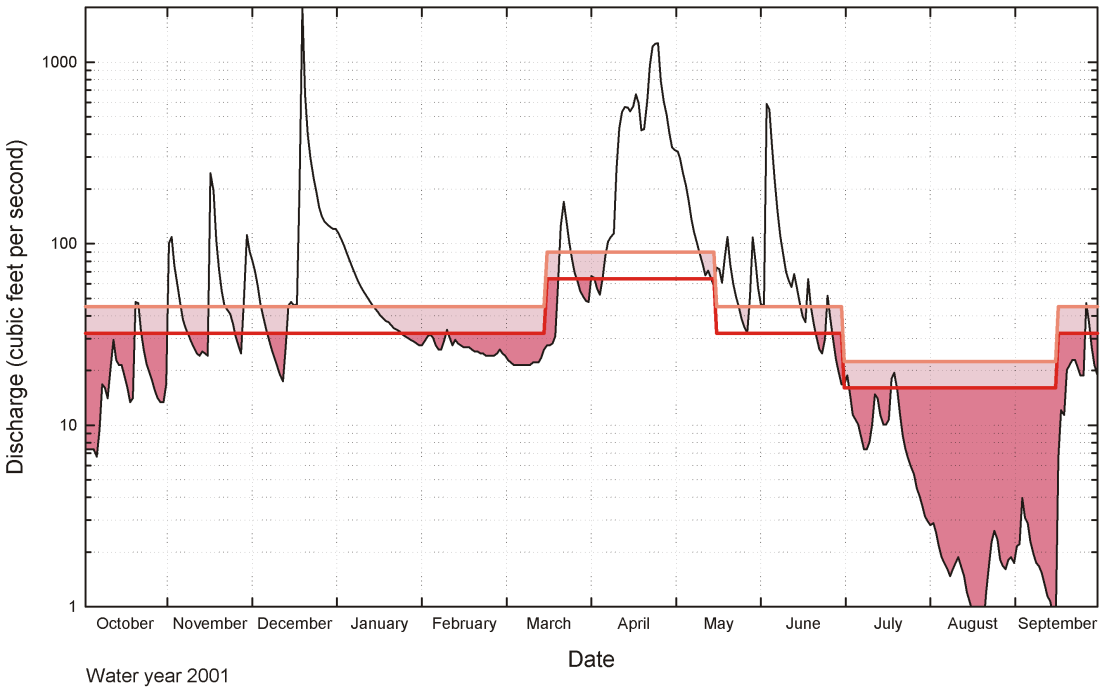
Water year 2002
Drainage area: 94.5 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)

Kingsbury Stream near Abbot Village



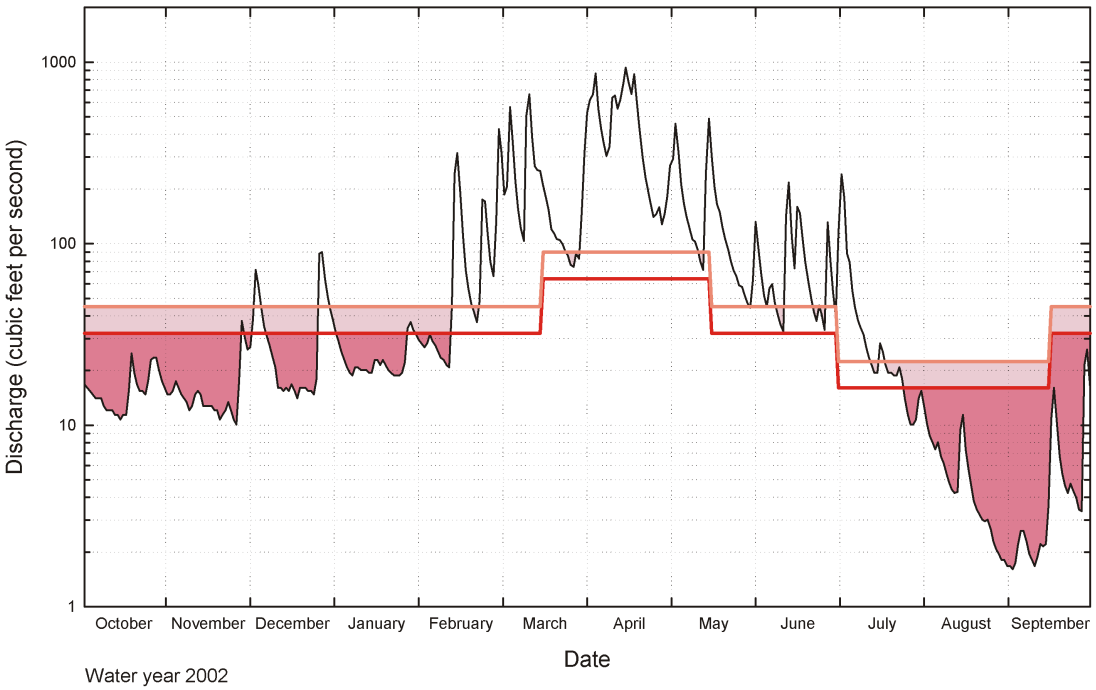
Water year 2003
Drainage area: 94.5 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)

Grower 37



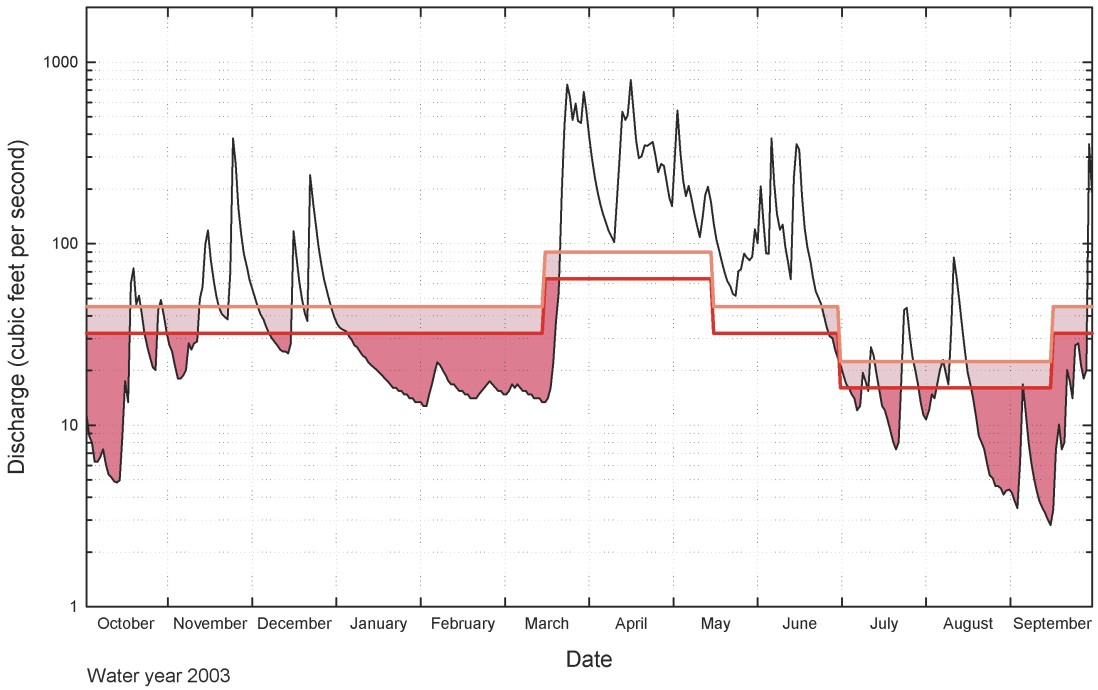
Water year 2001
Drainage area: 64 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Kingsbury Stream near Abbot Village

Grower 37



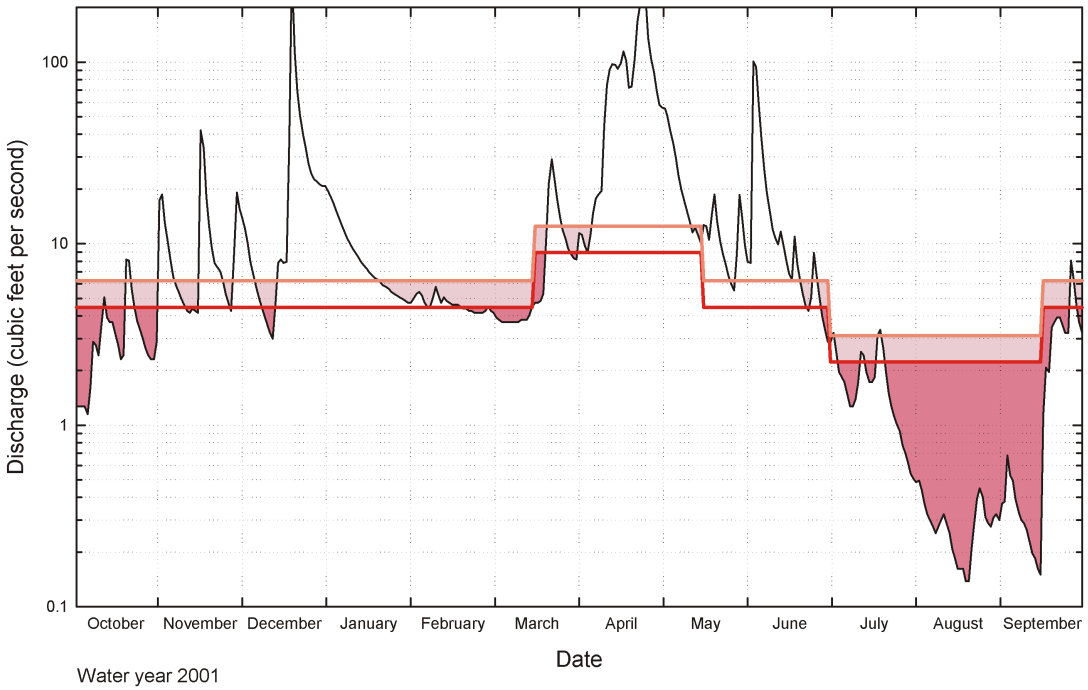
Water year 2002
Drainage area: 64 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Kingsbury Stream near Abbot Village

Grower 37



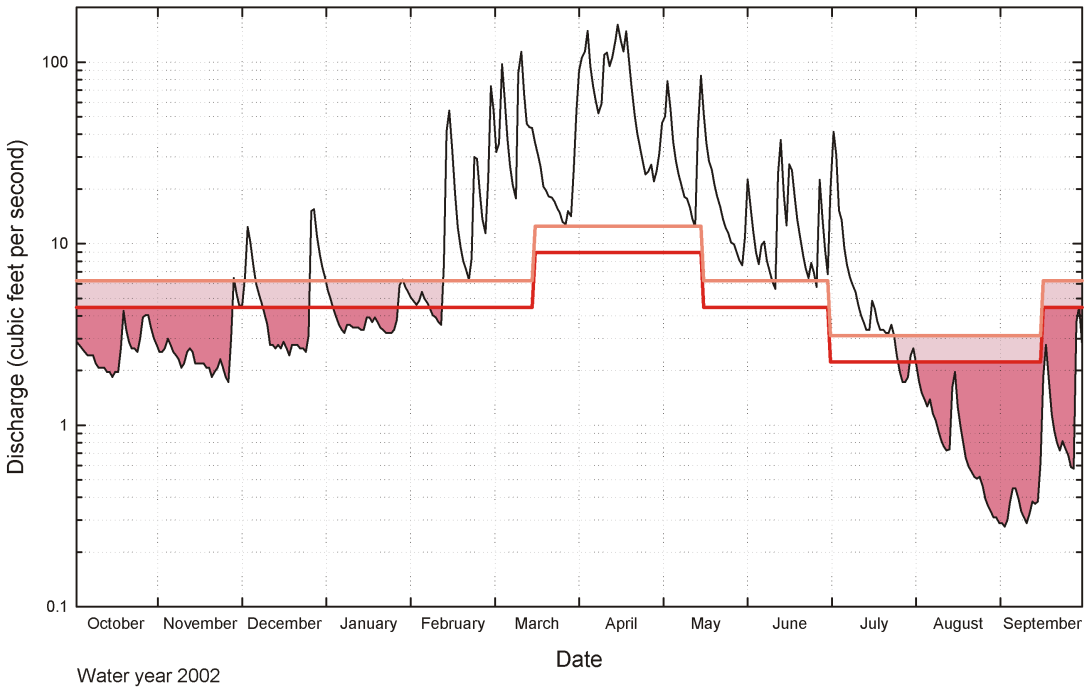
Water year 2003
Drainage area: 64 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Kingsbury Stream near Abbot Village

Grower 43



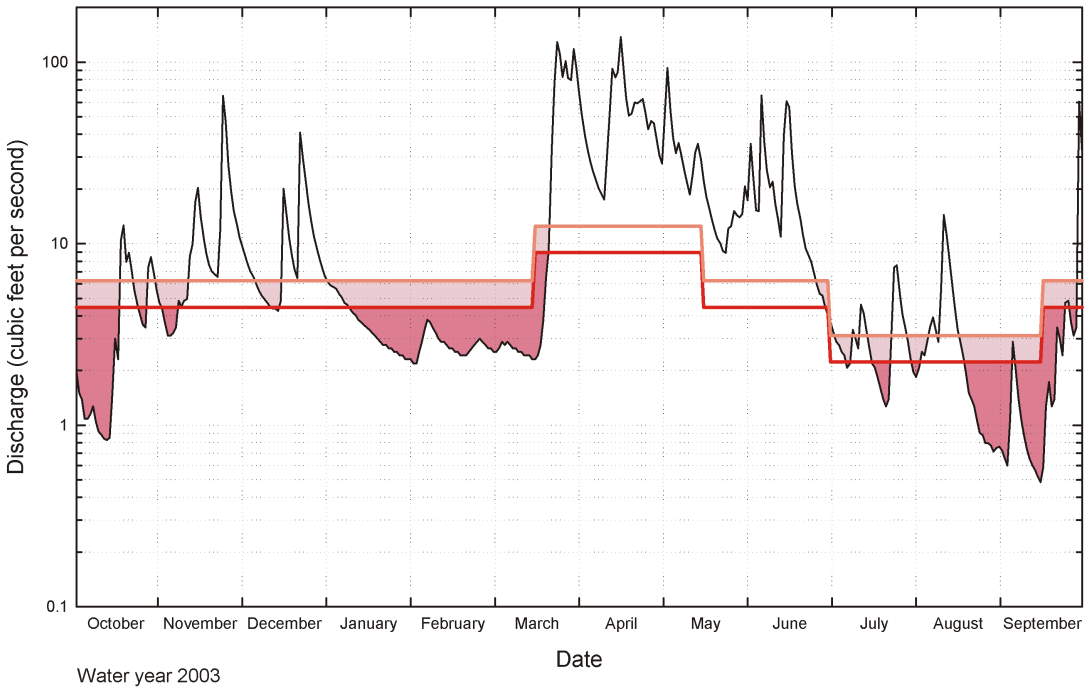
Water year 2001
Drainage area: 11 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Kingsbury Stream near Abbot Village

Grower 43



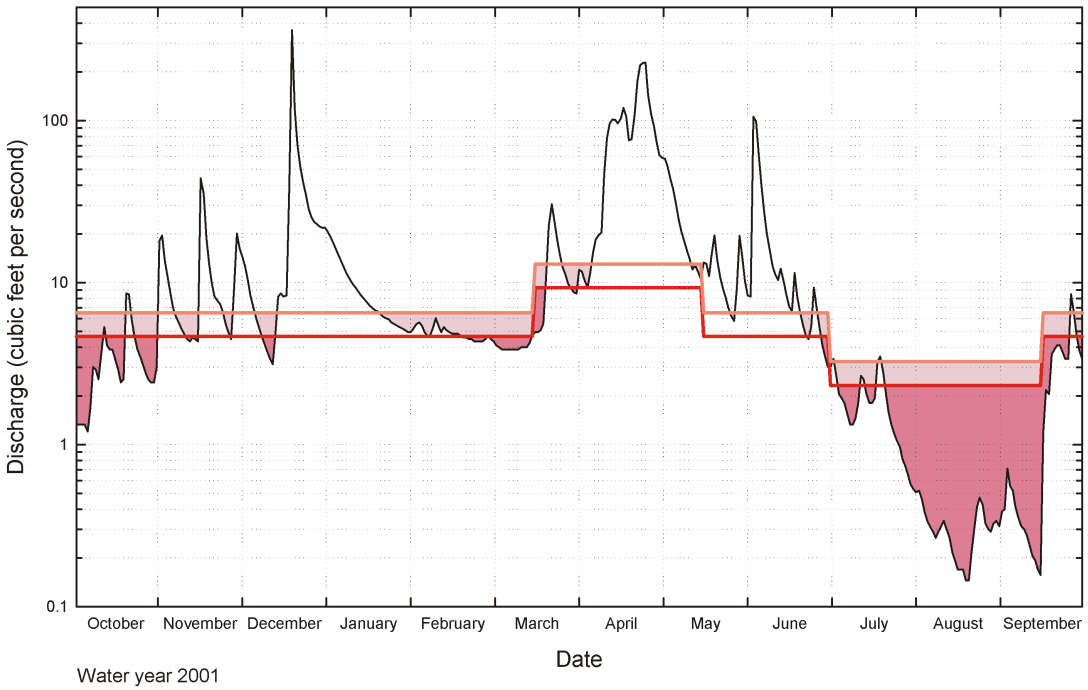
Water year 2002
Drainage area: 11 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Kingsbury Stream near Abbot Village

Grower 43



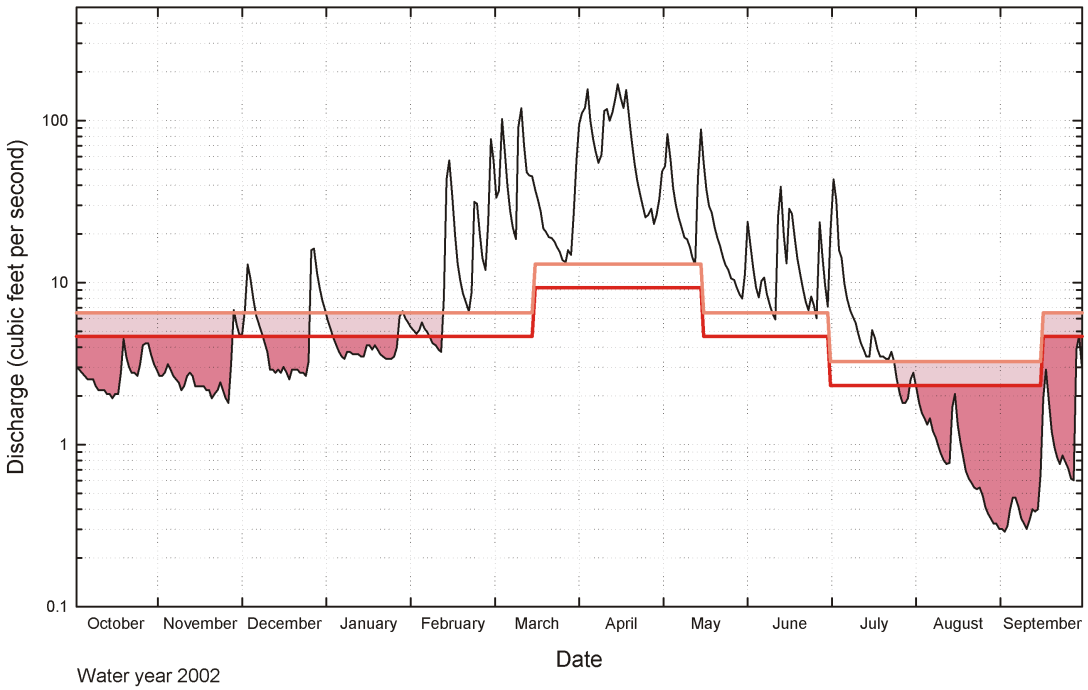
Water year 2003
Drainage area: 11 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Kingsbury Stream near Abbot Village

Carrabassett Valley



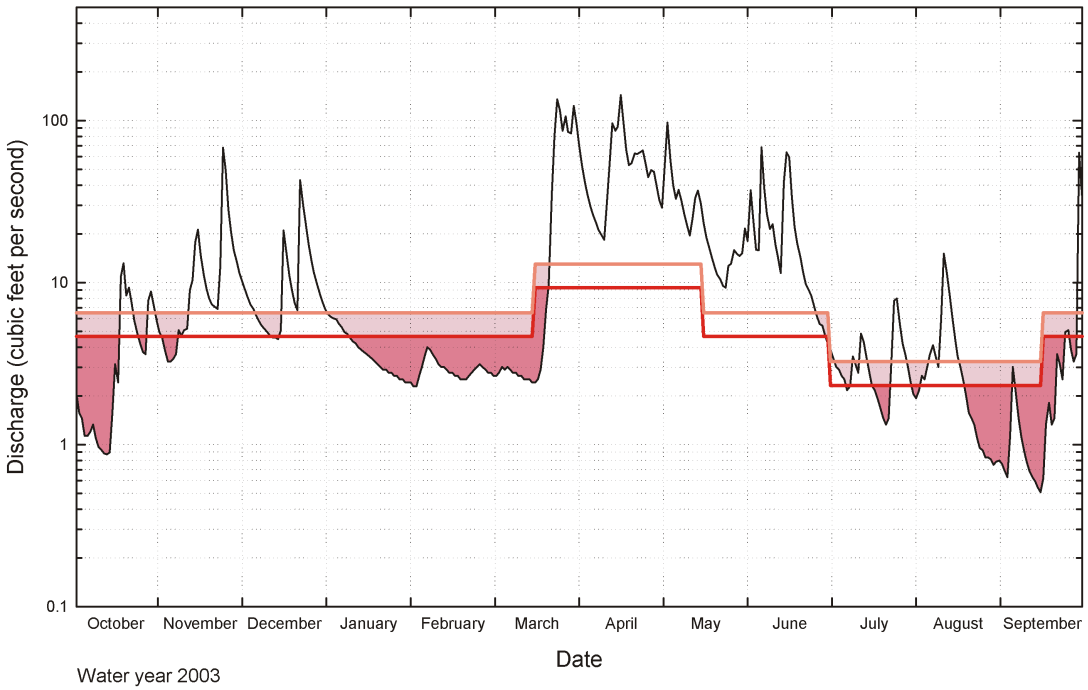
Water year 2001
Drainage area: 11.4 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Kingsbury Stream near Abbot Village

Carrabassett Valley



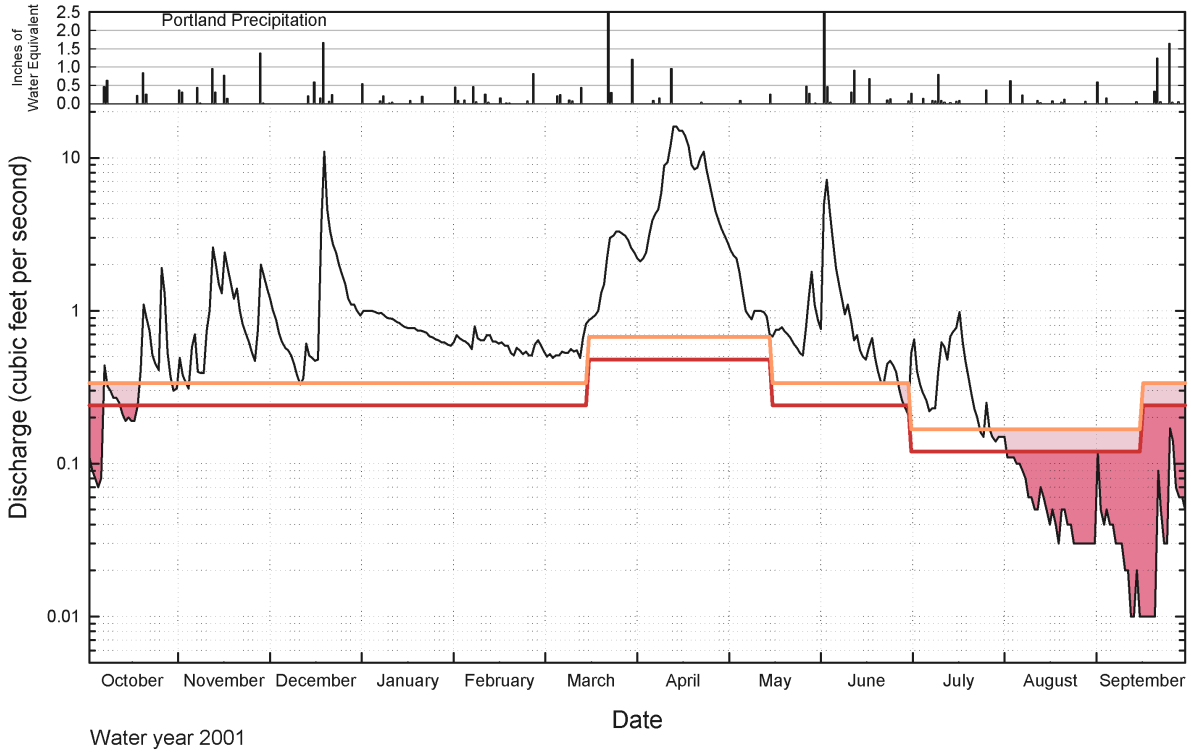
Water year 2002
Drainage area: 11.4 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Kingsbury Stream near Abbot Village

Carrabassett Valley



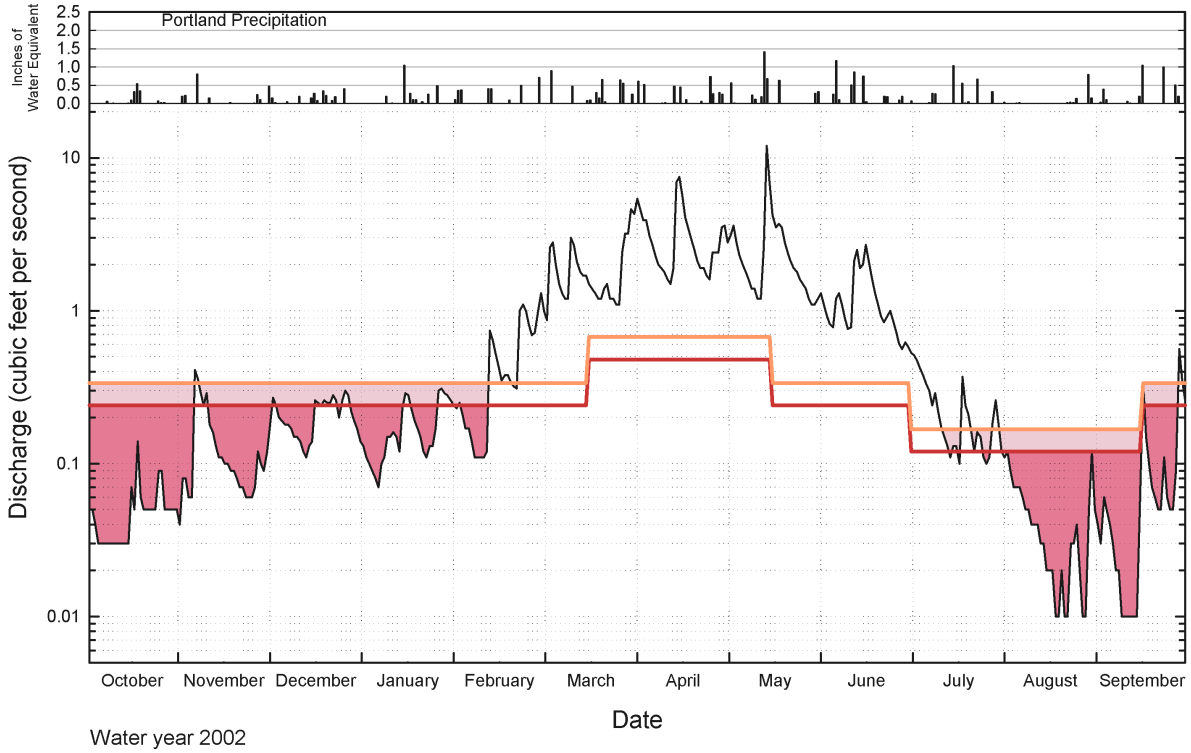
Water year 2003
Drainage area: 11.4 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Kingsbury Stream near Abbot Village

Stony Brook at East Sebago



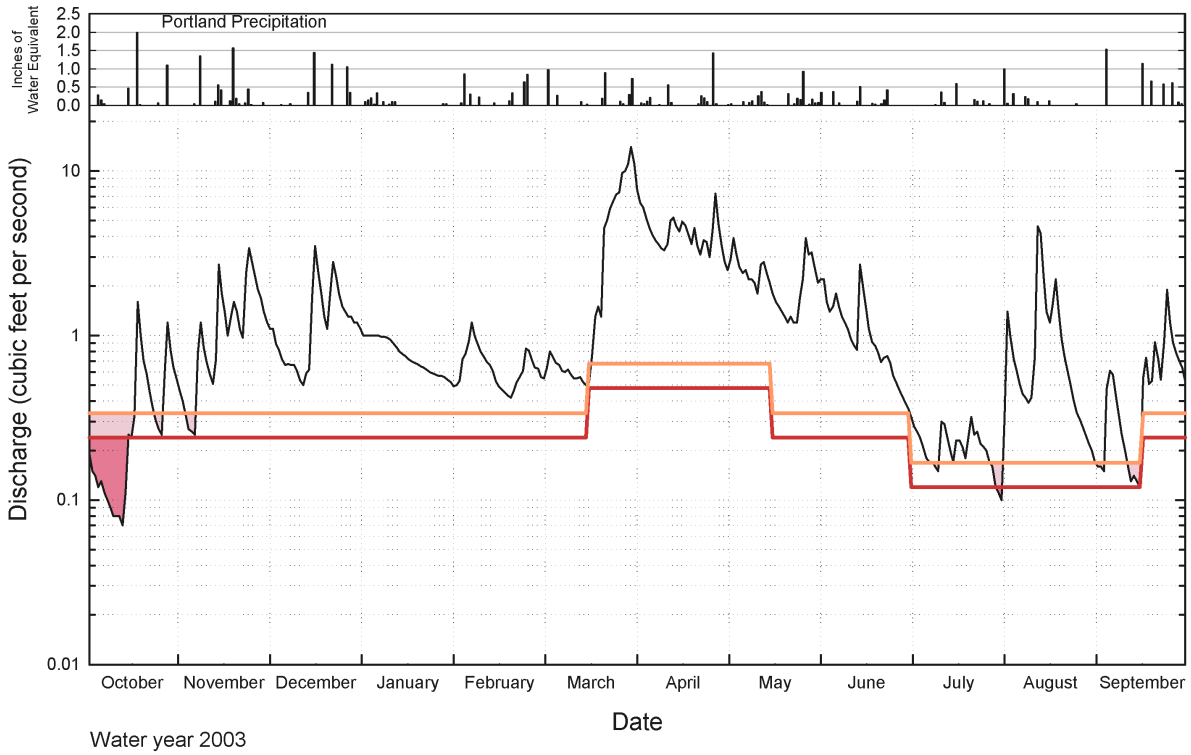
Water year 2001
Drainage area: 0.81 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)

Stony Brook at East Sebago

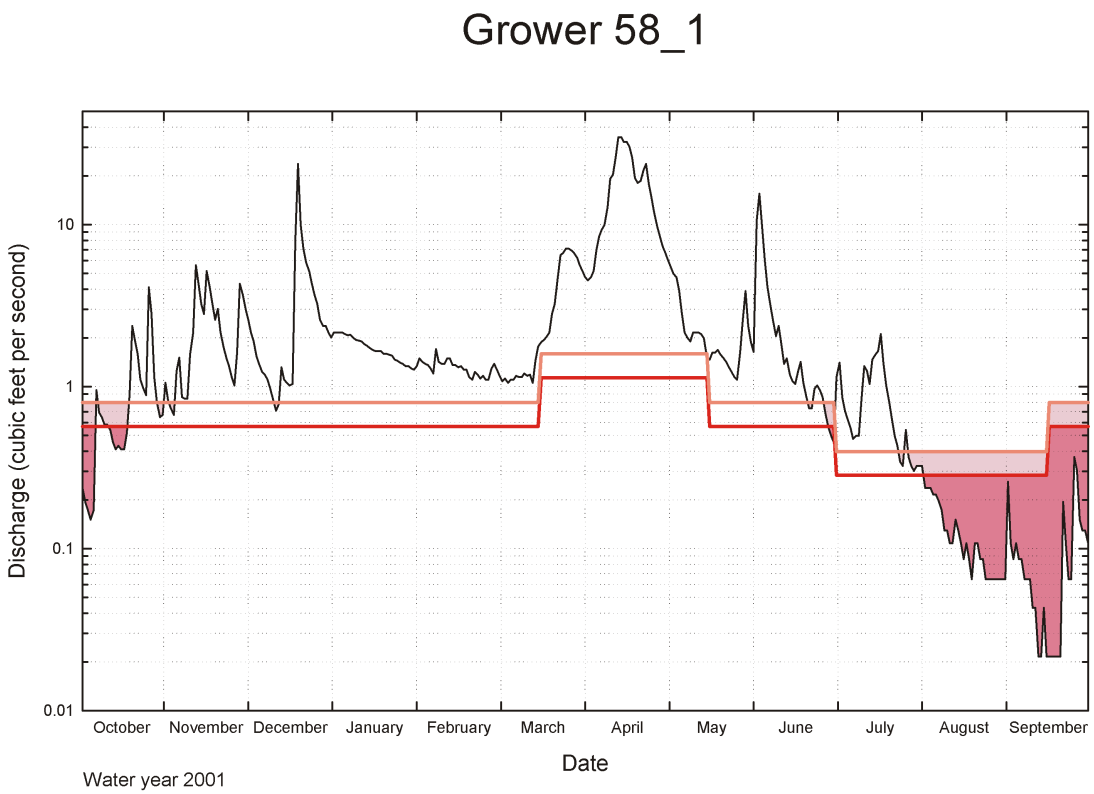


Water year 2002
Drainage area: 0.81 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)

Stony Brook at East Sebago

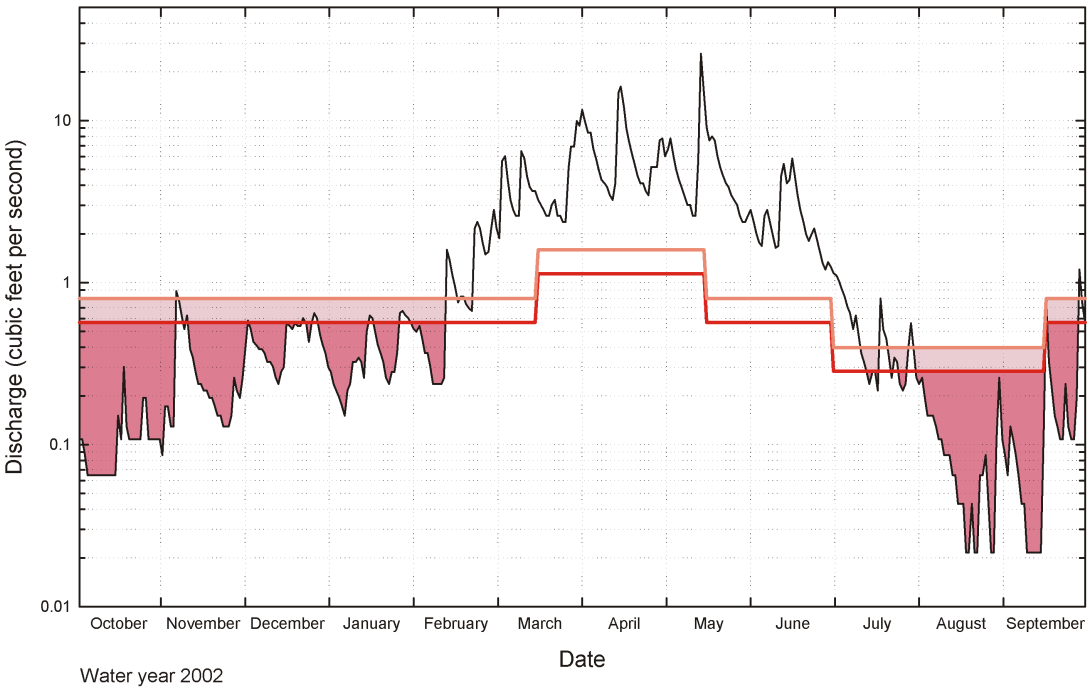


Water year 2003
Drainage area: 0.81 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)

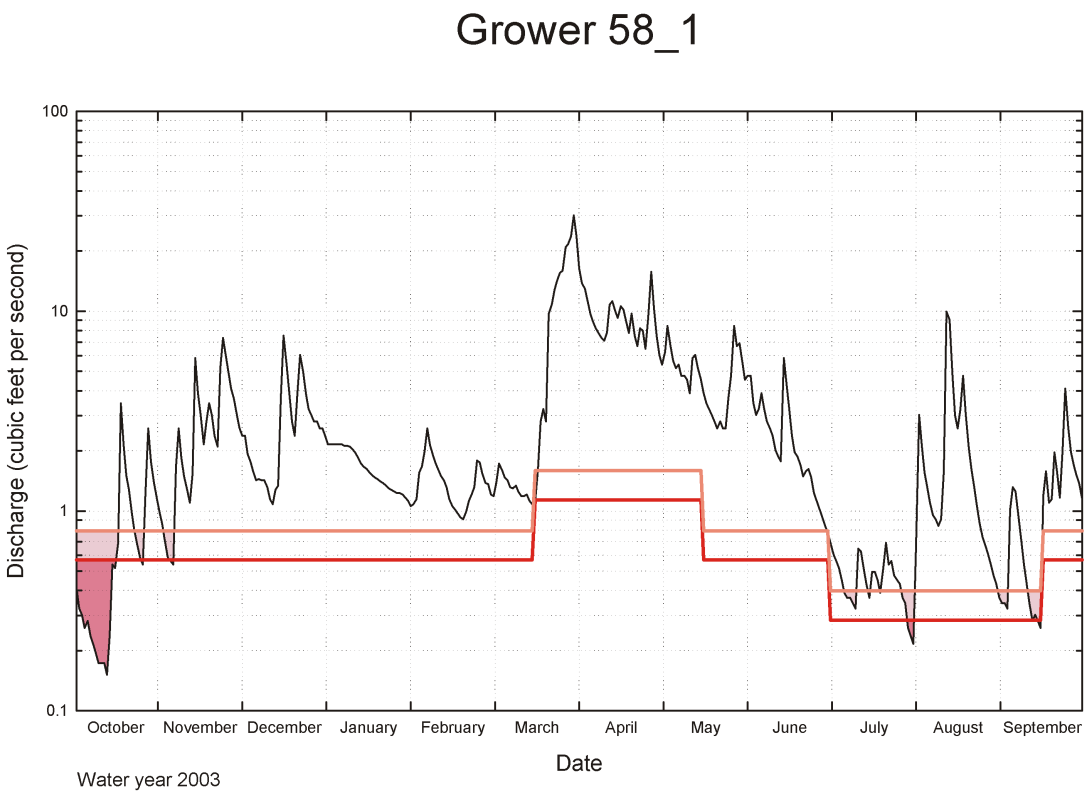


Water year 2001
Drainage area: 1.75 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Stony Brook at East Sebago

Grower 58_1

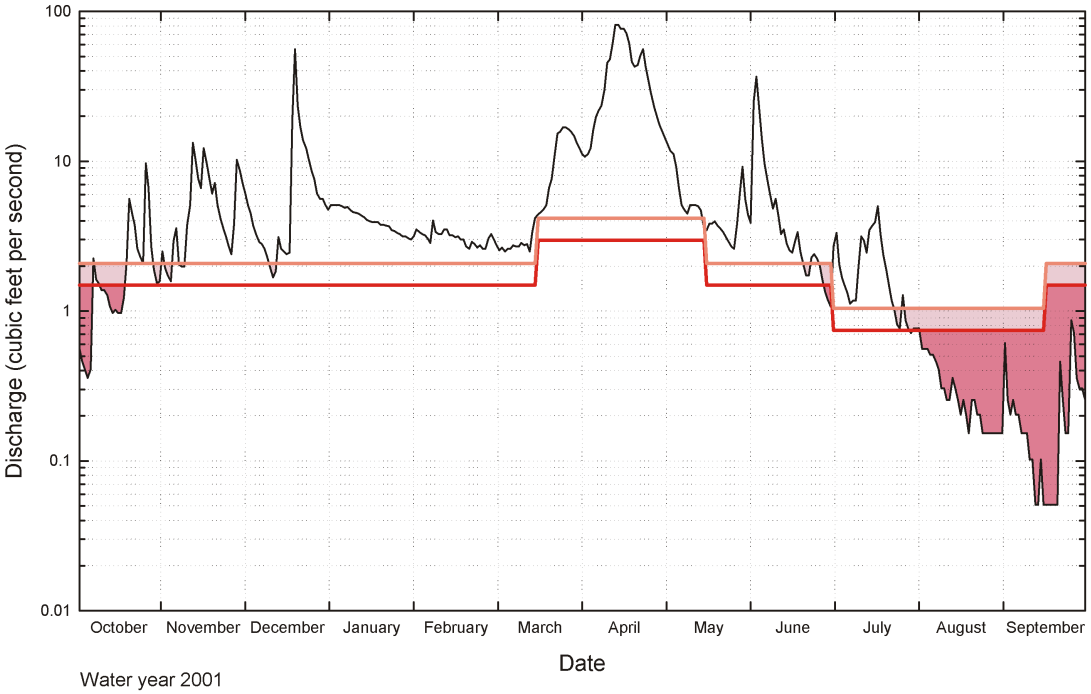


Water year 2002
Drainage area: 1.75 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Stony Brook at East Sebago



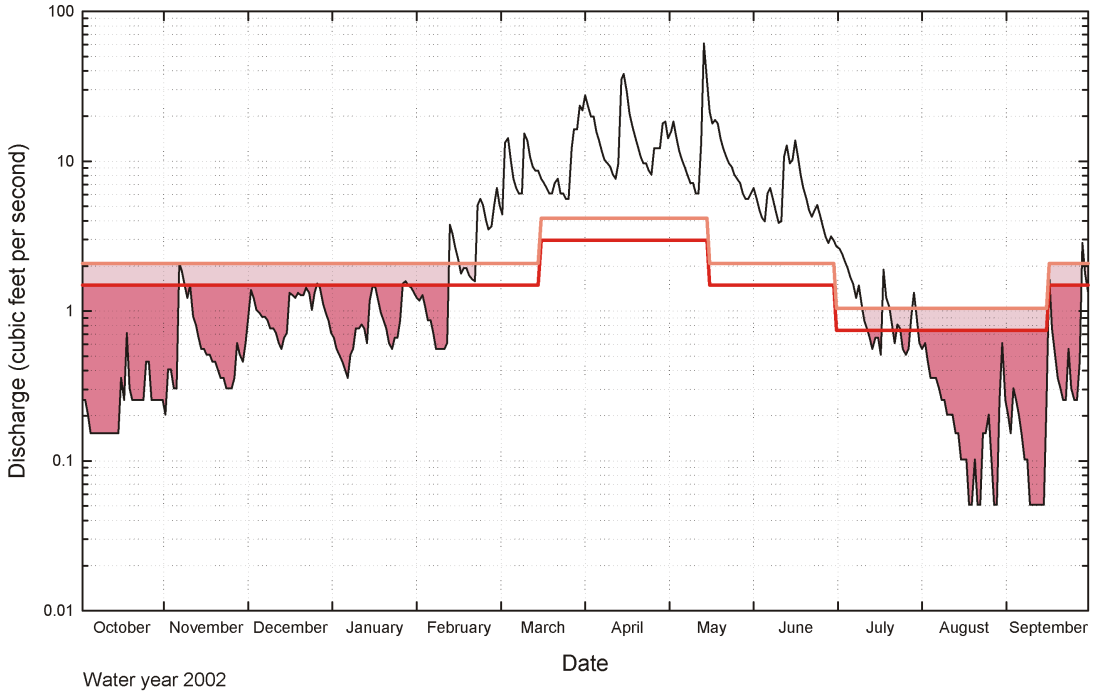
Water year 2003
Drainage area: 1.75 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Stony Brook at East Sebago

Grower 62



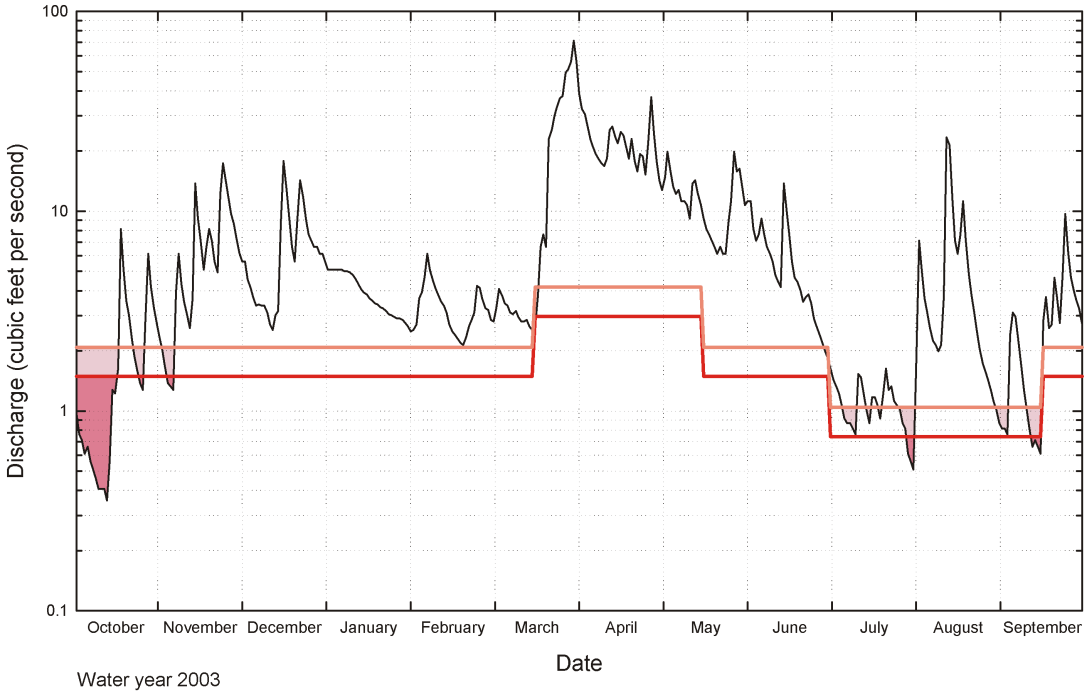
Water year 2001
Drainage area: 4.13 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Stony Brook at East Sebago

Grower 62



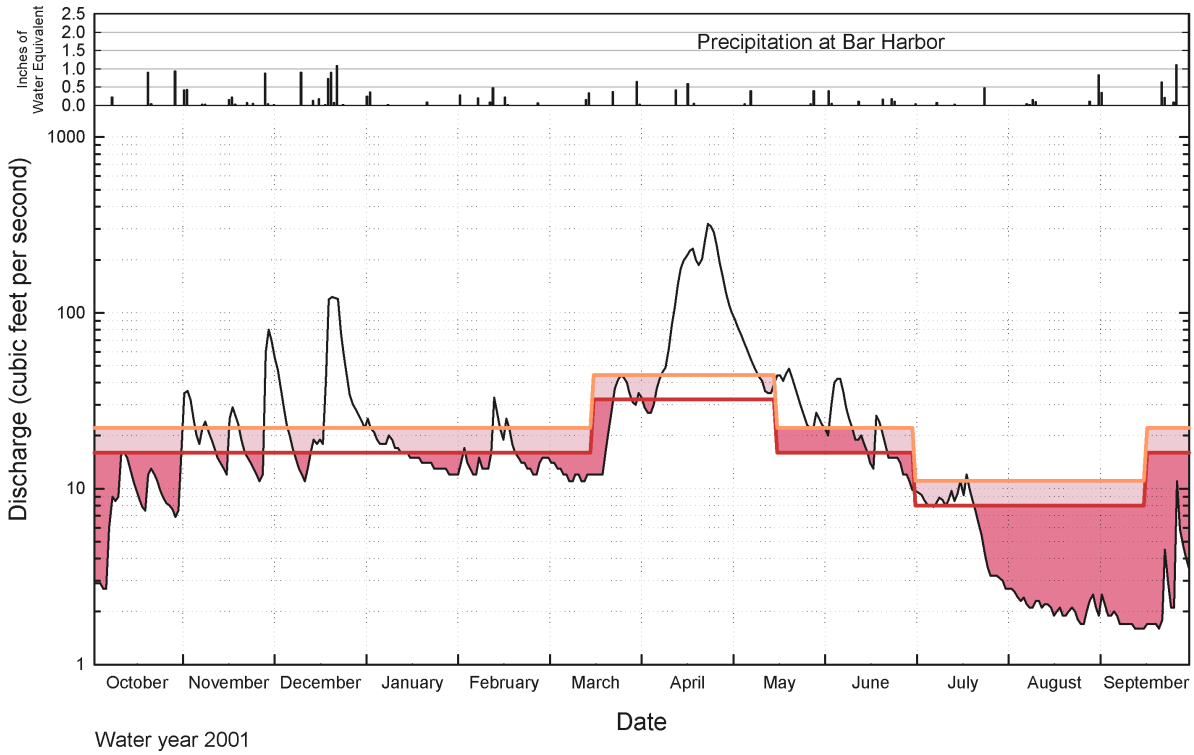
Water year 2002
Drainage area: 4.13 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Stony Brook at East Sebago

Grower 62



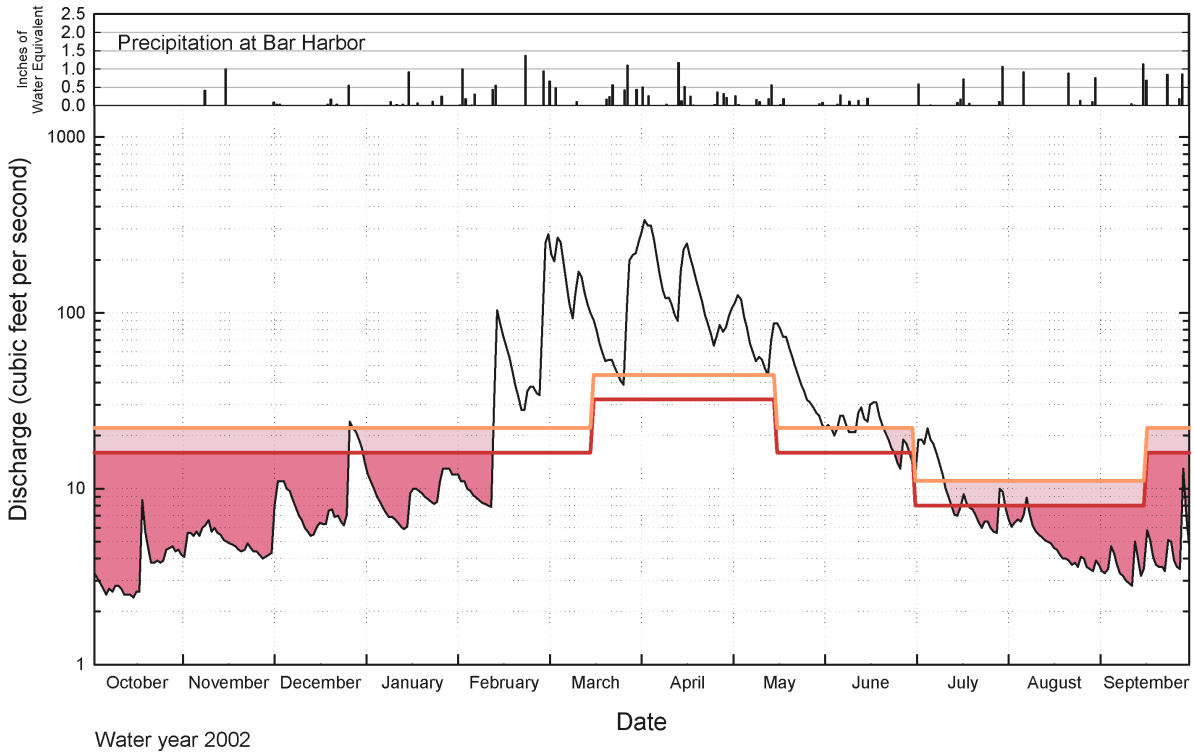
Water year 2003
Drainage area: 4.13 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)
Hydrograph: Stony Brook at East Sebago

Old Stream near Wesley



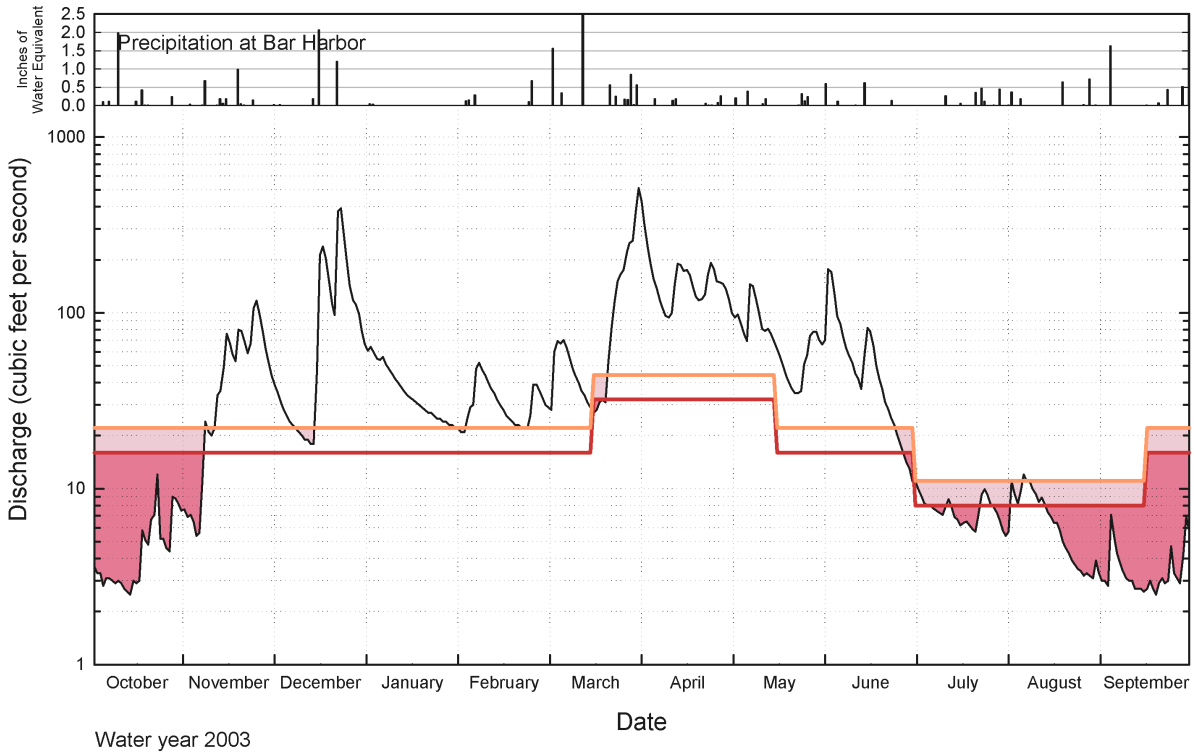
Water year 2001
Drainage area: 29.1 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)

Old Stream near Wesley



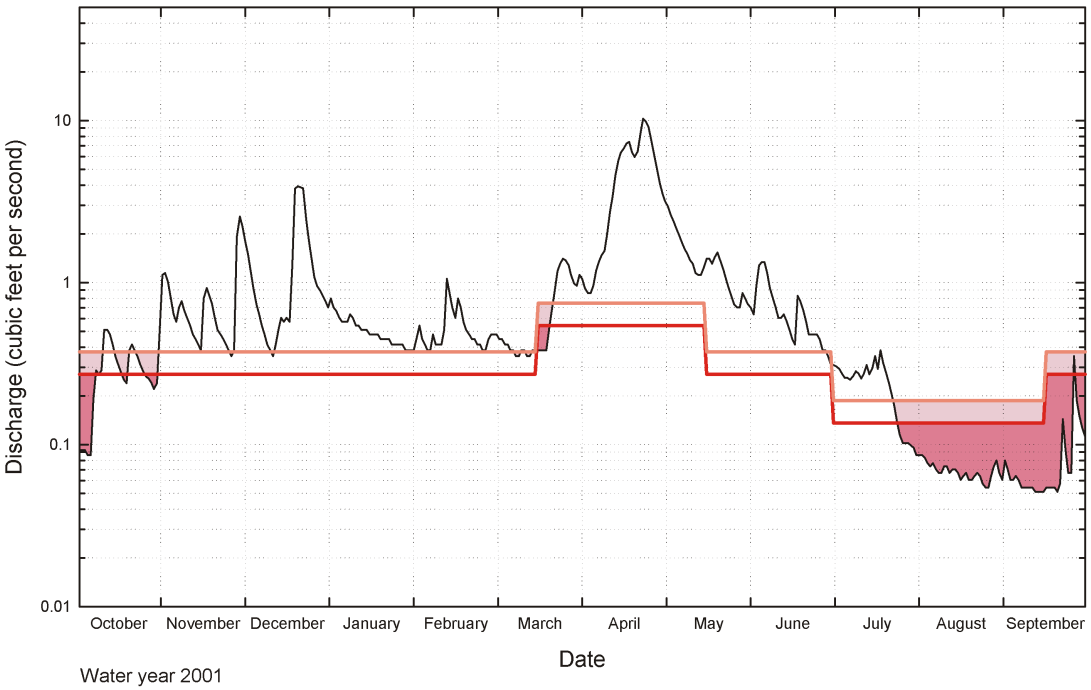
Water year 2002
Drainage area: 29.1 sq mi
Withdrawal threshold: Seasonal from Dudley (2003)

Old Stream near Wesley



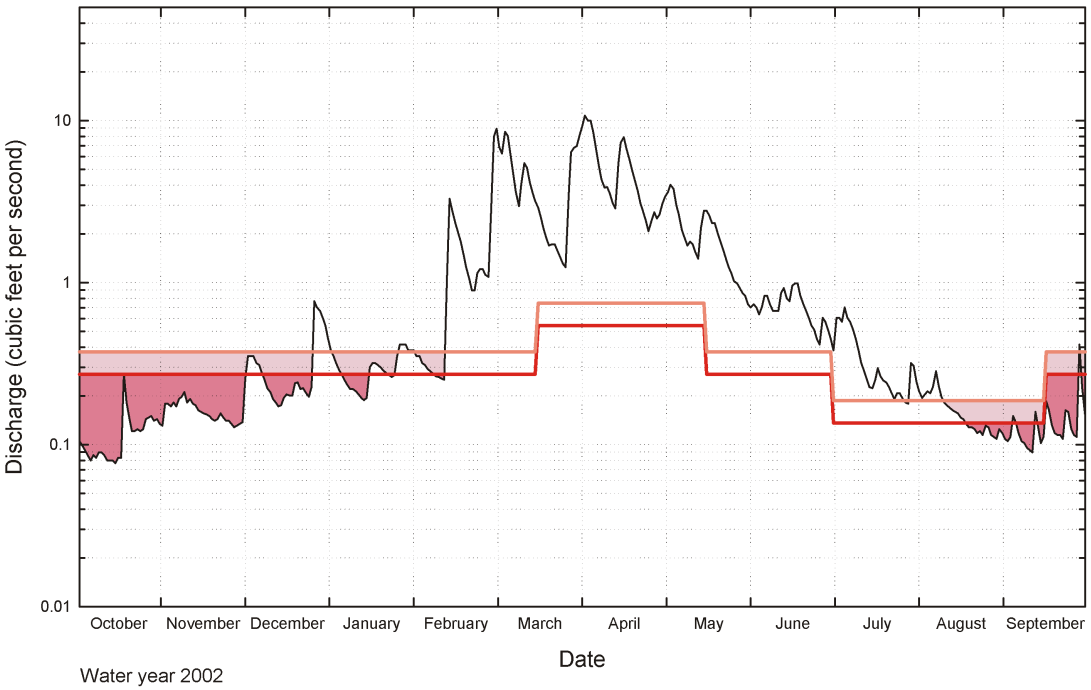
Water year 2003
Drainage area: 29.1 sq mi
Withdrawal threshold: Seasonal from Lombard (2004); 0-percent sand and gravel

Grower 50



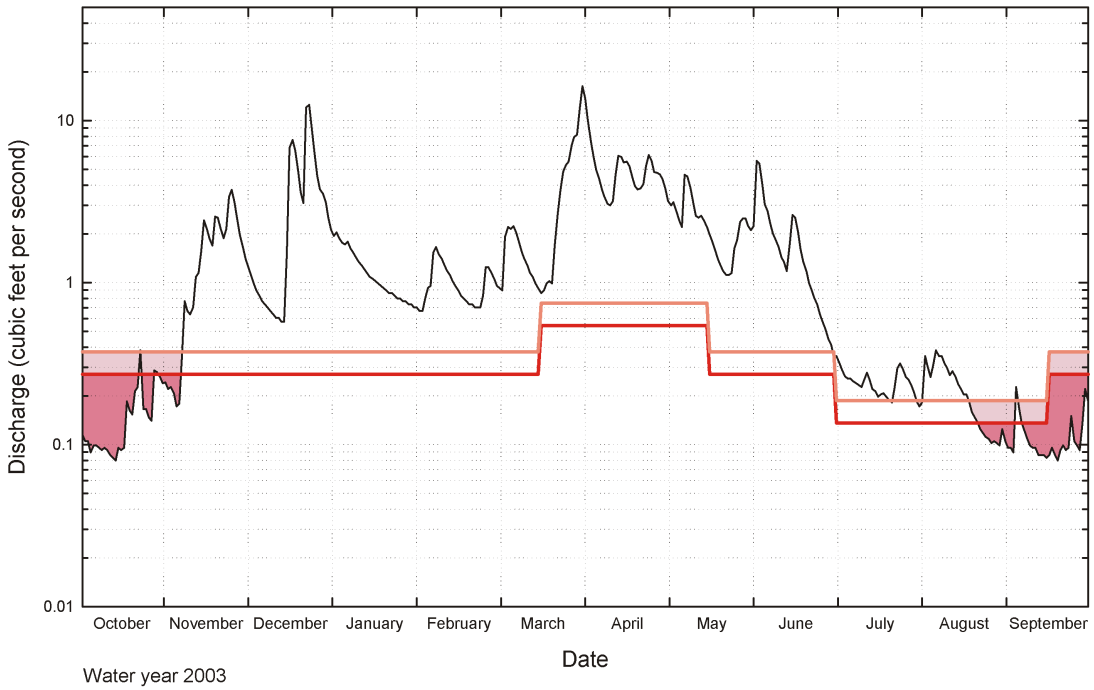
Water year 2001
Drainage area: 0.93 sq mi
Withdrawal threshold: Seasonal from Lombard (2004); 0-percent sand and gravel
Hydrograph: Old Stream near Wesley

Grower 50



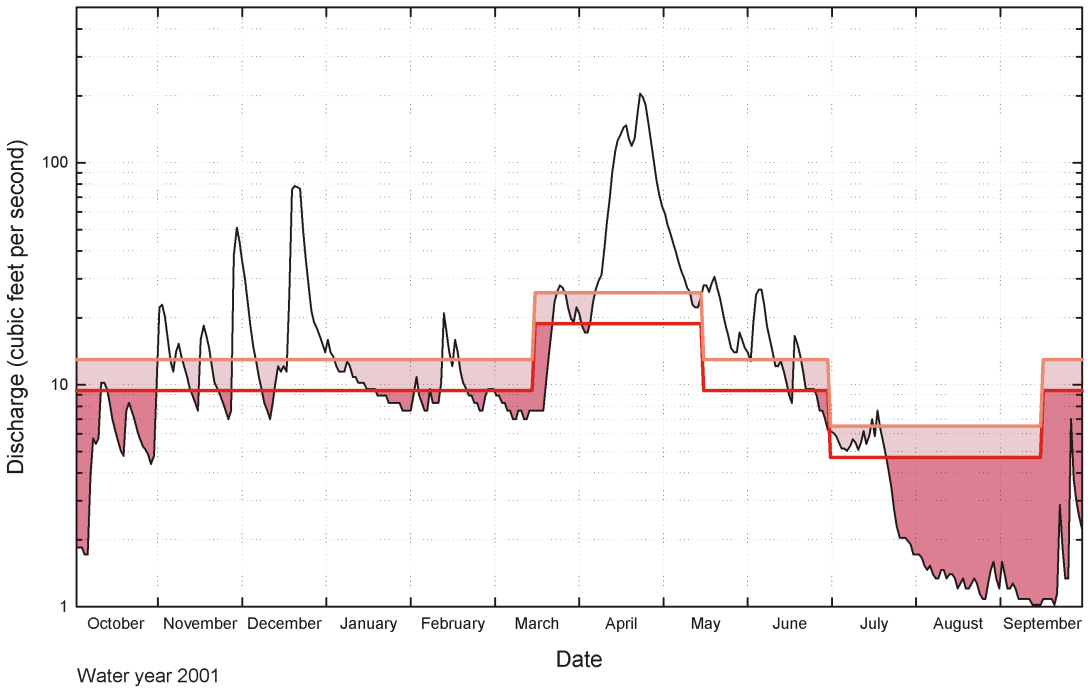
Water year 2002
Drainage area: 0.93 sq mi
Withdrawal threshold: Seasonal from Lombard (2004); 0-percent sand and gravel
Hydrograph: Old Stream near Wesley

Grower 50



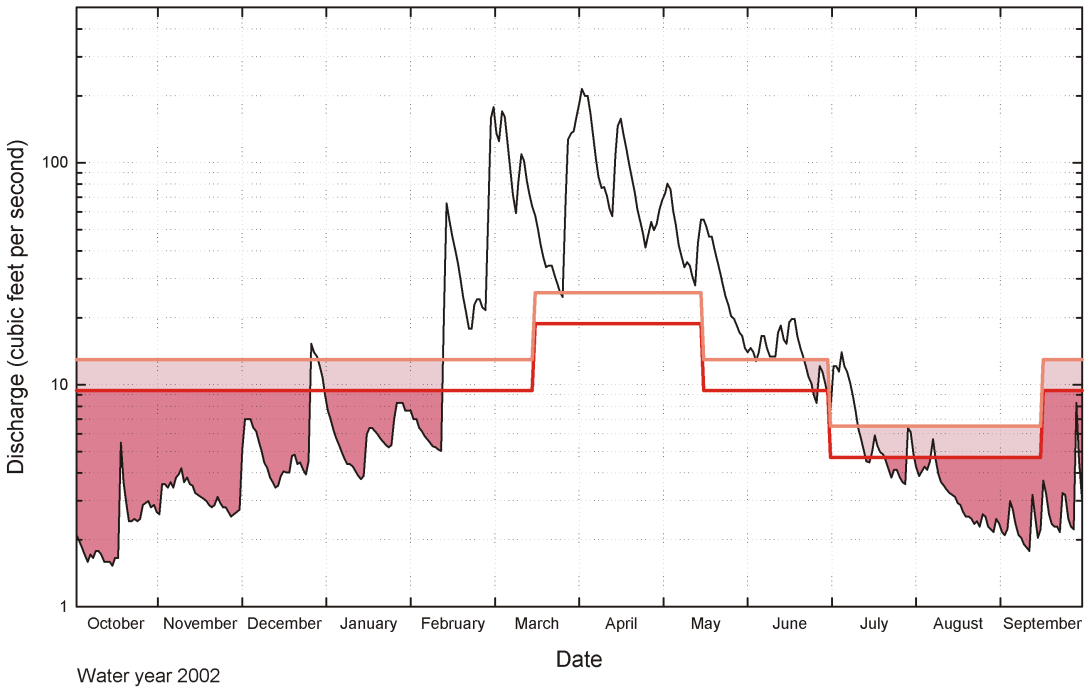
Water year 2003
Drainage area: 0.93 sq mi
Withdrawal threshold: Seasonal from Lombard (2004); 0-percent sand and gravel
Hydrograph: Old Stream near Wesley

Passamaquoddy



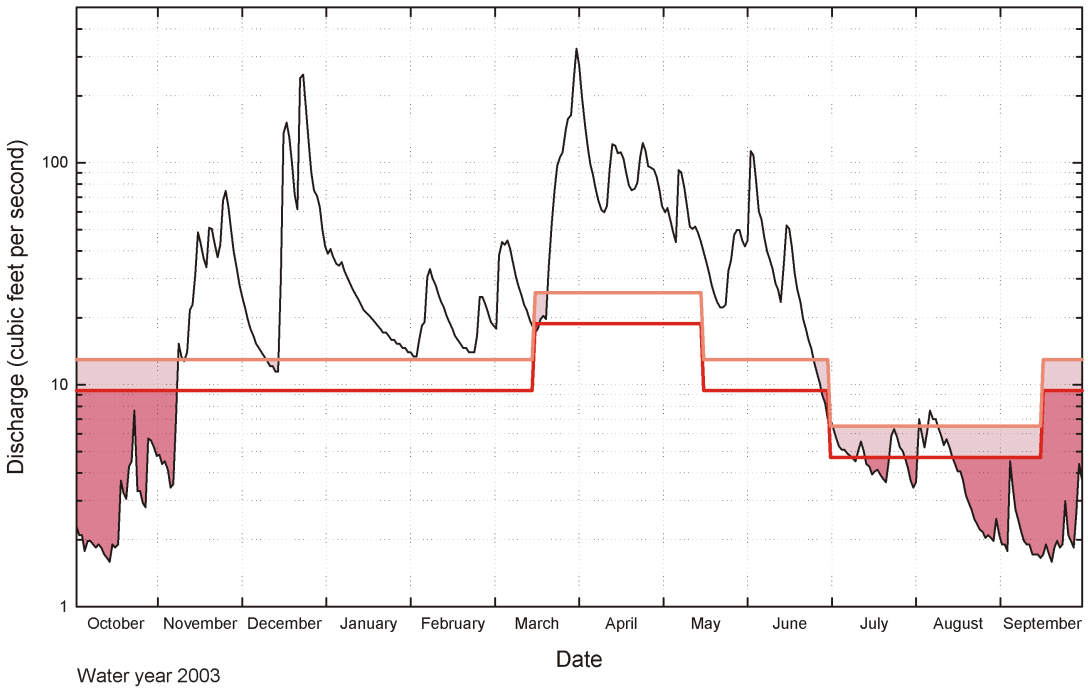
Water year 2001
Drainage area: 18.5 sq mi
Withdrawal threshold: Seasonal from Lombard (2004); 0-percent sand and gravel
Hydrograph: Old Stream near Wesley

Passamaquoddy



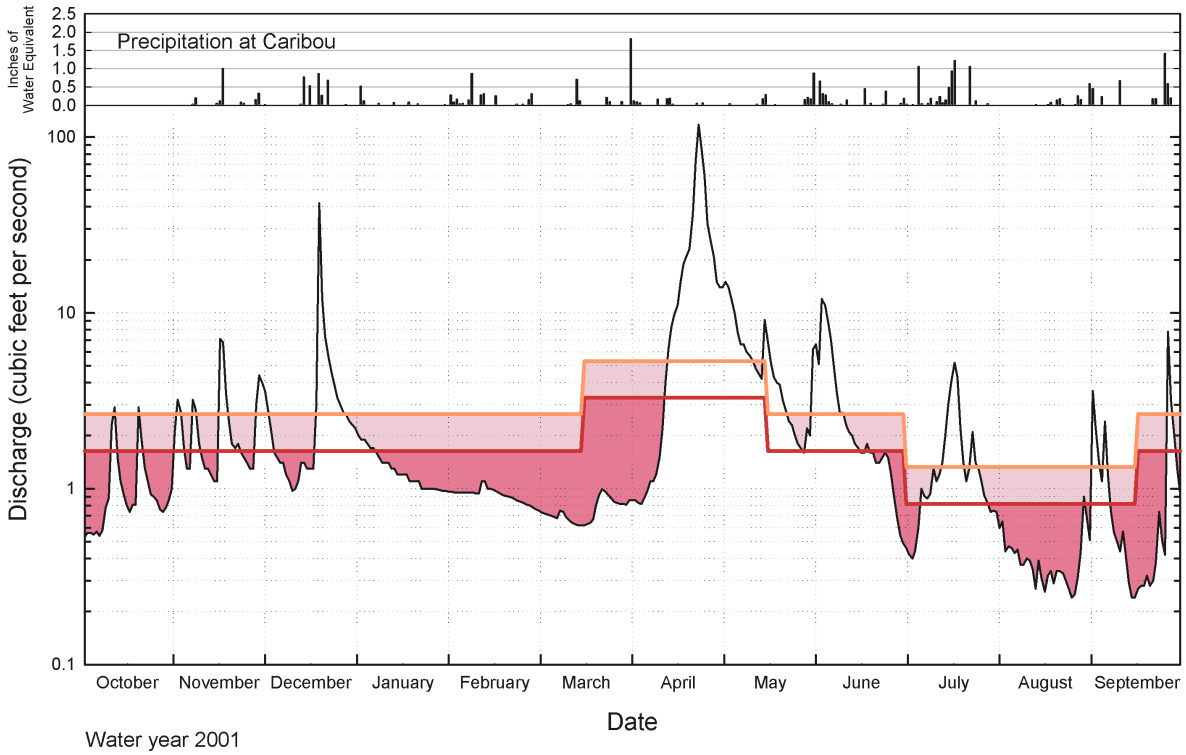
Water year 2002
Drainage area: 18.5 sq mi
Withdrawal threshold: Seasonal from Lombard (2004); 0-percent sand and gravel
Hydrograph: Old Stream near Wesley

Passamaquoddy



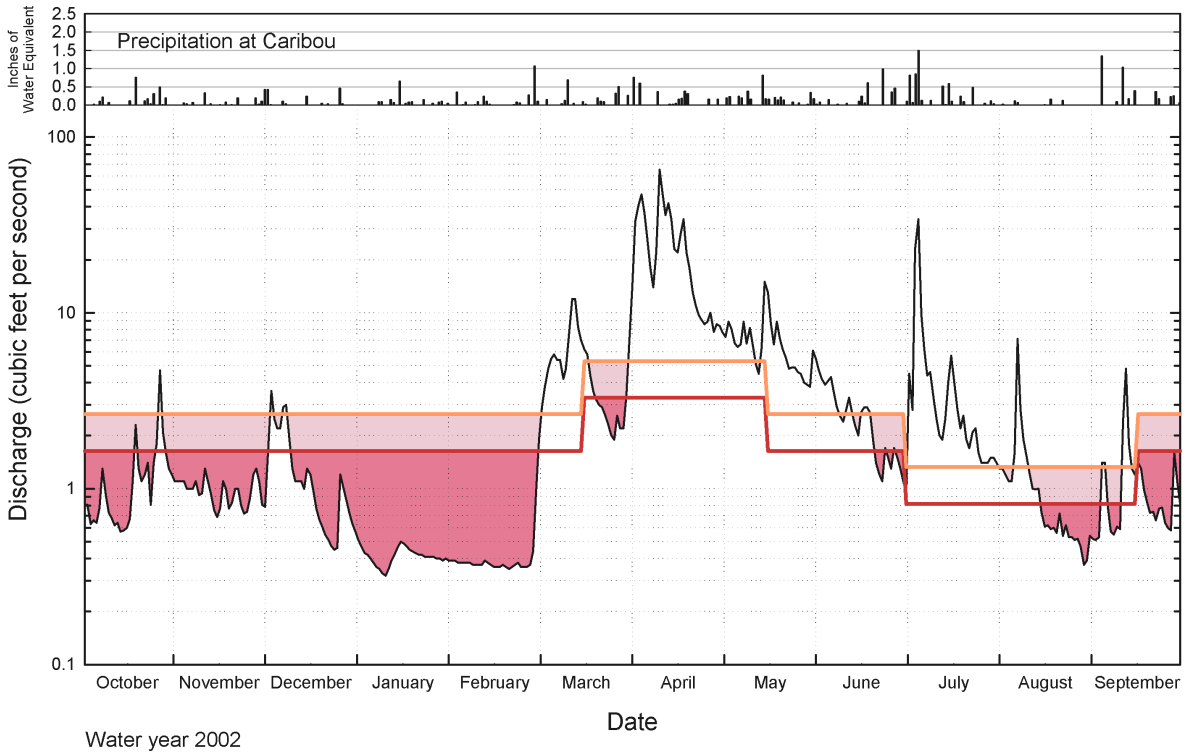
Water year 2003
Drainage area: 18.5 sq mi
Withdrawal threshold: Seasonal from Lombard (2004); 0-percent sand and gravel
Hydrograph: Old Stream near Wesley

Williams Brook near Phair



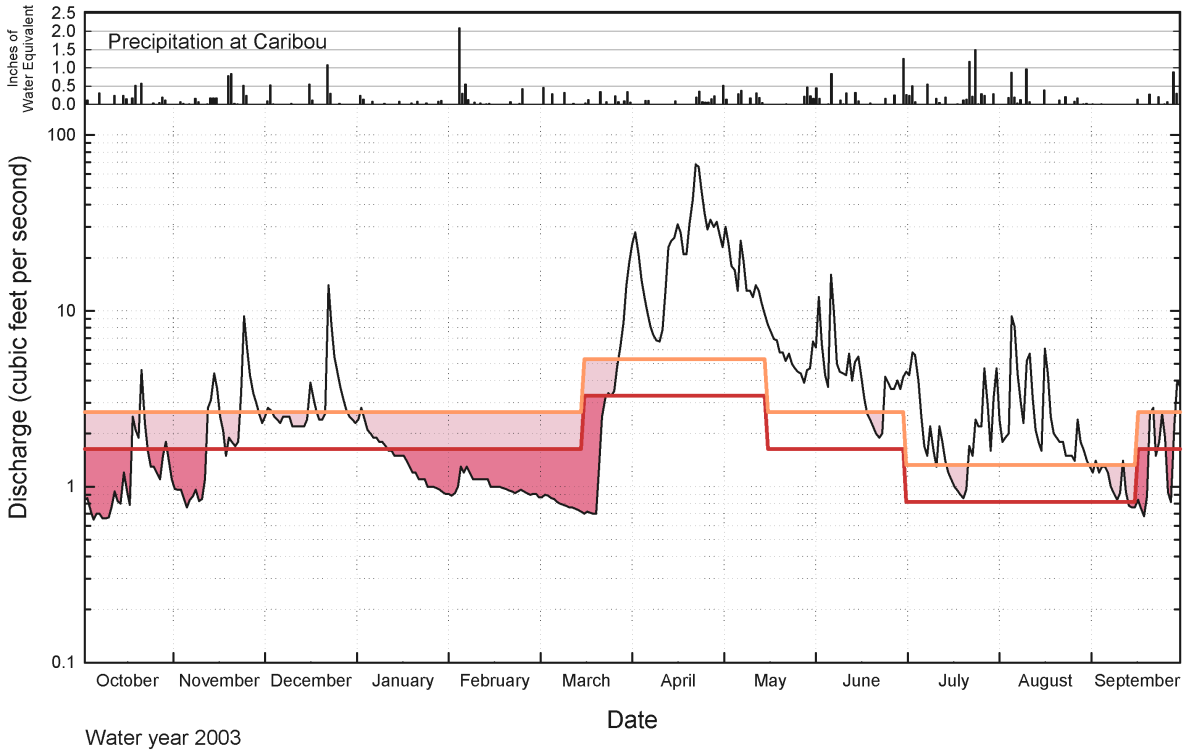
Water year 2001
Drainage area: 3.82 sq mi
Withdrawal threshold: Seasonal from Lombard and others (2003); 650 ft mean basin elevation

Williams Brook near Phair



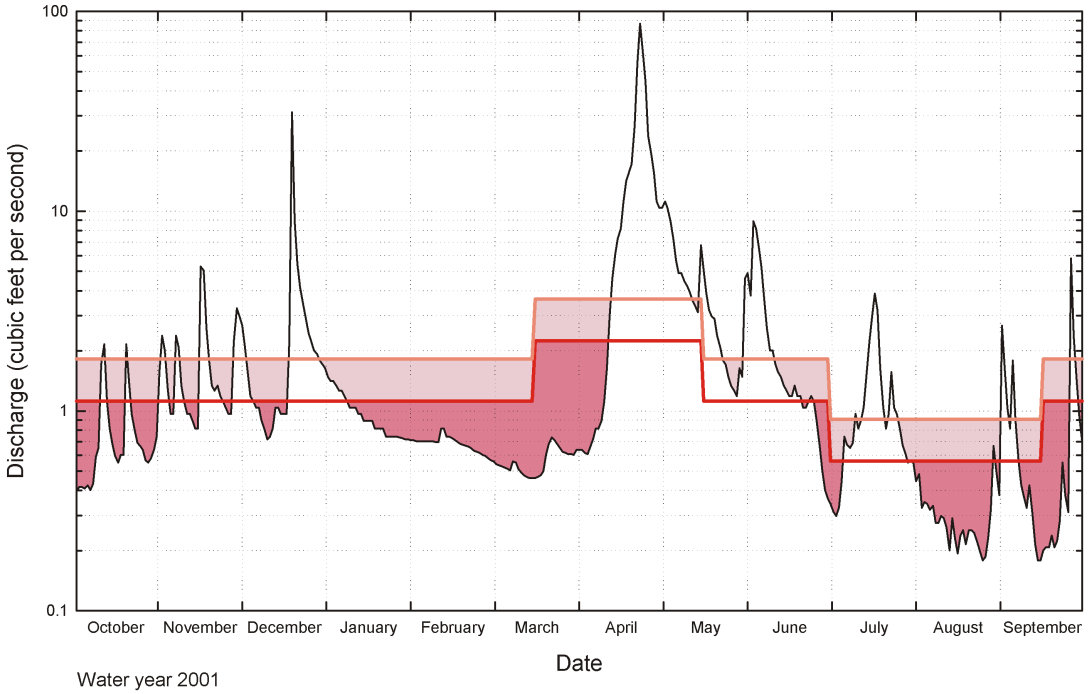
Water year 2002
Drainage area: 3.82 sq mi
Withdrawal threshold: Seasonal from Lombard and others (2003); 650 ft mean basin elevation

Williams Brook near Phair



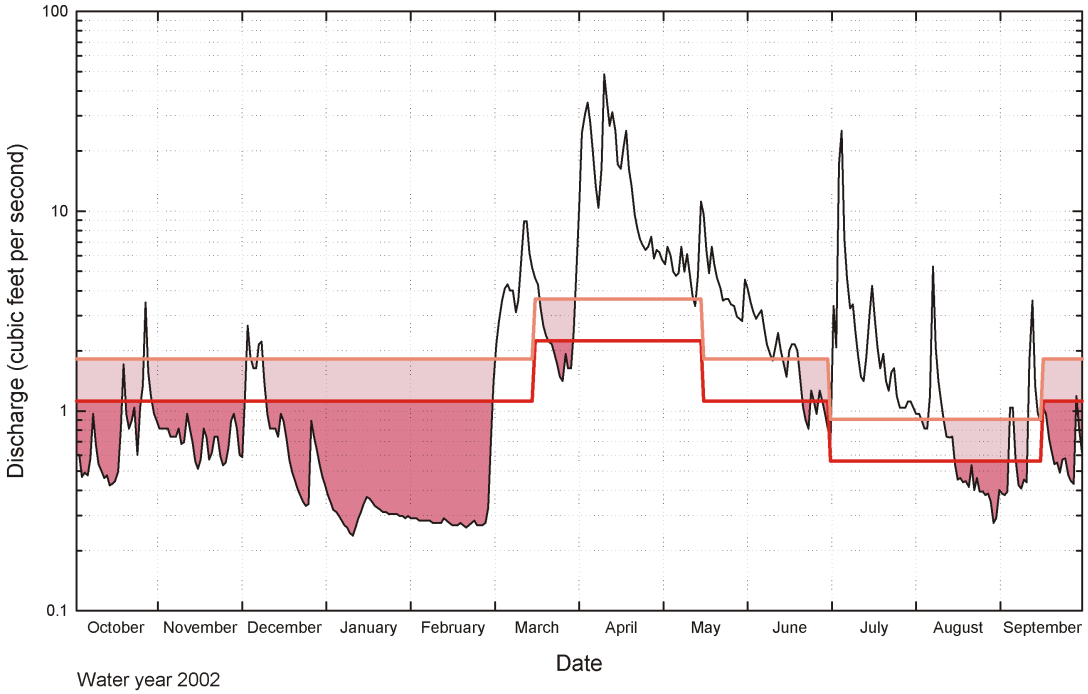
Water year 2003
Drainage area: 3.82 sq mi
Withdrawal threshold: Seasonal from Lombard and others (2003); 650 ft mean basin elevation

Grower 13



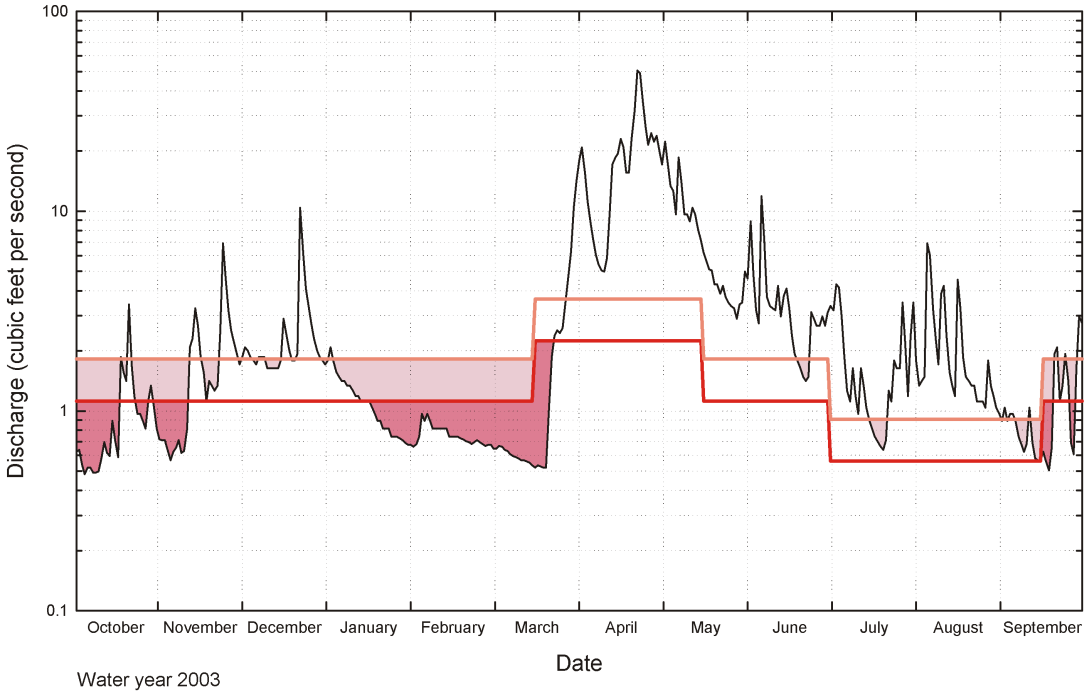
Water year 2001
Drainage area: 2.84 sq mi
Withdrawal threshold: Seasonal from Lombard and others (2003); 650 feet mean basin elevation
Hydrograph: Williams Brook near Phair

Grower 13



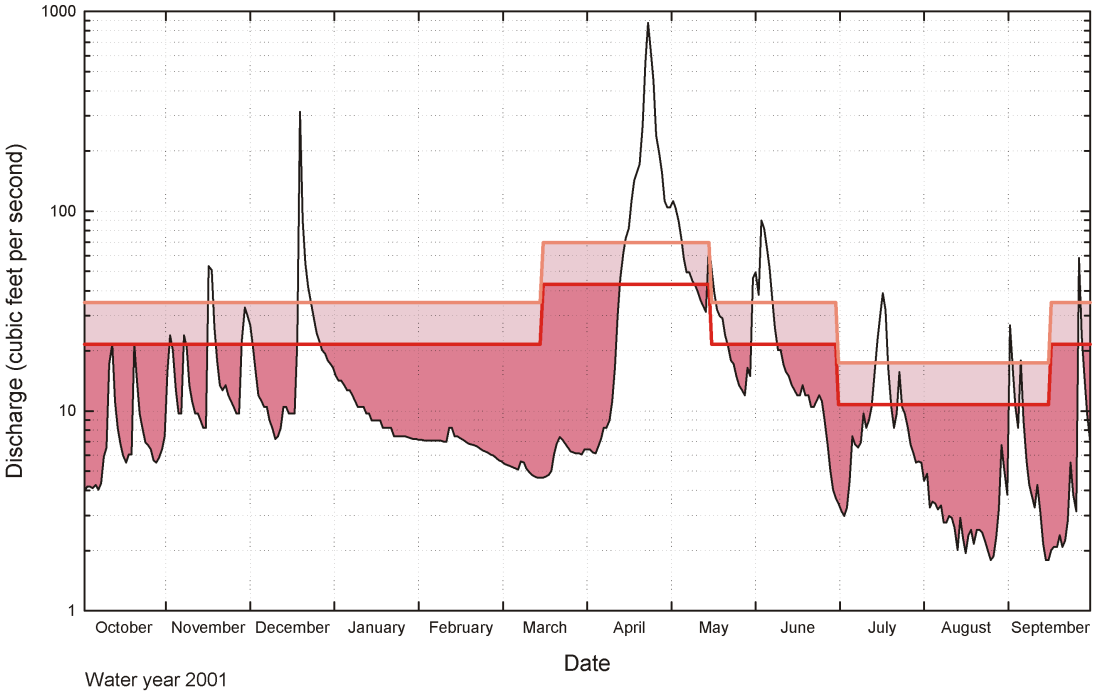
Water year 2002
Drainage area: 2.84 sq mi
Withdrawal threshold: Seasonal from Lombard and others (2003); 650 feet mean basin elevation
Hydrograph: Williams Brook near Phair

Grower 13



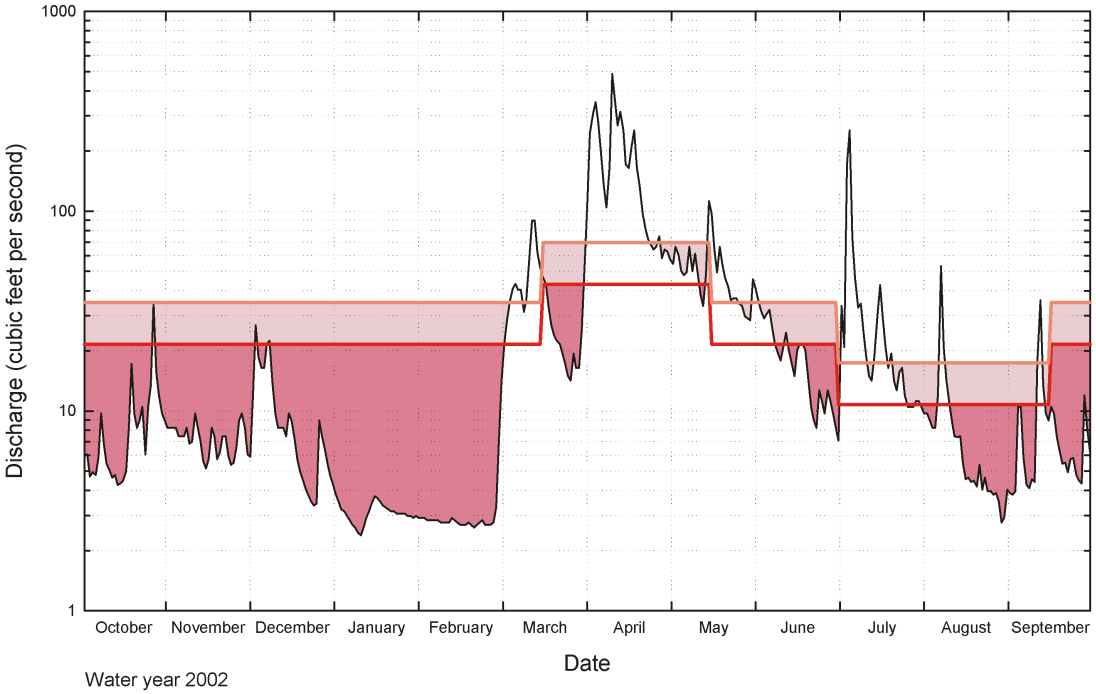
Water year 2003
Drainage area: 2.84 sq mi
Withdrawal threshold: Seasonal from Lombard and others (2003); 650 feet mean basin elevation
Hydrograph: Williams Brook near Phair

Fort Fairfield



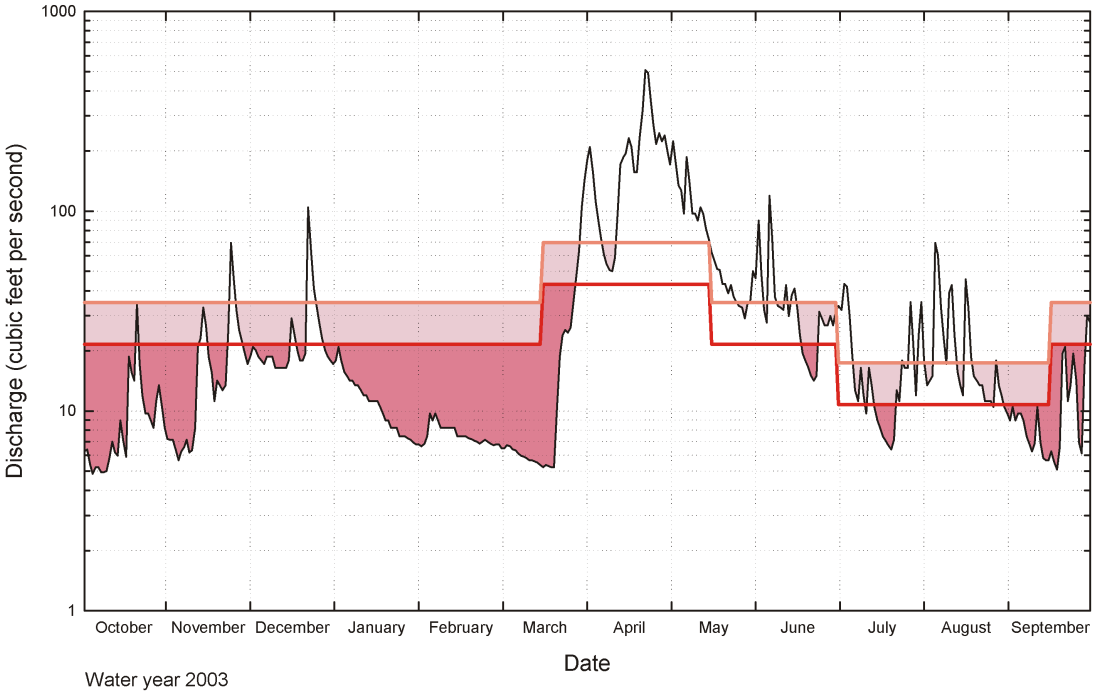
Water year 2001
Drainage area: 28.5 sq mi
Withdrawal threshold: Seasonal from Lombard and others (2003); 650 feet mean basin elevation
Hydrograph: Williams Brook near Phair

Fort Fairfield



Water year 2002
Drainage area: 28.5 sq mi
Withdrawal threshold: Seasonal from Lombard and others (2003); 650 feet mean basin elevation
Hydrograph: Williams Brook near Phair

Fort Fairfield



Water year 2003
Drainage area: 28.5 sq mi
Withdrawal threshold: Seasonal from Lombard and others (2003); 650 feet mean basin elevation
Hydrograph: Williams Brook near Phair