WATER RESOURCES DIVISION POLICY AND PROCEDURE

WRD-049 – Index Flow (50 Percent Exceedance Flow) Determination

Effective Date: January 15, 2019
Last Reviewed Date:
Last Revision Date:
Distribution: Groundwater Discharge Permits Program,
Surface Water Quality Program

ISSUE

Provides a procedure to determine the Index Flow (50 Percent Exceedance Flow) during a Site-Specific Review.

DEFINITIONS

ArcMap	Geographical Information System (GIS) software by ESRI, INC.
cfs	Cubic Feet per Second
DA	Drainage Area
DAR	Drainage Area Ratio
GLSU	Great Lakes Shorelands Unit
HSDSU	Hydrologic Studies and Dam Safety Unit
IF	Index Flow
MM	Miscellaneous measurements
SSR	Site Specific Review
SWAS	Surface Water Assessment Section
USGS	United States Geological Survey
WMA	Water Management Area
WRD	Water Resources Division

PROCEDURE

Step	Who	Does What
1.	GLSU Staff	Receives an SSR request and determines if an IF has been calculated for the impacted WMAs during a previous SSR.
2.	GLSU Staff	Email HSDSU staff a copy of the water withdrawal registration stating that an SSR is needed and requests the determination of the IF for the impacted WMA.
3.	HSDSU Staff	Computes the low flow values using the appropriate methodology based on the information available for the site. Each of the methods requires knowledge of its limitations, and professional judgement is required in the proper application of the methods. Each method uses data collected at USGS long-term water surface gaging stations (gaging stations). Three criteria are used in choosing the most appropriate gaging station: the proximity of the site to the gaging station (preferably within the same watershed); period of record, preferably a gaging station with a severe drought and/or longer period of record; and similar geology and land use between the site and the gaging station. Based on the above criteria the following methods are used: a) If there are no flow measurements at the site, flows are computed based on the flow at a gaging station, adjusted by the ratio of the DA between the site and the gaging station. The DAR uses the following equation: $Q_{site} = (DA_{site}/DA_{gage}) * Q_{gage}$ where Q is the stream flow (cfs) b) If there are MM located at the WMA, or surrounding WMA with similar characteristics, a correlation analysis is performed between the MMs and the daily values at the gaging station. The design flow is computed as follows: $Q_{site} = a * DA_{site}*(Q_{gage} /DA_{gage})^b$ Where a and b are the linear correlation coefficients (intercept and slope) determined from the regression analysis between the mean daily yield values (flow divided by drainage area in cfs per square mile) at the gaging station vs. instantaneous yield values at the site, on a logarithmic scale.

Step	Who	Does What
3. (cont)	HSDSU Staff	c) If there are less than four measurements, the DAR method is used and the computed flows are adjusted by the ratio of the watershed yield (cfs per square mile) between the site and the gaging station. When the flow at the gaging station is regulated by dams or other control structures, the flows are adjusted to reflect any additions or withdrawals. d) Other methods are also used: addition or subtraction of flow values of gaging stations, prorating of upstream and downstream gaging stations and the use of a gaging station for the summer months and another gaging station for the other months. IF there are no MMs at the home WMA or surrounding WMAs and no close-by gaging stations with similar geology as the WMA being studied, other gaging stations can be considered for the analysis above. If the analysis with different gaging stations yields conflicting results, the decision will be made using best hydrogeological judgment, and on a case-by-case basis, whether to use an averaged value based on the different results found from different gaging stations, and/or collect field measurements to support our determination or default to the IF value predicted by the Water Withdrawal Assessment Tool with the elimination of the safety factor of 50 percent. Examples of the most common methodologies are provided in Appendix 1.
4.	GLSU Staff	Calculates new cutoffs based on the new IF and makes cutoff corrections into the Water Withdrawal Assessment Tool's Account Table.
5.	GLSU Staff	Calculates depletions and determines whether an adverse resource impact will occur.
6.	GLSU Staff	Adds comments to the Water Withdrawal Assessment Tool's Account and Transaction tables.

APPENDICES

APPENDIX 1: EXAMPLES OF INDEX FLOW DETERMINATION METHODOLOGY

APPROVING AUTHORITY

Teresa Seidel, Director
Water Resources Division

HISTORY

Policy No.	Action	Date	Title
	Original		Index Flow (50 Percent Exceedance Flow) Determination

CONTACT/UPDATE RESPONSIBILITY

Any questions or concerns regarding this policy and procedure should be directed to Mr. Mario Fusco, Supervisor, Hydrologic Studies and Dam Safety Unit, Water Resources Division.

A DEQ policy and procedure cannot establish regulatory requirements for parties outside of the DEQ. This document provides direction to DEQ staff regarding the implementation of rules and laws administered by the DEQ. It is merely explanatory, does not affect the rights of or procedures and practices available to the public, and does not have the force and effect of law. DEQ staff shall follow the directions contained in this document.

APPENDIX 1

EXAMPLES OF INDEX FLOW DETERMINATION METHODOLOGY

All methodology examples in this appendix will be applied to Water Withdrawal Assessment Tool water management area ID No. 10368, Wanadoga Creek, located in Barry, Eaton, and Calhoun County. The watershed drainage area is equal to 54.2 square miles and the QE50 (50 percent exceedance flow or IF) was determined by the Water Withdrawal Assessment Tool to be equal to 18.7 cfs. This watershed was chosen because it has a gaging station on it, Gaging Station 04104945, with period of record from 1994 to the present, and also two sets of miscellaneous measurements with dates outside the Gaging Station's period of record.

EXAMPLE 1:

This example demonstrates the simplest method, where there is a gaging station located at the WMA and the IF is computed using the DAR with the WMA of the gaging station. The gaging station is located at the southern end of the watershed and it has a contributing drainage area of 48.3 square miles. The WMA 10368 is depicted in Figure 1.

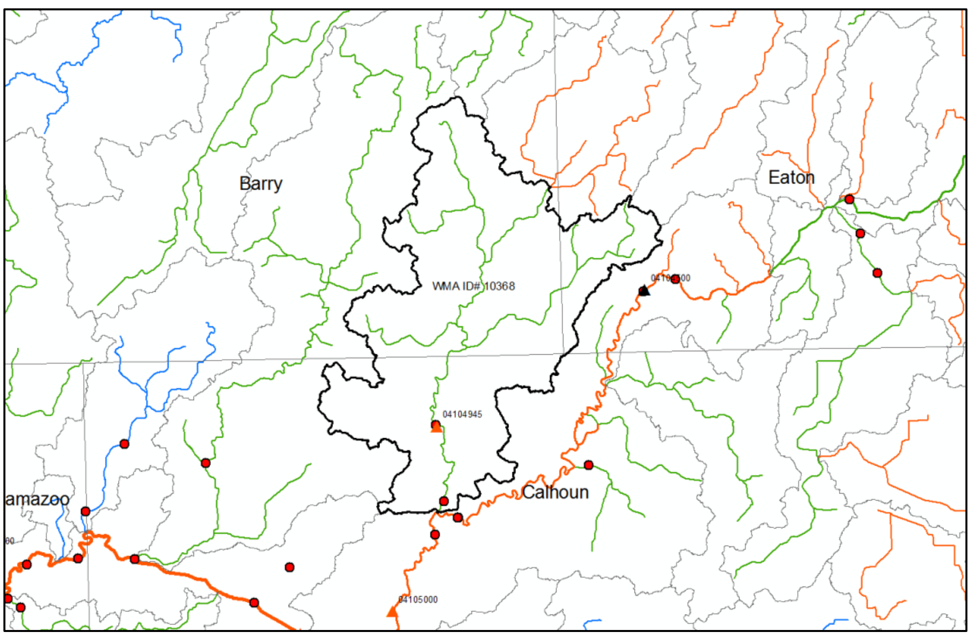
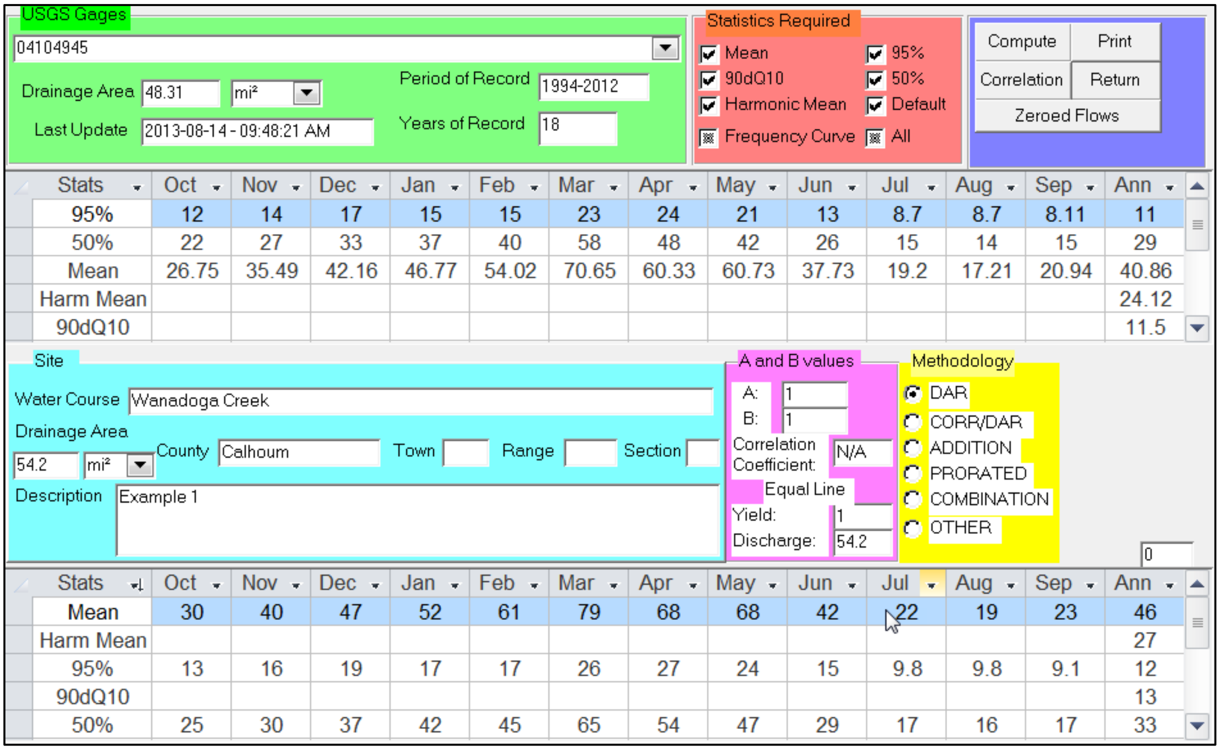


Figure 1. WMA ID No. 10368 showing Gaging Station ID No. 04104945

The Department of Environmental Quality (DEQ) uses its in-house database developed by Mr. Marlio Lesmez, Ph.D., P.E., to perform the calculations following the equations given in the methods section of the guidance. The results printout page is shown below in Figure 2. The IF is equal to 16 cfs, the smallest summer month 50 percent exceedance flow.


USGS Gages: 04104945
Drainage Area 48.31 mi²
Last Update 2013-08-14 - 09:48:21 AM
Period of Record 1994-2012
Years of Record 18

Statistics Required: Mean, 90dQ10, Harmonic Mean, Frequency Curve, 95%, 50%, Default, All

Compute | Print | Correlation | Return | Zeroed Flows

Stats	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
95%	12	14	17	15	15	23	24	21	13	8.7	8.7	8.11	11
50%	22	27	33	37	40	58	48	42	26	15	14	15	29
Mean	26.75	35.49	42.16	46.77	54.02	70.65	60.33	60.73	37.73	19.2	17.21	20.94	40.86
Harm Mean													24.12
90dQ10													11.5

Site
Water Course Wanadoga Creek
Drainage Area 54.2 mi²
County Calhoum Town Range Section
Description Example 1

A and B values
A: 1
B: 1
Correlation Coefficient: N/A
Equal Line
Yield: 1
Discharge: 54.2

Methodology: DAR, CORR/DAR, ADDITION, PRORATED, COMBINATION, OTHER

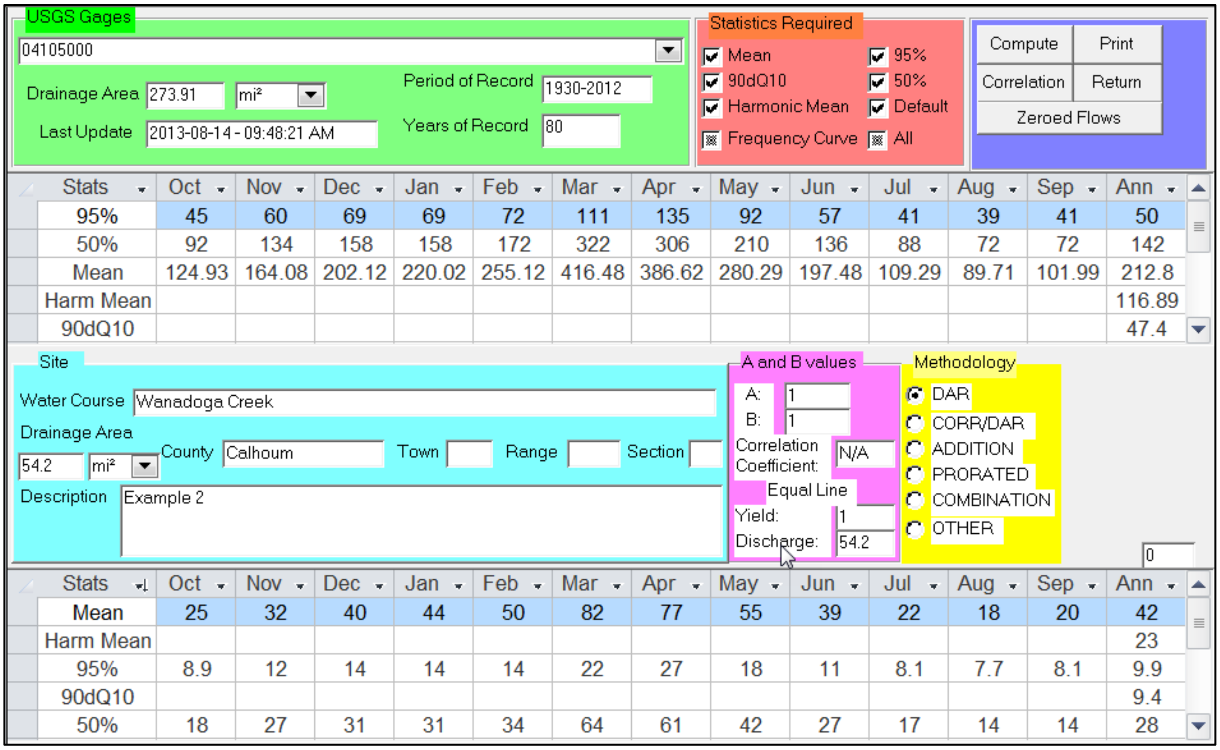
0

Stats	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
Mean	30	40	47	52	61	79	68	68	42	22	19	23	46
Harm Mean													27
95%	13	16	19	17	17	26	27	24	15	9.8	9.8	9.1	12
90dQ10													13
50%	25	30	37	42	45	65	54	47	29	17	16	17	33

Figure 2. DAR method with Gaging Station ID No. 04104945.

EXAMPLE 2:

This example still uses the DAR method. In this situation there is no gaging station at the WMA. In this example it was assumed that Gaging Station ID No. 04104945 did not exist and a close-by gaging station with similar geology would have to be chosen. Upon inspection we found that there is a Gaging Station, ID No. 04105000, on the Battle Creek at Battle Creek, Michigan, just downstream of WMA 10368. Similar to Example 1, the DEQ in-house database was used and it yields an IF value equal to 14 cfs as shown in Figure 3 below.



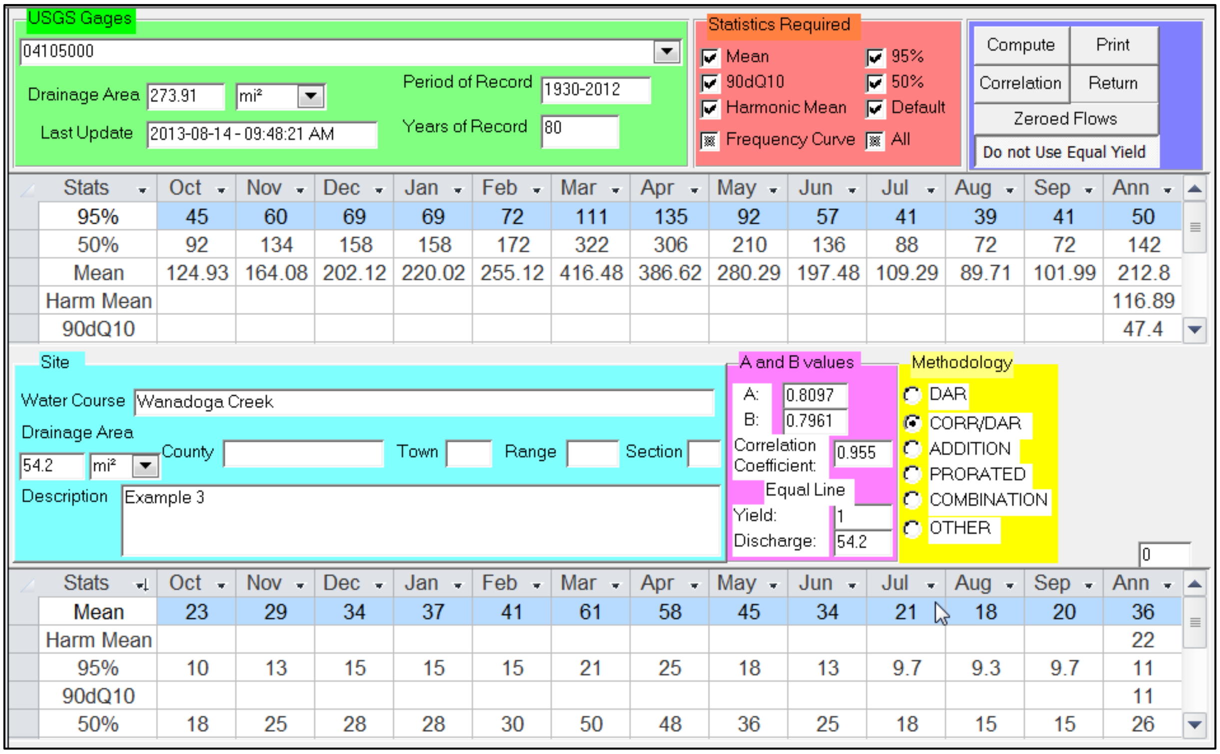
Stats	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
95%	45	60	69	69	72	111	135	92	57	41	39	41	50
50%	92	134	158	158	172	322	306	210	136	88	72	72	142
Mean	124.93	164.08	202.12	220.02	255.12	416.48	386.62	280.29	197.48	109.29	89.71	101.99	212.8
Harm Mean													116.89
90dQ10													47.4

Stats	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
Mean	25	32	40	44	50	82	77	55	39	22	18	20	42
Harm Mean													23
95%	8.9	12	14	14	14	22	27	18	11	8.1	7.7	8.1	9.9
90dQ10													9.4
50%	18	27	31	31	34	64	61	42	27	17	14	14	28

Figure 3. DAR method with Gaging Station ID No. 0410500, outside WMA.

EXAMPLE 3:

This example shows the correlation method (Hirsh, 1982) where there is at least a set of MMs with a minimum of four measurements in the watershed. In WMA 10368 there are two sets of MMs, the first at Gaging Station ID No. 04104945 with five measurements and the second at Gaging Station ID No. 04104950 with 18 measurements. Both sets of measurements can be used in the computations but if the number of measurements allows, the data outside the growing season (May to October) should not be used. Care should be taken to only use the data of the more downstream location if measurements were taken on the same day. The correlation in this example was done with Gaging Station ID No. 04105000 Battle Creek at Battle Creek, MI. Figure 4 shows the result table of the DEQ database for this situation, Figure 5 shows plot of the regression analysis, and Figure 6 shows the printout page of the correlation analysis.



Stats	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
95%	45	60	69	69	72	111	135	92	57	41	39	41	50
50%	92	134	158	158	172	322	306	210	136	88	72	72	142
Mean	124.93	164.08	202.12	220.02	255.12	416.48	386.62	280.29	197.48	109.29	89.71	101.99	212.8
Harm Mean													116.89
90dQ10													47.4

Stats	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
Mean	23	29	34	37	41	61	58	45	34	21	18	20	36
Harm Mean													22
95%	10	13	15	15	15	21	25	18	13	9.7	9.3	9.7	11
90dQ10													11
50%	18	25	28	28	30	50	48	36	25	18	15	15	26

Figure 4. Correlation method with Gaging Station ID No. 0410500, outside WMA.

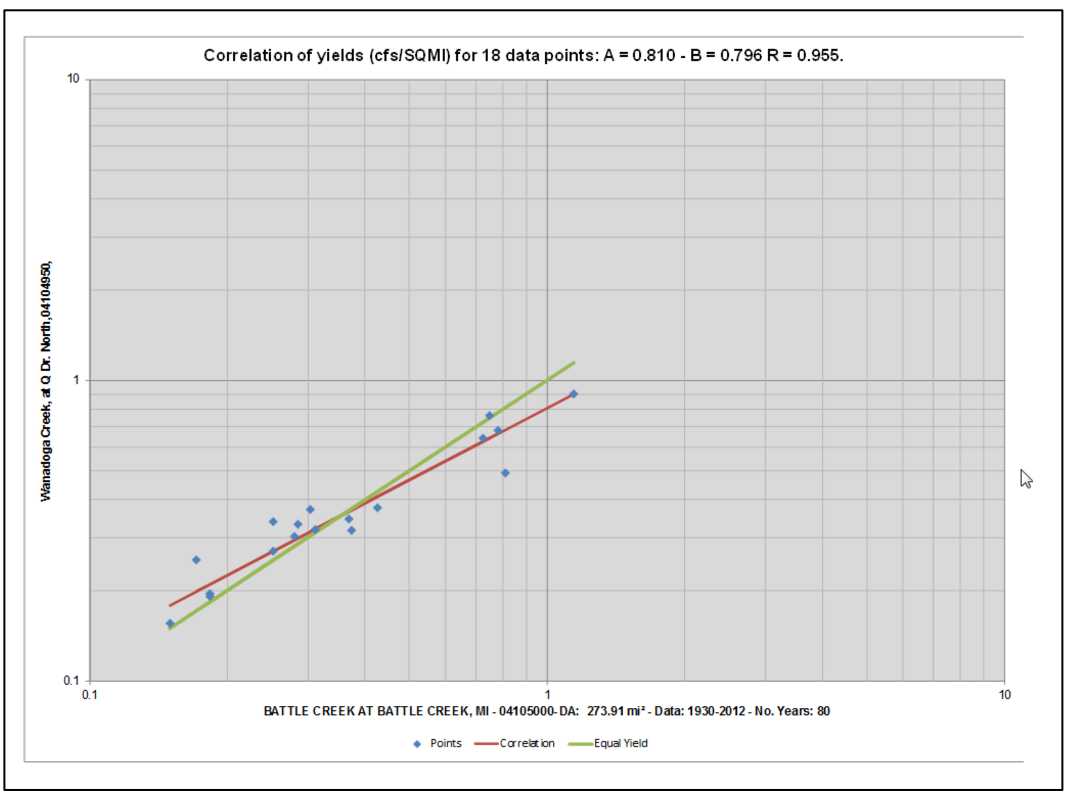


Figure 5. Correlation plot, multiple miscellaneous sites vs. Gaging Station ID No. 04105000.

MDEQ
Geological and Land Management Division

Low Flow Computations
Correlation
Tuesday, October 18, 2016

Hydrologic Studies Unit

Long-Term Station: BATTLE CREEK AT BATTLE CREEK, MI - 04105000- DA: 273.91 mi² - Data: 1930-2012 - No. Years: 80

Added Flow: 0

Short-Term Station: Wanadoga Creek, at Q Dr. North,04104950,

0

Coefficients: A = 0.8096 **B =** 0.7961 **Correlation Coefficient** 0.955 **Number of Data Points** 18

Statistics Derived By MOVE1

Mean of Concurrent Record at Long-Term Station	-0.446	Mean of Extended Record at Long-Term Station	-0.155
Standard Deviation at Long-Term Station	0.2648	Standard Deviation at Long-Term Station	2E-06
Mean of Concurrent Record at Short-Term Station	-0.446	Mean of Totalt Record at Long-Term Station	-0.417
Standard Deviation at Short-Term Station	0.2108	Standard Deviation at Long-Term Station	0.2659
Correlation Coreffficient for Concurrent Record	0.9554	Mean of Total Derived Record at Short-Term Station	2672
Alpha Parameter Used in Computations	1.9833	Standard Deviation at Short-Term Station	0.2116

	Long Station				Short Station				
Num	Date	Flow	Area	Yield	Date	Flow	Area	Yield	Exp Flow
6	1964.10.17	41	273.91	0.1497	10/17/1964	8.28	53.47	0.1549	9.544789
1	1973.07.25	222	273.91	0.8105	7/25/1973	23.7	48.31	0.4906	33.08898
2	1974.06.06	198	273.91	0.7229	6/6/1974	31	48.31	0.6417	30.20836
3	1974.07.19	78	273.91	0.2848	7/19/1974	16	48.31	0.3312	14.38967
4	1974.09.26	69	273.91	0.2519	9/26/1974	16.3	48.31	0.3374	13.05156
8	1983.06.09	313	273.91	1.1427	6/9/1983	47.9	53.47	0.8958	48.14231
9	1983.07.08	101	273.91	0.3687	7/8/1983	18.4	53.47	0.3441	19.56443
10	1983.08.09	77	273.91	0.2811	8/9/1983	16.1	53.47	0.3011	15.76387
12	1989.07.12	103	273.91	0.3760	7/12/1989	16.9	53.47	0.3161	19.87223
13	1989.08.23	83	273.91	0.3030	8/23/1989	19.8	53.47	0.3703	16.73422
14	1989.10.04	85	273.91	0.3103	10/4/1989	17	53.47	0.3179	17.05445
16	1990.05.02	214	273.91	0.7813	5/2/1990	36.3	53.47	0.6789	35.56865
17	1990.06.13	117	273.91	0.4271	6/13/1990	20.1	53.47	0.3759	21.99426
18	1990.07.24	206	273.91	0.7521	7/24/1990	40.6	53.47	0.7593	34.50601
19	1990.09.05	69	273.91	0.2519	9/5/1990	14.4	53.47	0.2693	14.4456
20	1999.08.03	50	273.91	0.1825	8/3/1999	10.2	53.47	0.1908	11.17837
21	1999.08.03	50	273.91	0.1825	8/3/1999	10.4	53.47	0.1945	11.17837
22	1999.10.27	47	273.91	0.1716	10/27/1999	13.5	53.47	0.2525	10.64108

Calculations extend the Short-Term streamflow record based on the maintenance of variance extension technique developed by USGS, Reston, Virginia, 1982. Source: R.M. Hirsch, "A Comparison of Four Streamflow Record Extension Techniques", Water Resources Research, Vol. 18, No. 4, Pages 1081-1088, August 1982. Program Developed by Ric Sorrell, P.E., October 1982. Modified for ACCESS by Mario Lesmez, Ph.D., P.E.

Figure 6. Correlation analysis

Reference Cited:

Hirsch, R.M., 1982, "A Comparison of Four Streamflow Record Extension Techniques", Water Resources Research, 18(4): 1081-1088.