Analysis Techniques: Flood Analysis Tutorial with Daily Data (Log-Perason Type III Distribution)

Information to get started:

- The lesson below contains step-by-step instructions and "snapshots" of what each step looks like when carried out in a Microsoft Excel workbook. Blue shading of information in the Excel illustrations denotes changes made from the previous step. Dots placed in three consecutive rows indicate that a portion of data is hidden from sight.
- You can download an Excel workbook containing the complete data set by clicking on the "Download Data" link below. It contains each calculation step on a separate worksheet. To move between steps, click on the tabs at the bottom of the excel window.
- When you download the file, it may open in your browser window. You may wish to use the "save as" function to save the file to a local drive and then reopen it in Excel. This will make it easier to flip between the online lesson and the example workbook.
- Finally, we want to remind you that the techniques explained on this site are statistically based; therefore results must be viewed as predictions and not as facts. Please use the techniques and the information obtained from them responsibly!

Download Data

Step 1: Obtain streamflow data

- Obtain daily streamflow data from the USGS web site.
 - o Go to http://oregon.usgs.gov
 - o Select Historical Water Data
 - o Select Surface Water
 - o Select Daily Data
 - o Check box under Site Identifier for Site Name and Submit
 - o Type in Alsea under Site Name and select match any part and Submit
 - o Select gage at TIDEWATER (140306500)
 - o Select Tab-separated data
 - For the tutorial, copy the data for water years 1990 through 2000 into an Excel worksheet
 - o Paste special as text (this will separate the data into columns
- Calculate the maximum discharge for each water year in the period of record.
- The AVERAGE, MAX, and MIN functions in excel can be used to calculate these values for each water year. It may be more efficient to calculate the mean, maximum, and minimum flows for each water year in the period of record at one time.

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	A	B	C	D	E	F	G	(H)
Į.	AGENCY	STATION			ANNUAL AVERAGES (CFS)	ANNUAL MAX (CFS)	ANNUAL MIN (CFS)	
Į.	USGS	14306500	10/1/90	83			1969 (P1294 CL 3 6349 CO 2	
Į.	USGS	14306500	10/2/90	85				
ł	USGS	14306500	10/3/90	93				
	USGS	14306500	10/4/90	96				
	USGS	14306500	10/5/90	101				
	USGS	14306500	10/6/90	106				
	USGS	14306500	10/7/90	94				
ŀ	USGS	14306500	10/8/90	87				
Į.	USGS	14306500	10/9/90	84				
ŀ	USGS	14306500	10/10/90	82				
Į.	USGS	14306500	10/11/90	83				
ł	USGS	14306500	10/12/90	94				
Į.	USGS	14306500	10/13/90	99				
Į.	USGS	14306500	10/14/90	97				
Į.	USGS	14306500	10/15/90	130				
	USGS	14306500	10/16/90	177				
Ļ	USGS	14306500	10/17/90	162				
1	USGS	14306500	10/18/90	241				
I.	USGS	14306500	10/19/90	350				
I.	USGS	14306500	10/20/90	209				
	USGS	14306500	10/21/90	272				
	USGS	14306500	10/22/90	575				
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ŧ.	USGS	14306500	9/27/00	83				
8	USGS	14306500	9/26/00	82				
ŧ.	USGS	14306500	9/29/00	83				
	USGS	14306500	9/30/00	66	1409	17400	67	

Step 2: Organize the information in a table.

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A	8	C	D	E	F	G	(H)	1	- 3 0	K	1	M	N.
VATER YEAR		EAMFLOW, Q				_				_			
	MEAN	MAX	MIN	-		_					-	-	
1991	1102	7470	66	-		_				_	-		
1992	795	9650	59	-						_			
1993	1252	7540	56			_					_		
1994	731	8170	61	-						_			
1996	1782	16600	58					_		_	-		
1996	2088	29400	86	_		_				_	_		_
1997	1837	20900	93	-		_		-					-
1998	1533	9060	75			_					_		_
1999	2148	28200	70			_					_		
2000	1409	17400	67							_	_		
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Step 3: Rank the data from largest discharge to smallest discharge. Add a column for Rank and number each streamflow value from 1 to n (the total number of values in your dataset).

	B	С	8	E	E:	G	OH:	1	23	K	
Nater Year	Max Streamflow, Q. (cfs)				Water Year	Ranked Max Streamflow, Q (cfs)					
1991	7470			1	1996	29400	_				-
1992	9650			2	1999	26200					T
1993	7540			3	1997	20900					
1994	8170			4	2000	17400					
1995	15500			5	1995	15500					
1996	29400			6	1992	9650					
1997	20900			2345678910	1994	8170					
1998	8060			8	1998	8060			-		
1999	28200			9	1993	7540					
2006	17400			10	1991	7470					
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Step 4: Create a column with the log of each max or peak streamflow using the Excel formula {log (Q)} and copy command.

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A	B	c	0 D	E	F	G	्रम	10	з	K	THE STREET	N
Rank	Water Year	Ranked Max Streamflow, Q (cfs)						_				-
1	1996	29400	4.466									-
2	1999	26200	4.450			-						
3	1997	20900	4.320									
4	2000	17400	4.241									
5	1995	15500	4.190									
6	1992	9650	3.985									
7	1994	8170	3.912									
В	1998	8060	3.905			-	-					-
9	1993	7540	3,877									
10	1991	7470	3.873				_					_
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Step 5: Calculate the Average Max Q or Peak Q and the Average of the log (Q)

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			and the second s	1 (P.)							
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					-				Ranked Max Streamflow, G		Rank V
								4.468	29400	1996	1
								4.450	28200	1999	2
								4.320	20900	1997	3
								4.241	17400	2000	4
								4.190	15500	1995	5
								3.985	9650	1992	
								3.912	8170	1994	7
								3.906	8060	1998	8
								3.877	7540	1993	9
								3.873	7470	1991	10
								Average	Average		
								4.122	15229		

Step 6: Create a column with the excel formula { (log Q avg(logQ))^2}

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		Ranked Max		(log Q -avg(logQ))*2		9					-		
1	1996	29400	4.468	0.120									
2	1999	28200	4.450	0.106									
3	1997	20900	4.320	0.039									
- 4	2000	17400	4.241	0.014									
5	1995	15500	4.190	0.005									
6	1992	9650	3.985	0.019									
7	1994	8170	3.912	0.044									
8	1996	8060	3.906	0.047						-			L
9	1993	7540	3.877	0.060						-			
10	1991	7470	3.873	0.062									
		Average	Average				-			-			-
		15229	4.122					-					_
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Step 7: Create a column with the excel formula { (log Q – avg(logQ)) ^3

AA31 E A B C D E F G H I J K Ranked Max Ranked Max <thranked max<="" th=""> <thranked max<="" th=""> R</thranked></thranked>							+ 198	1 · [E]		1 8 8			
Ranked Max flog Q avgflogQjj^2 flog Q avgflogQjj^3 1 1996 23400 4.468 0.120 0.041424 2 1999 28300 4.460 0.106 0.035256 3 1997 20900 4.320 0.039 0.007740 4 2000 17400 4.241 0.014 0.000562 5 1995 15500 4.190 0.005 0.000314 6 1932 9650 3.965 0.019 -0.002517 7 1998 8060 3.906 0.047 -0.010078 9 1993 7540 3.677 0.060 -0.014700 10 1991 7470 3.673 0.062 -0.015442		AA31		-									_
Rank Water Year Streamflow, Q (cfs) to Q (cfs) (log Q avg(log Q))*2 (log Q avg(log Q))*3 1 1996 29400 4.468 0.120 0.041424 2 1999 28200 4.460 0.106 0.03526 3 1997 20500 4.320 0.039 0.007740 4 2000 17400 4.241 0.014 0.000314 5 1996 15600 4.190 0.005 0.000314 6 1992 9650 3.965 0.019 -0.002617 7 1994 8060 3.906 0.047 -0.010078 9 1993 7540 3.877 0.060 -0.010776 9 1993 7540 3.873 0.062 -0.010776 10 1991 Average Average - -	P	A	B	C	D	E	Fi.	G	H		- 7/ J	(K)	
Rank Water Year Streamflow, Q (cfs) to Q (cfs) (log Q avg(log Q))*2 (log Q avg(log Q))*3 1 1996 29400 4.468 0.120 0.041424 2 1999 28200 4.460 0.106 0.03526 3 1997 20500 4.320 0.039 0.007740 4 2000 17400 4.241 0.014 0.000314 5 1996 15600 4.190 0.005 0.000314 6 1992 9650 3.965 0.019 -0.002617 7 1994 8060 3.906 0.047 -0.010078 9 1993 7540 3.877 0.060 -0.010776 9 1993 7540 3.873 0.062 -0.010776 10 1991 Average Average - -	l			Ranked Max									
1 1996 29400 4.468 0.120 0.041424 2 1999 28200 4.450 0.106 0.035258 3 1997 20900 4.320 0.039 0.007740 4 2000 17400 4.241 0.014 0.001652 5 1996 15500 4.190 0.005 0.000314 6 1992 9660 3.966 0.019 -0.002617 7 1994 8170 3.912 0.044 -0.009277 6 1998 8060 3.906 0.047 -0.010076 9 1993 7540 3.877 0.060 -0.014700 10 1991 7470 3.673 0.062 -0.015442 Average	h	Rank	Water Year	Streamflow, Q ic	fsì log Q (cfsì	flog Q .avg/logOil*2	flog Q -availog00^3						
4 2000 17400 4.241 0.014 0.001652 5 1996 15500 4.190 0.005 0.000314 6 1992 9650 3.965 0.019 -0.0022617 7 1994 8170 3.912 0.044 -0.009277 8 1998 8060 3.905 0.047 -0.010078 9 1993 7540 3.877 0.060 -0.014700 10 1991 7470 3.873 0.062 -0.015442	đ	1											
4 2000 17400 4.241 0.014 0.001652 5 1996 15500 4.190 0.005 0.000314 6 1992 9650 3.965 0.019 -0.0022617 7 1994 8170 3.912 0.044 -0.009277 8 1998 8060 3.905 0.047 -0.010078 9 1993 7540 3.877 0.060 -0.014700 10 1991 7470 3.873 0.062 -0.015442	8	2	1999	28200	4.450	0.108	0.035258						
4 2000 17400 4.241 0.014 0.001652 5 1996 15500 4.190 0.005 0.000314 6 1992 9650 3.965 0.019 -0.0022617 7 1994 8170 3.912 0.044 -0.009277 8 1998 8060 3.905 0.047 -0.010078 9 1993 7540 3.877 0.060 -0.014700 10 1991 7470 3.873 0.062 -0.015442	ľ	3	1997	20900									
7 1994 8170 3.912 0.044 -0.009277 8 1998 8060 3.906 0.047 -0.010078 9 1993 7540 3.877 0.060 -0.014700 10 1991 7470 3.873 0.062 -0.015442 Average	ĩ	4	2000	17400	4.241	0.014	0.001662						-
7 1994 8170 3.912 0.044 -0.009277 8 1998 8060 3.906 0.047 -0.010078 9 1993 7540 3.877 0.060 -0.014700 10 1991 7470 3.873 0.062 -0.015442 Average	ī	5	1995	15500	4.190	0.005	0.000314						
8 1996 8060 3.906 0.047 -0.010076 9 1993 7640 3.877 0.060 -0.014700 10 1991 7470 3.873 0.062 -0.015442 Average Average Average Average Average	ľ	6	1992	9660	3.965	0.019	-0.002617						-
9 1993 7540 3.877 0.060 -0.014700 10 1991 7470 3.873 0.062 -0.015442 Average Average	ī	7	1994	8170	3.912	0.044	-0.009277						
10 1991 7470 3.873 0.062 -0.015442 Average Average	ľ	8	1998	8060	3.906	0.047	-0.010078						
Average Average	Į.		1993	7540	3.877	0.060	-0.014700						-
	Ī	10	1991	7470	3.873	0.062	-0.015442						
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Step 8: Create a column with the return period (Tr) for each discharge using Excel formula $\{(n+1)/m\}$. Where n = the number of values in the dataset and m = the rank.

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		Water Year	Ranked Max Streamflow, Q (cfs)		flog Q -avgflogQ))^Z	(log Q .avg(logQ))*3	Return Period	m		3:	~
ł	1	1996	29400	4.468	0.120	0.041424	11.00				
ŝ	2	1999	28200	4.450	0.108	0.035258	5.50				
Ì	3	1997	20900	4.320	0.039	0.007740	3.67				
ł	4	2000	17400	4.241	0.014	0.001652	2.75				
l	5	1995	15500	4.190	0.005	0.000314	2.20				
l	6	1992	9650	3.985	0.019	-0.002617	1,83				
Ī	7	1994	8170	3.912	0.044	-0.009277	1.57				
Į	8	1998	8060	3.906	0.047	-0.010078	1.38			-	
g	9	1993	7540	3.877	0.060	-0.014700	1.22				
l	10	1991	7470	3.873	0.062	-0.015442	1.10				
9			Average	Average	C420000			-			
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Step 9: Complete the table with a final column showing the exceedence probability of each discharge using the excel formula {=1/Return Period or 1/Tr} and the copy command.

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A	B	0	D	E	Ŧ	G	H	1	- 1 - A
lank		Ranked Max Streamflow, Q (cfs)		(log Q_avg(logQ))^2	(log Q -avg(logQ))*3	Return Period, Tr = [(n+1)/m]	Exceedence Probability (1/Tr)		
1	1996	29400	4.468	0.120	0.041424	11.00	0.0909		
2	1999	28200	4.450	0.108	0.035258	5.60	0.1618		
3	1997	20900	4.320	0.039	0.007740	3.67	0.2727		
4 5	2000	17400	4.241	0.014	0.001652	2.75	0.3636		
5	1995 1992	15500 9650	4.190	0.005	0.000314	2.20	0.4545 0.5455		
9	1992	8170	3.905	0.044	-0.002617	1.65	0.6364		-
8	1996	8060	3.912	0.044	-0.010078	1.38	0.6364		
9	1993	7540	3.800	0.060	-0.014700	1.30	0.6162		
10	1991	7470	3.677	0.062	-0.015442	1.10	0.9091		
	1551	Average	Average	0.002	10.010442	1.10	u 2001		
		15229	4.122						
		1342.5	4.164						

Step 10: Calculate the Sum for the $\{(\log Q - avg(\log Q))^2\}$ and the $\{(\log Q - avg(\log Q))^3\}$ columns.

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A A	B		D	F		(F	н	
		Ranked Max Streamflow, Q (cfs)		= (log Q .avg(logQ))*2	(log Q -avg(logQ))*3	Return Period,	Exceedence Probability (1/Tr)	
1	1996	29400	4.468	0.120	0.041424	11.00	0.0909	
2	1999	28200	4.450	0.108	0.035258	5.50	0.1818	
з	1997	20900	4.320	0.039	0.007740	3.67	0.2727	
4	2000	17400	4.241	0.014	0.001652	2.75	0.3636	
5	1995	15500	4.190	0.005	0.000314	2.20	0.4545	
6	1992	9650	3.985	0.019	-0.002617	1.83	0.5455	
7	1994	8170	3.912	0.044	-0.009277	1.57	0.6364	
8	1998	8060	3.906	0.047	-0.010078	1.38	0.7273	
9	1993	7540	3.877	0.060	-0.014700	1.22	0.8182	
10	1991	7470	3.873	0.062	-0.015442	1.10	0.9091	
		Average	Average	Sum	Sum			
		15229	4.122	0.517	0.034			
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Step 11: Calculate the variance, standard deviation, and skew coefficient as follows:

variance =

$$\frac{\sum_{i=1}^{n} (\log Q - avg(\log Q))^2}{n-1}$$

standard deviation =

$$\sigma \log Q = \sqrt{\text{variance}}$$

skew coefficient =

$$\frac{n \times \sum_{i}^{n} (\log Q - avg(\log Q))^3}{(n-1)(n-2)(\sigma \log Q)^3}$$

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A	В	C	D	E	F	G	H	1 J
lank	Water Year	Ranked Max Streamflow, Q (cfs)		(log Q .avg(logQ))*2	(log Q -avg(logQ))*3	Return Period, Tr = [(n+1)/m]	Exceedence Probability (1/Tr)	
1	1996	29400	4.468	0.120	0.041424	11.00	0.0909	
2	1999	26200	4.450	0.108	0.035258	5.50	0.1618	
3	1997	20900	4.320	0.039	0.007740	3.67	0.2727	
4	2000	17400	4.241	0.014	0.001852	2.75	0.3636	
6	1995	15500	4.190	0.005	0.000314	2.20	0.4545	
6	1992	9650	3.965	0.019	-0.002617	1.83	0.5455	
7	1994	8170	3.912	0.044	-0.009277	1.57	0.6364	
8	1998	8060	3.906	0.047	-0.010078	1.38	0.7273	
9	1993	7540	3.877	0.060	-0.014700	1.22	0.8182	
10	1991	7470	3.873	0.062	-0.015442	1.10	0.9091	
		Average	Average	Sum	Sum			
		15229	4.122	0.517	0.034			
	1							
				al an inclusion of the	Landston I			
				variance	0.0574			
	_			standard deviation	0.2396			
	-			skew coefficient	0.3460			
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Step 12: Calculate k values

- Use the **frequency factor table** and the skew coefficient to find the **k values** for the 2,5,10,25,50,100, and 200 **recurrence intervals**
- If the skew coefficient is between two given skew coefficients in the table than you can linearly extrapolate between the two numbers to get the appropriate k value. To view the frequency factor table click on the button below.

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Z29	-	-	D	E	F				
A	8	Ranked Max	U	-	T.	G Return Period,	H		
lank	Water Year	Streamflow, Q (cfs)	log (cfs)	(log Q -avg(logQ))^2	(log Q -avg(logQ))^3	Tr = [(n+1)/m]	Probability (1/Tr)		
1	1996	29400	4.468	0.120	0.041424	11.00	0.0909		
2	1999	28200	4.450	0.108	0.035258	5.50	0.1618		
3	1997	20900	4.320	0.039	0.007740	3.67	0.2727		
4	2000	17400	4.241	0.014	0.001652	2.75	0.3636		
5	1995	15500	4,190	0.005	0.000314	2.20	0.4545		
6	1992	9650	3.965	0.019	-0.002617	1.83	0.5455		
7	1994	8170	3.912	0.044	-0.009277	1.57	0.6364		
8	1998	8060	3.906	0.047	-0.010078	1.38	0.7273		
9	1993	7540	3.677	0.060	-0.014700	1.22	0.8182		
10	1991	7470	3.873	0.062	-0.015442	1.10	0.9091		
	- 0752	Average	Average	Sum	Sum	11997	0.00020		
		15229	4.122	0.517	0.034				
				variance	0.0574				
				standard deviation	0.2396				
				skew coefficient	0.3460				
			1		100000		in an	in and the	
			Tr	K(0.3)	K(0.4)	slope	K(0.3460)	Q (cfs)	
			2	0.050	-0.066	-0.16	-0.057		
			5	0.824	0.616	-0.08	0.820		
			10	1.309	1.317	0.08	1.313		
			25	1.849	1.880	0.31	1.863		
			50	2.211	2.261	0.5	2.234		
			100	2.544	2.615	0.71	2.577		
			200	2.866	2,949	0.93	2.899		

Analysis Techniques: Flood Frequency Analysis Tutorial with Daily Data from Streamflow Evaluations for Watershed Restoration Planning and Design, http://water.oregonstate.edu/streamflow/, Oregon State University, 2002-2005.

Step 13: Using the general equation, list the discharges associated with each recurrence interval

general equation =

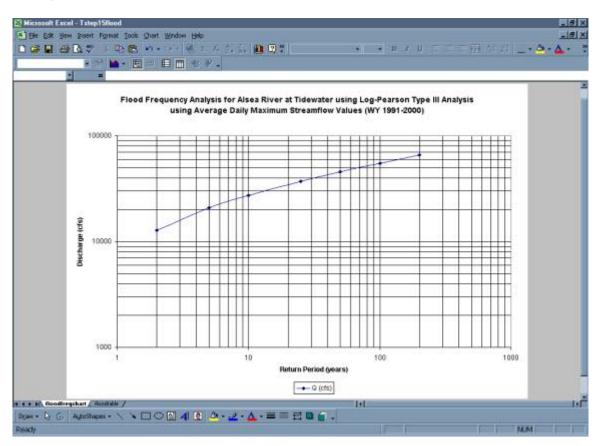
$\log QTr = avg(\log Q) + [K (Tr, Cs)] \times \sigma \log Q$

1996 1969 1997 2000 1995 1992 1994	C Ranked Max Streamflow, Q (cfs) 29400 28200 28200 20900 17400 15500 99650	D 4.468 4.450 4.320 4.241 4.20	E (log Q .avg(logQ))^2 0.120 0.108 0.039	F (log Q -avg(logQ))^3 0.041424 0.035258	11.00	H Exceedence Probability (1/Tr) 0.0909	1	J
ter Year S 1996 1999 1997 2000 1995 1992 1994	Ranked Max Streamflow, Q (cfs) 29400 28200 20900 17400 15500	log Q (cfs) 4.468 4.450 4.320 4.241	(log Q _avg(logQ))*2 0.120 0.108	0.041424	Return Period, Tr = [(n+1)/m] 11.00	Exceedence Probability (1/Tr)	1	3
1996 1969 1997 2000 1995 1992 1994	29400 28200 20900 17400 15500	4.468 4.450 4.320 4.241	0.120	0.041424	11.00		-	
1997 2000 1995 1992 1994	20900 17400 15500	4.320 4.241		0.035258				
2000 1995 1992 1994	17400 15500	4.241	0.039		5.50	0.1818		
1995 1992 1994	15500			0.007740	3.67	0.2727		
1992 1994	100.77	4 4 6 6	0.014	0.001652	2.75	0.3636		
1994	9650	4.190	0.005	0.000314	2.20	0.4545		
110.00 1		3.965	0.019	-0.002617	1.83	0.5455		
	8170	3.912	0.044	-0.009277	1.57	0.6364		
1996	8060	3.906	0.047	-0.010078	1.38	0.7273		
1993	7540	3.677	0.060	-0.014700	1.22	0.8182		
1991	7470	3.673	0.062	-0.015442	1.10	0.9091		
	Average	Average	Sum	Sum		1.1.00.000		
	15229	4.122	0.517	0.034				
			variance	0.0574				
			standard deviation	0.2396				
			skew coefficient	0.3460				
		Tr	K/0.3)	K(0.4)	slope	K(0.3460)	Q (cfs)	
		2	-0.050	-0.066	-0.16	-0.057	12841	
		5	0.824	0.816	-0.08	0.820	20841	
		10	1.309	1.317	0.06	1.313	27346	
		25	1.849	1.880	0.31	1.863	37063	
		50	2.211	2.261	0.5	2.234	45463	
		100	2.544	2.615	0.71	2.677	54925	
		200	2.856	2.949	0.93	2.899	65608	
		Average 15229	15229 4.122 	15229 4.122 0.517 variance standard deviation skew coefficient	15229 4.122 0.517 0.034 variance 0.0574 standard deviation 0.2396 skew coefficient 0.3460 Tr K(0.3) 2 -0.050 5 0.824 10 1.309 50 2.211 25 1.849 100 2.544 2815	15229 4.122 0.517 0.034 variance 0.0574 standard deviation 0.2396 skew coefficient 0.3460 Tr K(0.3) K(0.4) 2 -0.050 -0.066 5 0.824 0.816 10 1.309 1.317 0.08 25 1.849 1.980 0.31 50 2.211 2.261 0.5 100 2.544 2.615 0.71	15229 4.122 0.517 0.034 variance 0.0574 standard deviation 0.2396 skew coefficient 0.3400 Tr K(0.3) K(0.4) 2 -0.050 -0.066 -0.066 -0.16 -0.057 5 0.824 0.816 10 1.309 1.317 0.06 25 1.849 1.860 0.31 50 2.211 2.261 0.5 2.234 100 2.544 2.615 0.71 2.677	15229 4.122 0.517 0.034 variance 0.0574 standard deviation 0.2396 skew coefficient 0.3460 7r K(0.3) 2 -0.050 -0.066 -0.16 -0.067 12841 5 0.824 0.016 -0.060 10 1.309 1.317 0.08 25 1.849 100 2.261 0.5 2.234 25 1.849 100 2.544 2615 0.71 2677 5.4925

Step 14: Create table of Discharge values found using the log -**Pearson analysis**

		·····································							
30 <u>-</u>	8	¢	D	E	F	0	н	T	1
lood Frequen	cy Calculations using lo	og Pearson Analysis III							
	(period of record WY 199	1-2000)							
Return Period	Skew Coefficient	Discharge					_		
(years)	K(0.3460)	Q (cfs)							
2	-0.057	12841							
5	0.820	20841							
10	1.313	27346							
25	1.863	37053							
50	2.234	45463							
100	2.677	54925							
200	2.899	65608							
	0.000000	5969/978 115							

Step 15: Create Plot



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• Below is a comparison of flood frequency analysis completed using mean daily data versus instantaneous discharge data. As can be seen, had you completed this analysis using instantaneous peak discharge data, the result would have been a more conservative estimation of the discharges associated with each return period.

