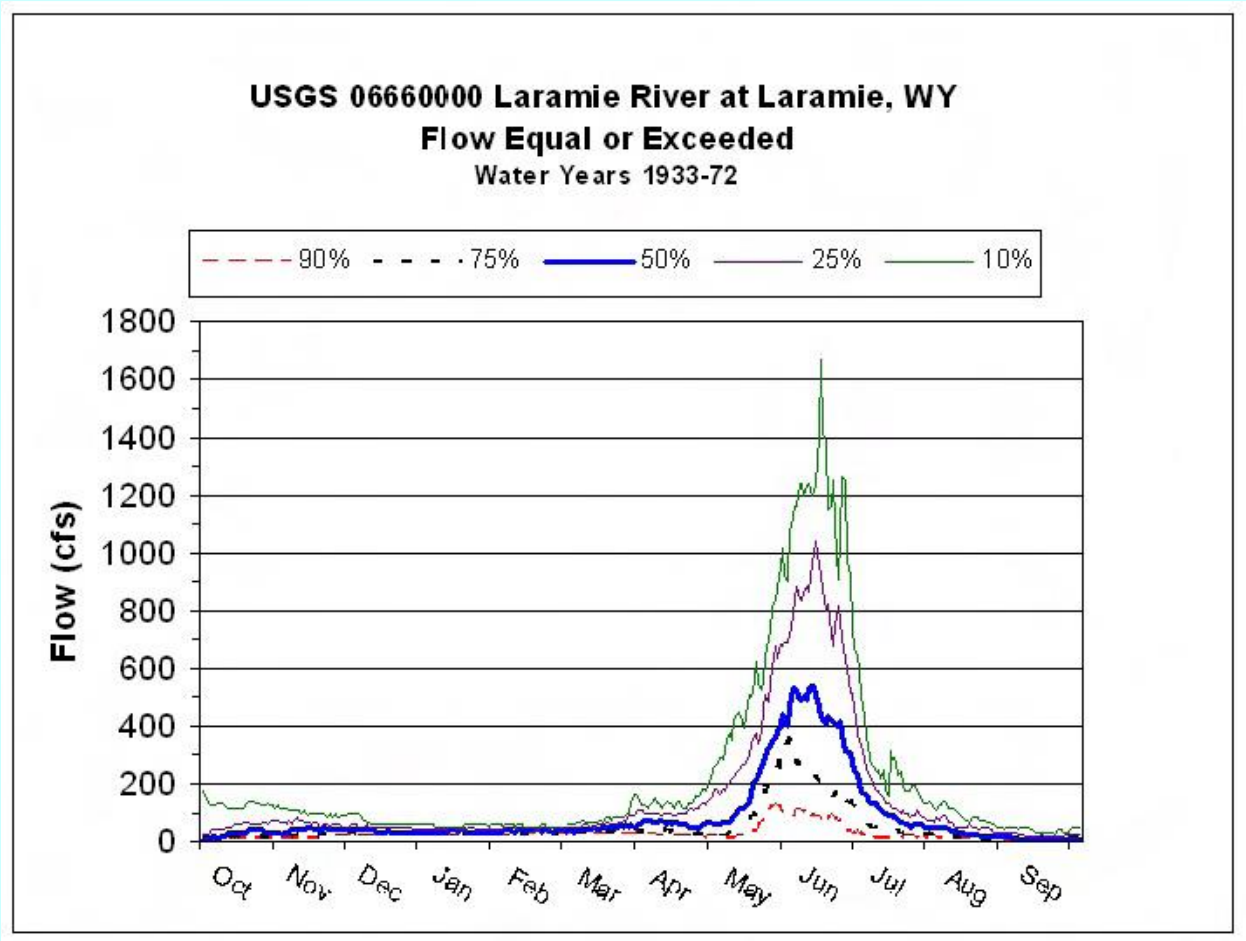
Homework #10 2016, Earth Surface Processes, Humphrey

We have been talking about the variability of river discharge. There are many ways of looking at how river discharge varies. A useful type of plot is shown below, which nicely shows that the Laramie river typically has only one flood (snow melt dominated) in early summer.



For this exercise, we are going to look at something that is of major interest to many, the question of the likelihood of large floods. Here is some recent data from the Laramie river at Laramie (this is the only recent data of which I am aware):

Flow measurements as reported on UPRR quarterly Discharge Monitoring Reports (DMR) for WDEQ Permit WY0032590,
Laramie Tie Plant.

Year	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**Apr**	**May**	**June**	**July**	**Aug**
	Sept										
	Streamflow (cfs)										
1987	8.1	77	49		54	65	62	157	46	22	7.8
	4.5										
1988	28	40	26	7.9	7.0	68	201	508	680	48	8.9
	5.5										

1989	17	44	34	7.1	2.0	61	nr	16	45	13	11
	13										
1990	36	75	60	27	30	189	36	30	351	50	20
	10										
1991	7.9	41	76	11	24	104	20	169	612	19	21
	11										
1992									231		
1993	49	102	147	196	264	309	39	407	1016	115	11
	36										
1994	14	38	67	177	209	93	53	288	77	7.6	7.0
	4.7										
1995	45	55	53	86	65	68	6.8	111	1281	281	14
	15										
1996	51	62	88	77	68	79	107	552	1136	420	20
	21										
1997	115	128	115	55	62	82	101	503	1277	149	110
	87										
1998	34	55	63	70	75	87	100	305	425	139	66
29											
1999	20	18	67	56	60	75	68	496	1126	267	20
	17										
2000	18	40	13	84	72	45	54	297	101	18	6
	13										
2001	56	20	54	77	90	75	21	177	66	11	18
	26										
2002	11	16	21	160	207	174	32	68	56		
2003	18	49	68	28	22	22	20	230	556		
	14										
2004	131	122	113	68	83	72					
2005	47	49	81	94	98	90	53	306	1115	95	80
	16										
2006	188	201	200	126	109	107	159	386	105	187	109
	115										
2007	143	104	68	200	186	281	146	549	378	78	109
	34										
2008				68	68	68	98	469	1715	316	180
	169										

The above table shows several problems with flood analysis. Real data sets have missing and questionable data. The above table lists measurements taken once a month, obviously it probably misses the actual flood peaks. There are more subtle problems with stream data: even if you find more continuous data (e.g. USGS typically reports daily discharge), the actual discharge is not measured, but estimated from river depth. Any bed or bank erosion or deposition will create errors in this depth based estimate, this is especially a problem at high flows when erosion/deposition is common. The biggest problem with the Laramie river data, is that over time, various water projects have diverted water from the river. As a result, the flood data is not 'stationary', in other words the flood data does not represent a sample from the same river over time. The river has been changing, so that we can't trust the old data to predict the future.

Question 1.
Use Google Earth to find the width of the Laramie river near Optimist Park, specifically near the bridge on W Garfield st..
a) The largest flood in the above record was in 2008, at 1715cfs. How deep would this flow have been under the Garfield bridge, **IF** the river stayed in its banks. Use Manning's equation, and try to get a measure of the slope of the river reach that flows thru Laramie.

b) It turns out that the actual flood depth was over 3m, despite the fact that the river overflowed its banks and had a flow width of about 50m. Make a comment on why the flood depth was so deep despite the fact that the cross-sectional area went up so much?

Question 2
Grey River, at Dobson New Zealand
1968 to 2004

year	Max flow (m3/s)		
1997	5950.8		
1988	5840.4		
1998	5670.0		
1970	4899.1		
1994	4844.5		
1977	4841.4		
1984	4814.3		
1983	4228.2		
1969	4203.4		
1972	4125.6		
1975	4117.8		
1980	4039.4		
1973	4012.5		
1979	4000.9		
1982	3975.2		
1996	3866.7		
2000	3809.5		
1974	3771.7		
1968	3678.3		
2002	3517.9		
1976	3463.4		
1981	3448.9		
1993	3422.3		
2001	3342.7		
1978	3302.9		
2004	3224.6		
2003	3221.9		
1989	3217.1		
1995	3185.8		
1992	3177.6		
1991	3091.4		
1999	3070.0		
1990	2806.8		
1971	2420.5		
1987	2385.4		
1986	2364.9		
1985	1794.8		
	Mean 3761.0		

Question 2

To continue thinking about river floods, we will look at some better quality data from the Grey river.

a. Calculate the **recurrence intervals** for floods on the Grey River. Recurrence intervals are what are usually somewhat misleadingly quoted in the popular media as the 100 year flood or whatever the news person wants to emphasize. There are a variety of methods to calculate recurrence interval, but probably the simplest is as follows: order your data from largest to smallest (this I have done for you). Now apply the following formula to each datum:
   $T_r = (N+1)/n$, where N is the total number of observations, n is the ranking in the above list from top to bottom (eq the second from the top is n=2) and T_r is the recurrence interval in years.
b. Plot the recurrence intervals on a semi log plot. Use log time on the x-axis and discharge on the y-axis. We will use a log axis, however there is considerable discussion in the literature about the expected shape of a recurrence interval curve, or more precisely, how floods should be distributed in time. (If you would like to investigate this more, look up Gumbel Distribution on the web.) We use a log plot since it is straightforward to plot, not because it is correct.
c. Use your plot to estimate the 100year flood on the Grey river. Comment on the accuracy of your prediction.
d. The channel forming discharge for a meandering river is typically about the 2year flood. What is the 2 year flood on the Grey River.

Question 3

Even though the Laramie river data is not very good quality, Calculate the recurrence intervals for the Laramie river as in Question 2.

a) Estimate the 'channel forming' discharge for the Laramie river.

b) Use the observed width and slope of the river from Question 1, and calculate the channel forming depth.

c) The bed material of a river is largely sorted during floods. Using the information from part (b), calculate the basal shear stress at the 2 yr flood stage.

d) Finally use the Shield Equation, and remember that we discussed that bedload tends to be in the size range where the critical shear stress (Shields) is about the same as the basal shear stress. What is the approximate bed material size in the Laramie river?