ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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Automated Streamflow Frequency and Recharge Estimation Tool for Streams and Watersheds in New Hampshire

Water resource management requires an understanding of the seasonal quantity of streamflow within a river's watershed and the amount of precipitation that is recharged into aquifers underlying watersheds.

Historically, the status of New Hampshire's rivers and streams is monitored by stream gaging stations, which measure the flow of water over a period of time, providing information on the amount and timing of surface water passing the station. Since it is not feasible to monitor all streams in the state, gaging stations are established at selected locations, and data for other watersheds are estimated by applying hydrologic principles. Similarly, because site-specific studies to determine aquifer recharge rates on an annual or seasonal basis are often not feasible for a given aquifer, the amount of recharge from precipitation that occurs can be estimated by citing studies in other watersheds with similar physical characteristics.

The New Hampshire Department of Environmental Services (NHDES) and United States Geological Survey (USGS) have developed analytical equations that estimate seasonal and annual streamflow and aquifer recharge rates at gauged and ungauged streams and watersheds for any part of the state. The equations were derived by regression analysis, which statistically relates the streamflow statistics for a group of data-collection stations to physical characteristics of the drainage basins for those stations. Physical characteristics for a site where no streamflow data are available can be measured and inserted into the regression equations to obtain estimates of streamflow quantiles and low-flow frequencies, and estimates of groundwater recharge for a selected site. The research behind the development of the streamflow equations is documented in a report titled, "Development of Regression Equations to Estimate Flow Durations and Low-Flow Frequency Statistics in New Hampshire Streams – WRI 02-4298." This report is on USGS' website. The research behind the development of the recharge equations hosted by USGS as well.

Regression analysis has a long tradition as a method of estimating streamflow at ungauged sites, but practical applications have been limited because, until recently, measurement of the physical watershed characteristics needed to both develop and solve the equations has been labor intensive and time consuming to perform. The resulting equations can be complex and therefore difficult to interpret and use. NHDES and the USGS have developed a Streamflow Statistics and Recharge Estimation Tool that eliminates these limitations. The tool automates the estimation procedure by integrating regression equations with digital coverages that describe the physical characteristics of a watershed in a geographic information system (GIS). This allows for streamflow frequency and recharge estimates to be developed within a few minutes for any reach of stream and watershed in New Hampshire.

In order to obtain an estimate of seasonal and annual streamflow frequencies and recharge rates, you must delineate the upstream watershed that drains to a selected pour point on a stream, and provide this information on a USGS topographic map at an appropriate scale for NHDES to digitize (see Figure 1). DES will then generate reports of recharge and streamflow frequency estimates similar to the reports shown in Tables 1 and 2 on the following pages. Data requests can be made to Derek Bennett at derek.bennett@des.nh.gov, (603) 271-6685 (phone), or (603) 271-0656 (FAX), or Gregory Barker at gregory.barker@des.nh.gov , (603) 271-7332 (phone), or (603) 271-3305 (FAX).

End-users of the streamflow frequency and recharge estimation tool are responsible for the accuracy and appropriateness of the delineation of the watershed for a given site. Similarly, users of the tool are responsible for understanding the applicability of the tool, limitations of the tool, and statistical errors of the regression equations as documented in the research reports referenced in this fact sheet.

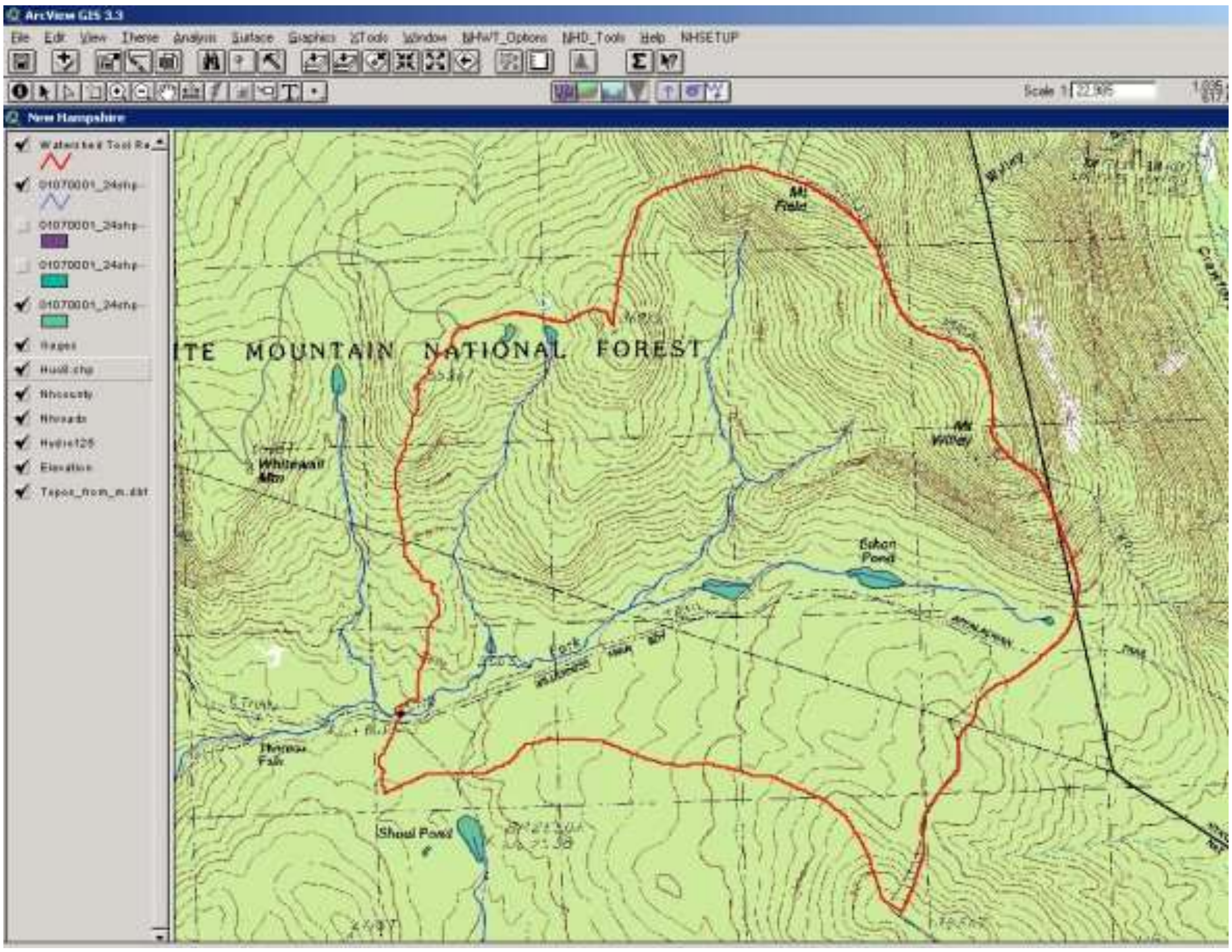

Figure 1: Typical Watershed Delineation with Pour Point Shown

Table 1: Typical Duration and Low Flow Estimates Output Reports

Duration and low flow estimates for North Fork East Branch Pemigewasset

Drainage area (sq. mi.)	3.60
Average basin slope (percent)	21.90
Max. basin elevation (ft.)	4315.65
Summer gage precip. (in.)	25.87
Spring gage precip. (in.)	12.56
Winter basin precip. (in.)	12.32
Mean annual temp. (F)	38.66
Mean summer temp. (F)	54.89
Percent coniferous	74.88
Percent coniferous/deciduous	21.10

Seasonal and period of record flow durations

SEASON	% TIME FLOW EXCEED.	FLOW FROM EQN.	Bias CORRECTED FLOW	+SE (%)	-SE (%)	90% Prediction Inv Upper	Lower
WINTER	60*	2.45	2.49	25.35	-20.22	3.57	1.68
	70*	2.08	2.12	24.68	-19.80	3.01	1.44
	80*	1.81	1.83	21.58	-17.75	2.50	1.30
	90*	1.42	1.45	22.92	-18.65	2.01	1.01
	95*	1.15	1.18	25.00	-20.00	1.68	0.79
	98*	0.95	0.98	33.54	-25.12	1.54	0.58
SPRING	60	9.57	9.64	13.23	-11.68	11.79	7.78
	70	7.39	7.43	12.33	-10.98	8.98	6.08
	80	5.55	5.59	13.27	-11.72	6.84	4.51
	90	3.75	3.78	14.76	-12.86	4.72	2.97
	95	2.69	2.72	16.08	-13.85	3.46	2.10
	98	1.98	2.01	19.89	-16.59	2.68	1.46
SUMMER	60*	2.60	2.73	50.12	-33.39	5.13	1.32
	70*	2.00	2.13	55.13	-35.54	4.18	0.96
	80*	1.98	2.13	59.86	-37.45	4.34	0.90
	90*	1.38	1.52	69.60	-41.04	3.34	0.57
	95*	1.09	1.23	79.62	-44.33	2.91	0.41
	98*	0.78	0.88	86.25	-46.31	2.20	0.27
FALL	60*	3.81	3.90	27.95	-21.85	5.76	2.53
	70*	2.99	3.07	31.38	-23.89	4.71	1.89
	80*	2.33	2.41	33.94	-25.34	3.80	1.43
	90*	1.58	1.65	39.15	-28.13	2.74	0.91
	95*	1.06	1.13	48.65	-32.73	2.06	0.55
	98*	0.69	0.77	66.87	-40.07	1.63	0.29
ALL RECORD	60*	4.61	4.68	21.75	-17.86	6.41	3.32
	70*	3.68	3.75	25.21	-20.14	5.37	2.53
	80*	2.72	2.81	35.45	-26.17	4.52	1.64
	90*	1.76	1.86	49.39	-33.06	3.45	0.90
	95*	1.24	1.34	59.35	-37.24	2.70	0.57
	98*	0.92	1.02	75.43	-43.00	2.35	0.36

Seasonal and annual seven-day flow statistics

WINTER	2*	1.85	1.88	20.84	-17.25	2.54	1.35
	10*	1.08	1.10	26.65	-21.04	1.60	0.72
SPRING	2*	2.74	2.76	17.73	-15.06	3.60	2.08
	10*	1.56	1.58	20.60	-17.08	2.14	1.14
SUMMER	2*	1.39	1.59	79.26	-44.22	3.69	0.52
	10*	0.76	0.96	117.89	-54.11	2.79	0.21
FALL	2*	2.37	2.43	28.07	-21.92	3.58	1.56
	10*	1.11	1.18	47.10	-32.02	2.11	0.58

ANNUAL	2*	1.26	1.45	78.61	-44.01	3.33	0.48
	10*	0.66	0.84	120.80	-54.71	2.48	0.17

Explanation of Terms Used in Table 1

Stream Flow Units – All flows are in cubic feet per second (ft^3/s)

Seasonal Periods for Flow Duration Estimates
Winter: January 1 – March 15
Spring: March 16 – May 31
Summer: June 1 – October 31
Fall: November 1 – December 31

Seasonal and Period of Record Flow Durations - %Time Flow Exceed: This is a flow duration statistic. For example, for the column labeled "% time flow exceed" and row labeled "95" represents the streamflow that is equaled or exceeded 95 percent of the time.

Seasonal and Annual Seven-Day Flow Statistics - %Time Flow Exceed: This is a low-flow frequency statistic. For example, the column labeled "% time flow exceed" and row labeled "2" provides the expected seasonal or annual minimum flow for seven days that is expected to not be exceeded in one of two years, or that has a 0.5 probability of not being exceeded in a given year. Similarly, the column labeled "% time flow exceed" and row labeled "10" provides the expected seasonal or annual minimum flow for seven days that is expected to not be exceeded in one of 10 years, or that has a 0.1 probability of not being exceeded in a given year.

Flow from Eqn: Flow from equation estimates flow in cubic feet per second for the specified flow duration with a 90 percent confidence prediction interval.

Bias Corrected Flow: Provides estimated flow based on the use of regression equations and the application of bias correction factors to correct bias that are inherent to the use of retransformed logarithmic equations.

+SE/-SE: Estimate of **standard error** is an estimate of the potential range of error associated the estimated flow values.

90% Prediction Inv (upper and lower): The 90% prediction interval means the confidence interval. This interval specifies a 90% level of assurance that the true value of the streamflow statistic for an ungaged site will be within the lower and upper interval.

Warning messages are provided when certain basin characteristics are outside the ranges of those sites used to develop regression equations. Limitations of the regression equations are documented in the research reports referenced in this fact sheet.

Table 2: Typical Recharge Estimation Reports

Annual recharge estimate for
North Fork East Branch Pemigewas
Annual centroid precipitation (ACP) = 64.72 inches
Percent coniferous (CNF) = 74.88
Annual gage precipitation (AGP) = 62.17 inches
Jan-Mar basin temperature (WBT) = 7.99 degrees F
Spring gage precipitation (SPP) = 12.56 inches
Annual snow accumulation (ASC) = 180.52 inches
Summer gage precipitation (SUP) = 25.87 inches
Annual basin temperature (ABT) = 38.66 degrees F
Percent mixed conifer/deciduous(MCD) = 21.10
Autumn centroid precipitation (FCP) = 12.68 inches

**WARNING: CNF out of range of observations 3.07 to 56.20
**WARNING: AGP out of range of observations 35.80 to 53.10
**WARNING: SPP out of range of observations 6.83 to 11.54
**WARNING: SUP out of range of observations 16.46 to 23.11

SEASON	RECHARGE (INCHES)	STANDARD ERROR OF PREDICTION	90% PREDICTION INTERVALS UPPER	LOWER
ANNUAL	22.96	3.26	28.43	17.49
WINTER	4.77	0.93	6.33	3.22
SPRING	13.29	1.45	15.72	10.86
SUMMER	9.12	1.31	11.33	6.92
AUTUMN	3.08	0.71	4.27	1.89

Explanation of Terms Used in Table 2

Seasonal Periods for Recharge Estimates
Winter: January 1 – March 15
Spring: March 16 – May 31
Summer: June 1 – October 31
Fall: November 1 – December 31

Standard Error of Prediction: Estimate of "standard error of prediction" is an estimate of the potential error associated with the recharge estimate.

90% Prediction Inv (upper and lower): The 90% prediction interval means the confidence interval. This interval specifies a 90% level of assurance that the true value of the recharge for ungaged watersheds site will be within the lower and upper interval.

Warning messages are provided when certain basin characteristics are outside the ranges of those sites used to develop regression equations. Limitations of the regression equations are documented in the research reports referenced in this fact sheet.

For More Information
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