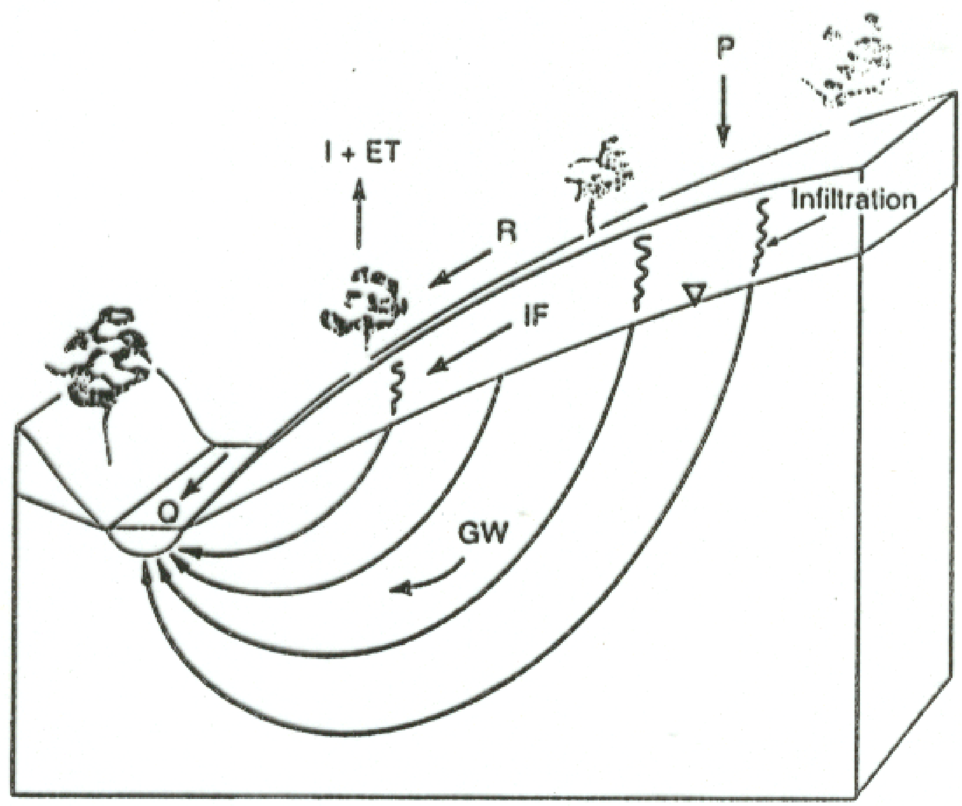
River Processes

River action (fluvial) is probably the single most important geomorphic agent and their influence in geomorphology can hardly be overestimated.

River Processes

To understand the complexity associated with river flow it is necessary to understand the mechanism of how water interacts with the land surface to eventually produce river flow. This can be accomplished by understanding ***slope hydrology.***



River Processes

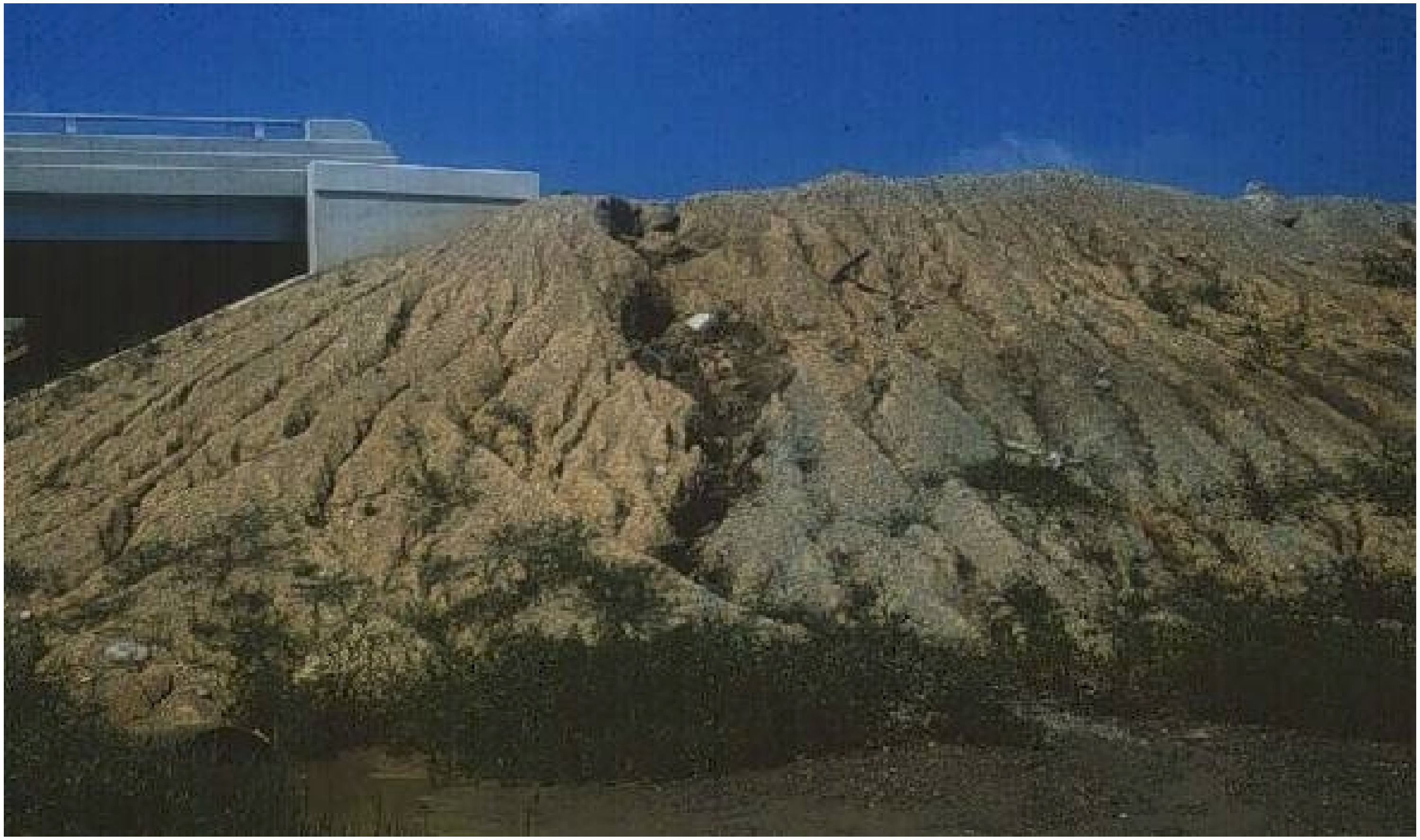
Initiation of channels and the drainage network

When rainfall intensity exceeds the infiltration capacity, overland flow occurs and only then does erosion become possible.

River Processes

Initiation of channels and the drainage network

Erosion starts as small rills that grow in size until well established gullies and channels are present.



River Processes

Drainage Basins

The many tributaries define a **drainage basin** or **watershed** of the trunk river.

The drainage basin of a river system:

- is the surface upstream and uphill from a channel that sheds water and sediment into that channel,
- is an open system into and from which energy and matter flow,
- its boundaries are normally well defined,
- Is the fundamental unit of geomorphic analysis.

River Processes

Drainage Basins

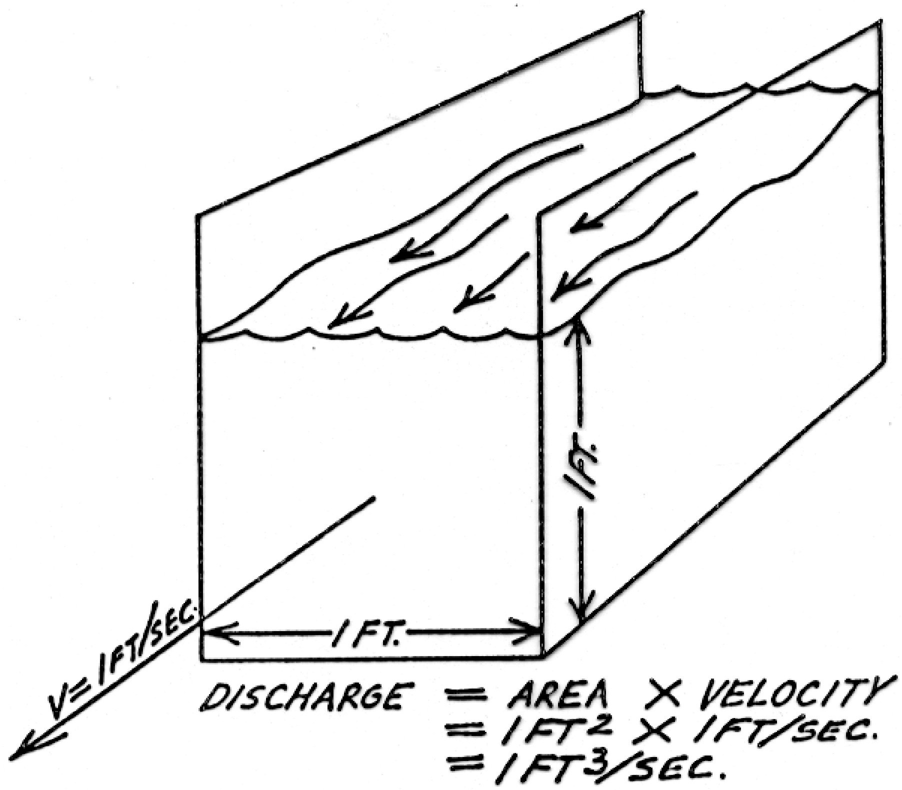
River Processes

Discharge

The continuity equation:

$$Q = w * d * v$$

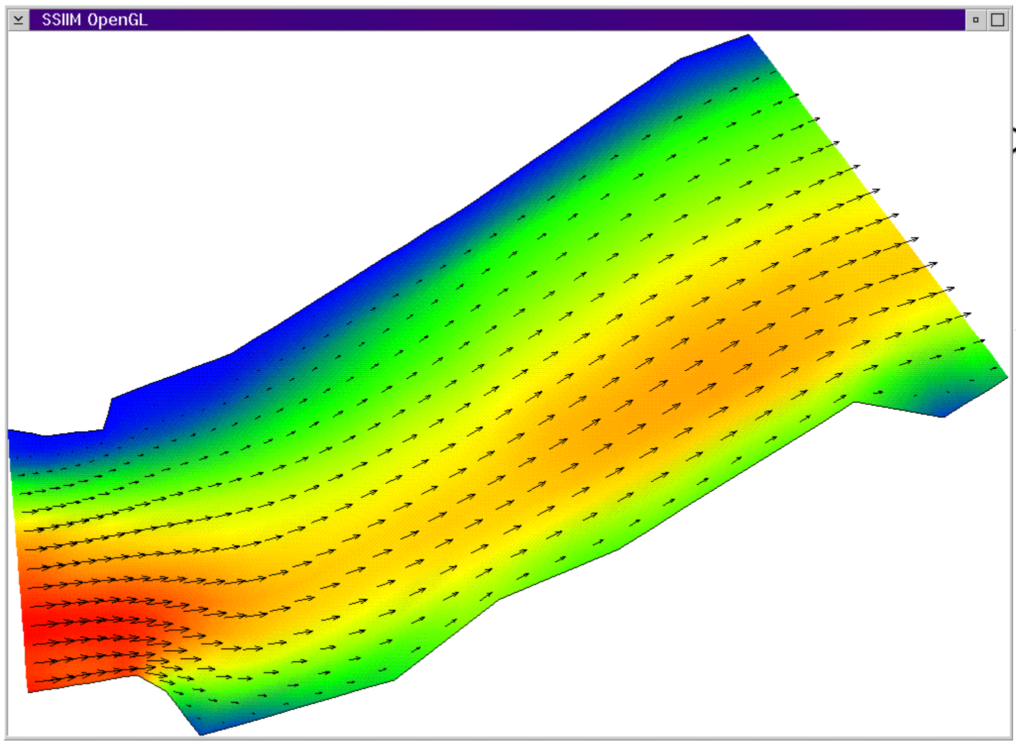
where Q is discharge,
w is width of a channel,
d is depth of the channel, and
v is velocity.

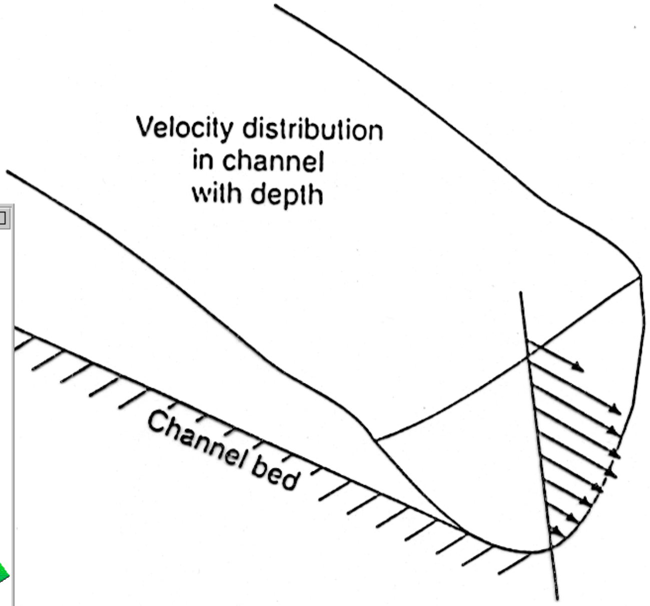


River Processes

Discharge

Measuring the variables of channel cross-sectional area and velocity are challenging – most notably for velocity.



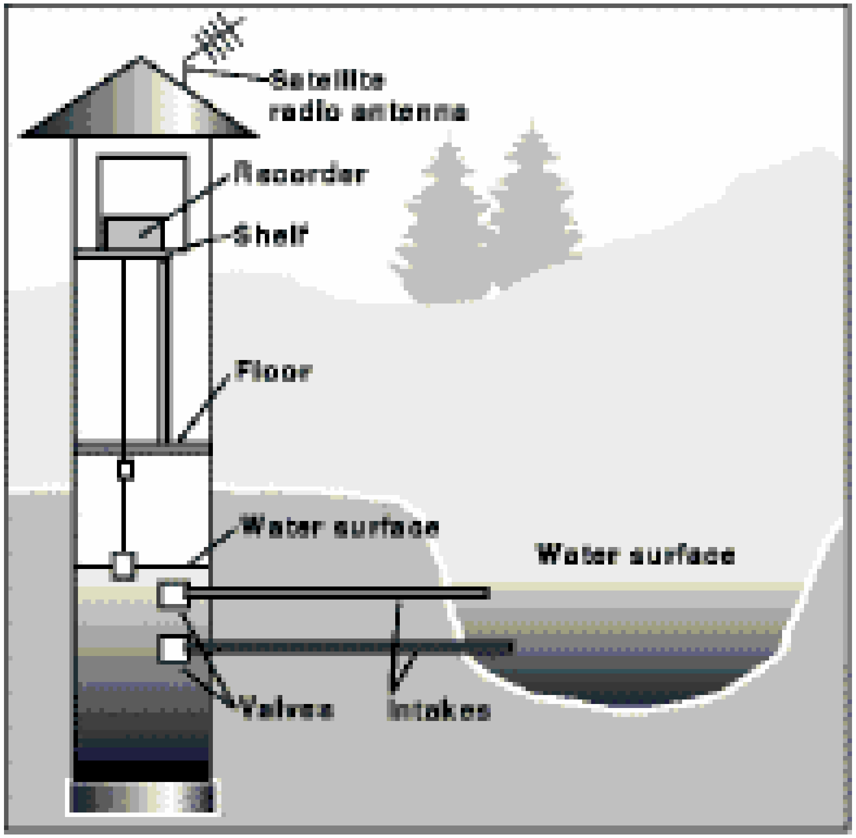


River Processes

Discharge

Measuring discharge is accomplished in several different ways.

Stilling Wells



River Processes

Discharge

Measuring discharge is accomplished in several different ways.

Stilling Wells

River Processes

Discharge

Measuring discharge is accomplished in several different ways.

Stilling Wells

River Processes

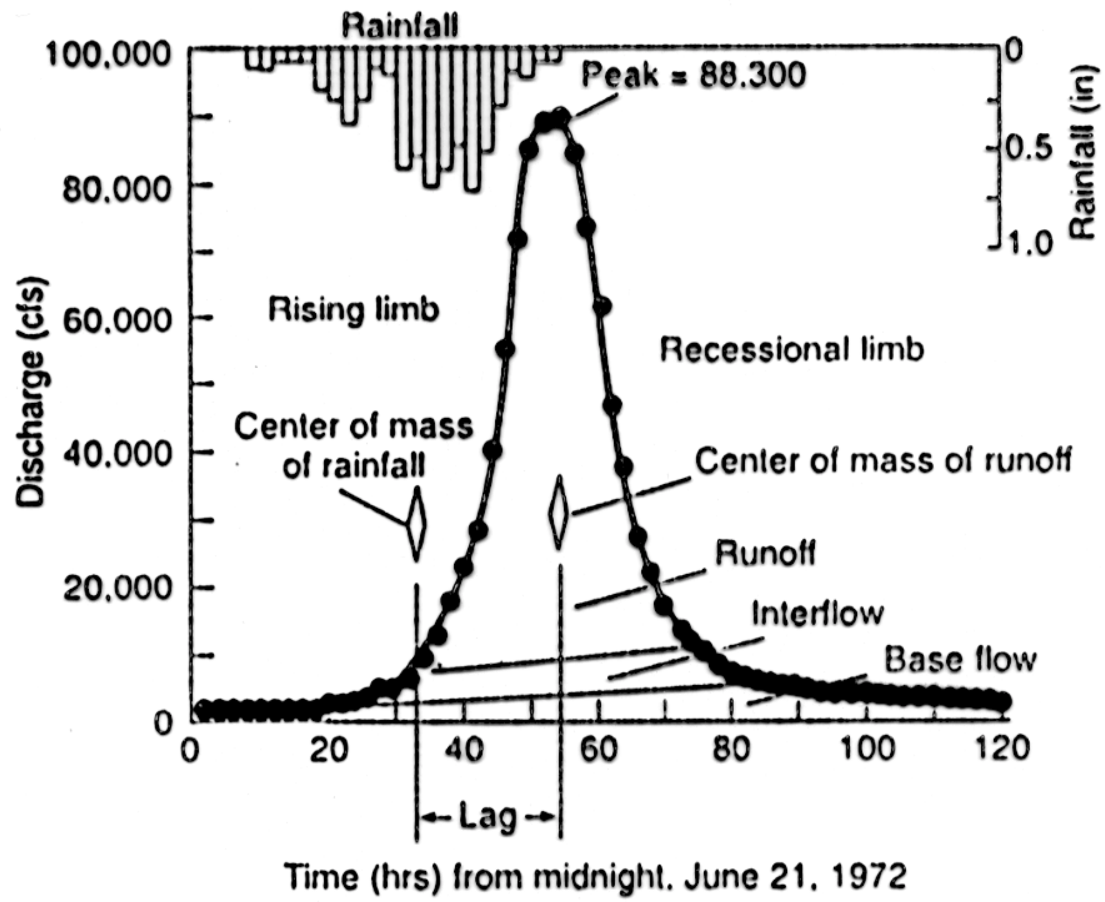
Discharge

Measuring discharge is accomplished in several different ways.

Stream gaging

River Processes

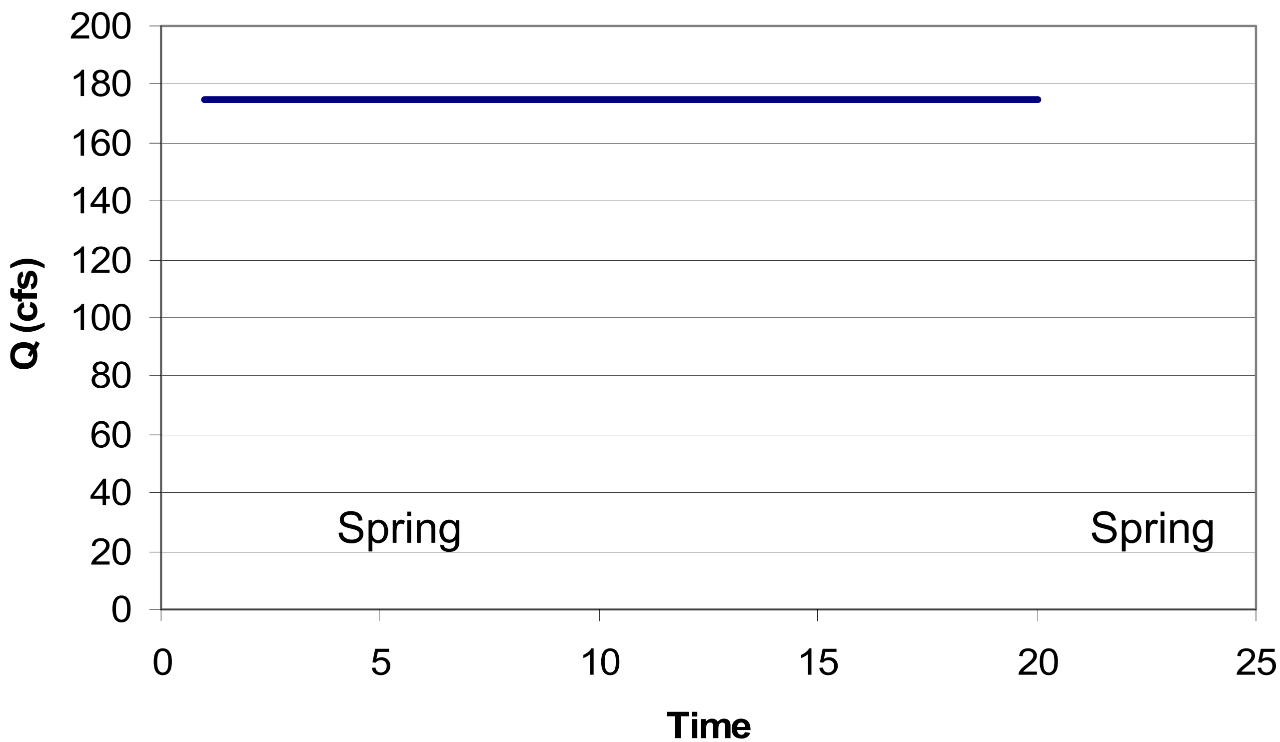
We can measure discharge over time for a stretch of a river and use that data to construct a **hydrograph**, which show river flow as a function of time.



River Processes

Hydrographs can be used to help us understand the dynamics of river systems and ultimately get at what influences water flow in specific systems.

Dismal River



River Processes

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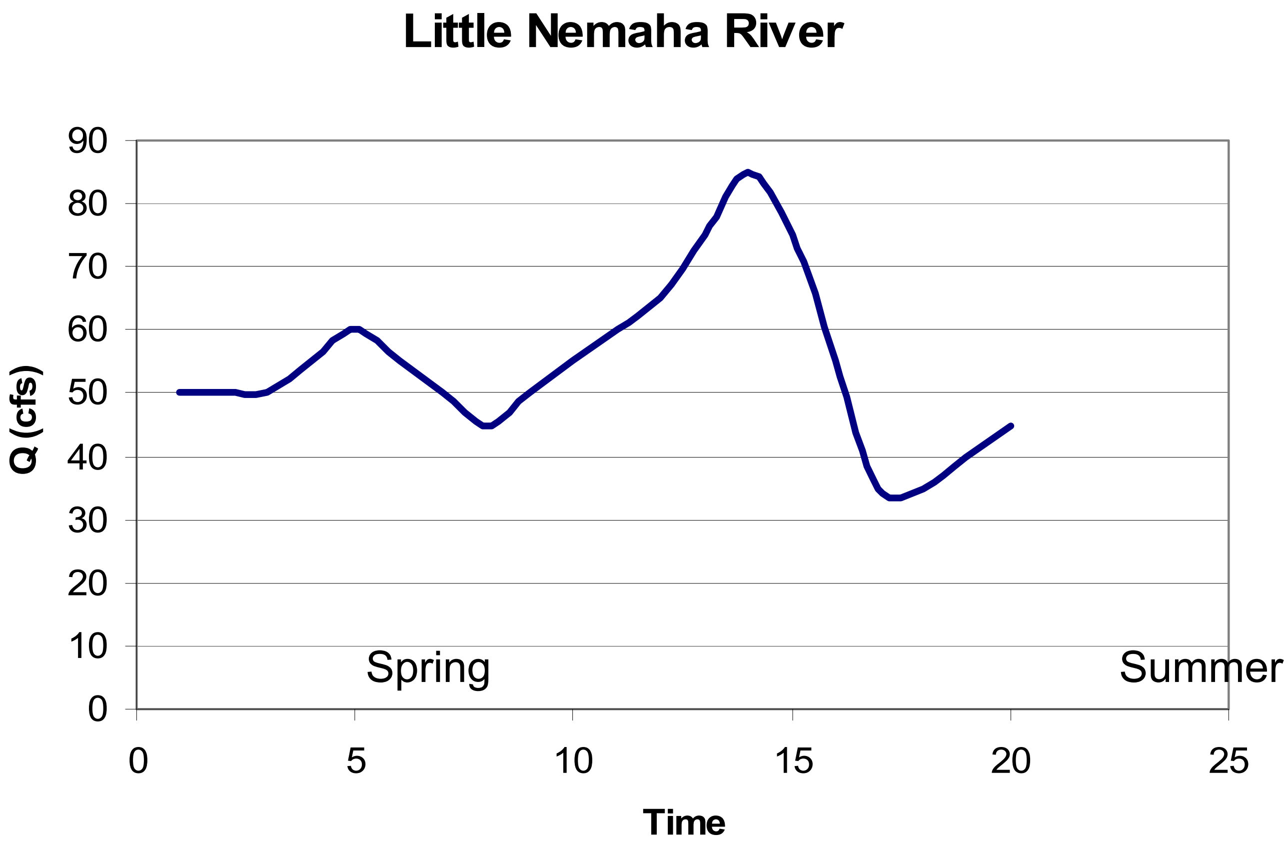

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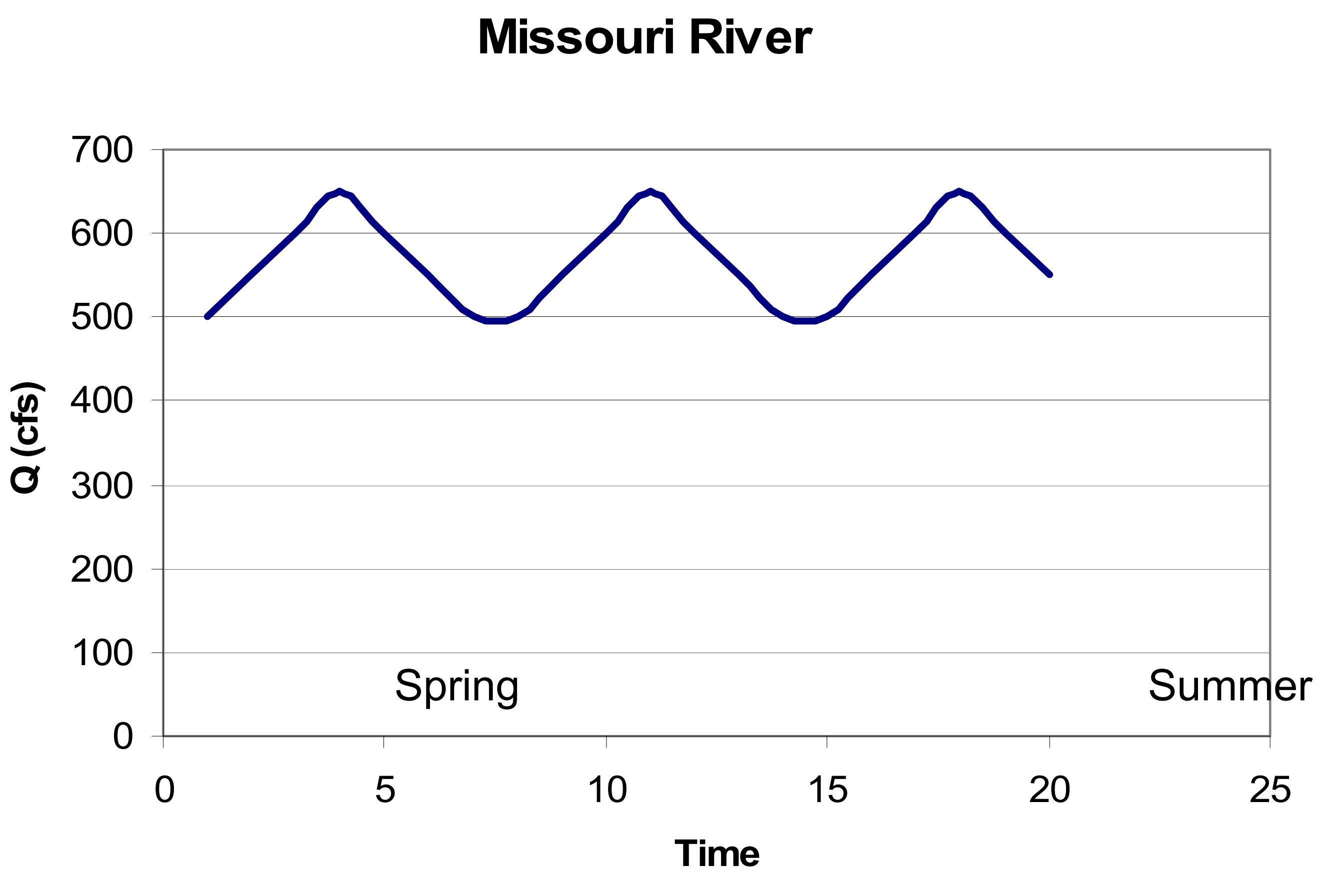

River Processes

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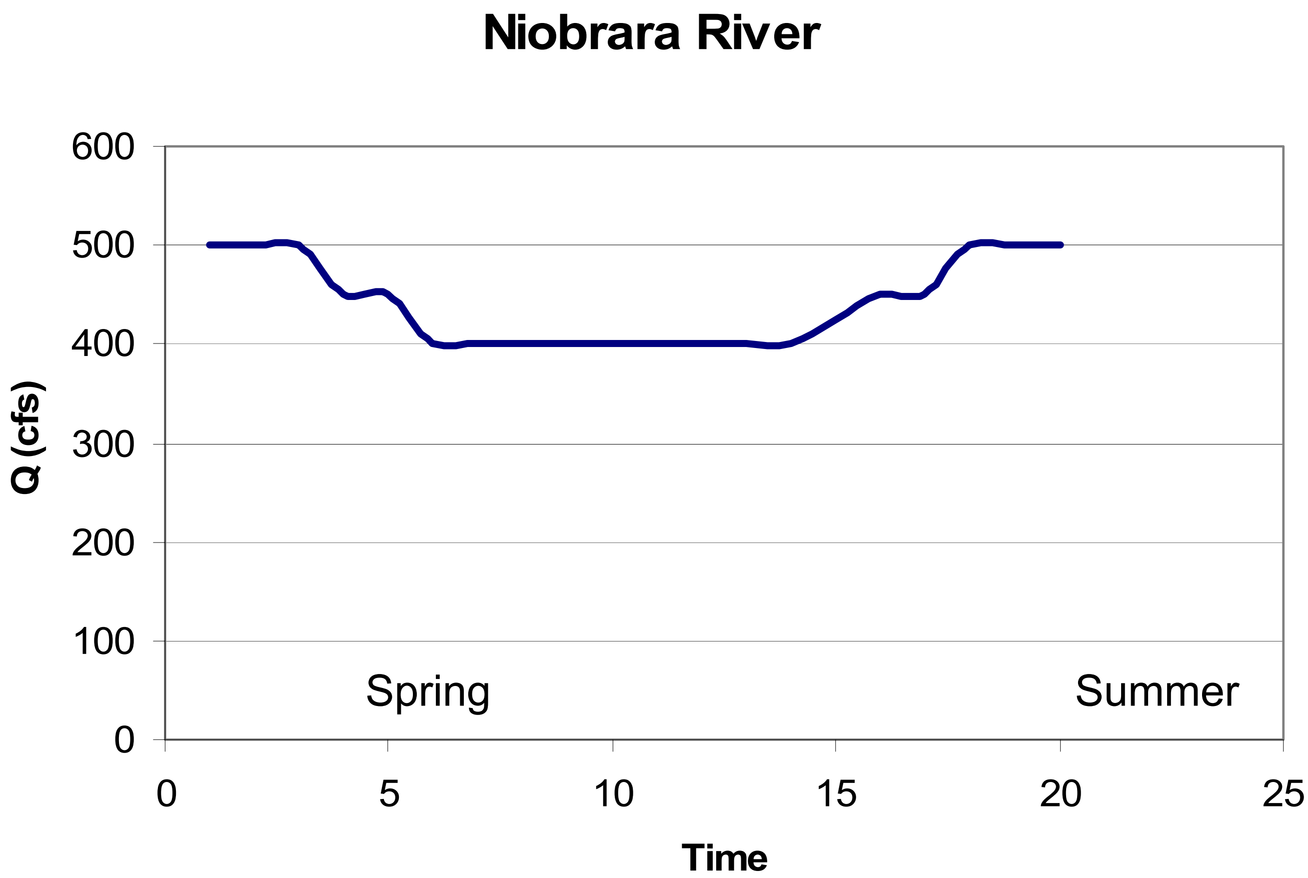

River Processes

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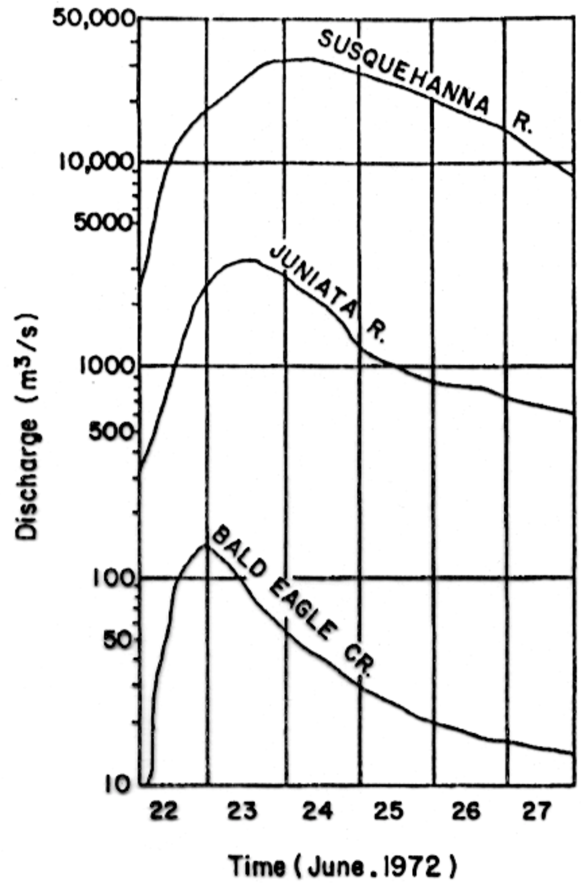
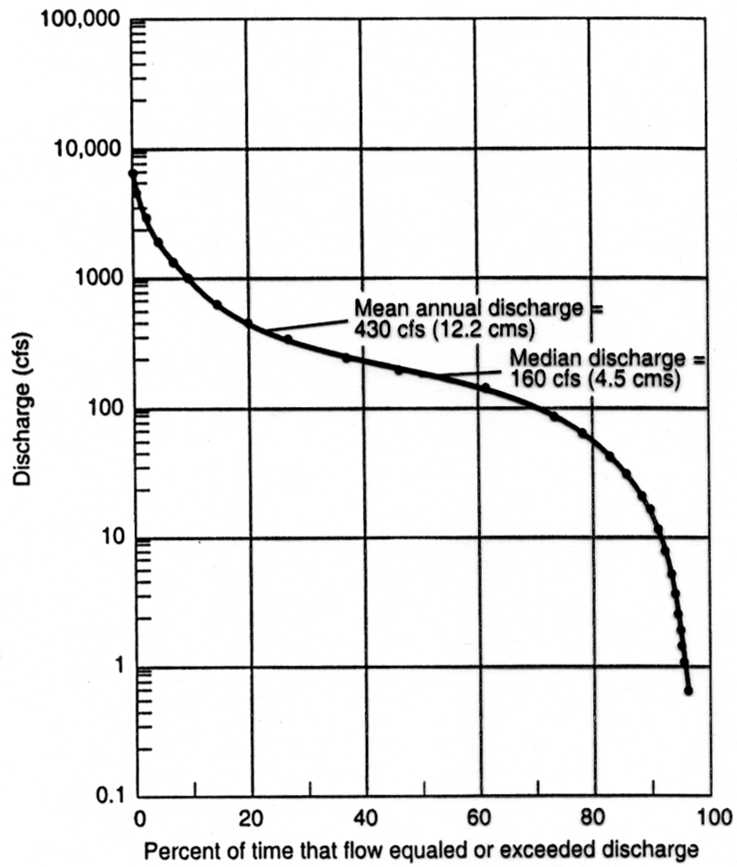


Hydrographs of streams in the Susquehanna River basin, Pennsylvania, as affected by the June 1972 floods (after Ritter et al., 1995). Bald Eagle Creek at Tyrone has a 115 km^2 drainage basin area and had a peak discharge 143 m^3/s. The Juniata river at Mapleton has a 5280 km^2 drainage basin area and had a peak discharge of 3540 m^3/s. The Susquehanna River at Marietta has a 67,600 km^2 drainage basin area and had a peak discharge of 30,500 m^3/s.

River Processes

Geomorphologists are interested in the ***frequency and magnitude*** of flow events because each has a decided bearing on how watershed systems work.

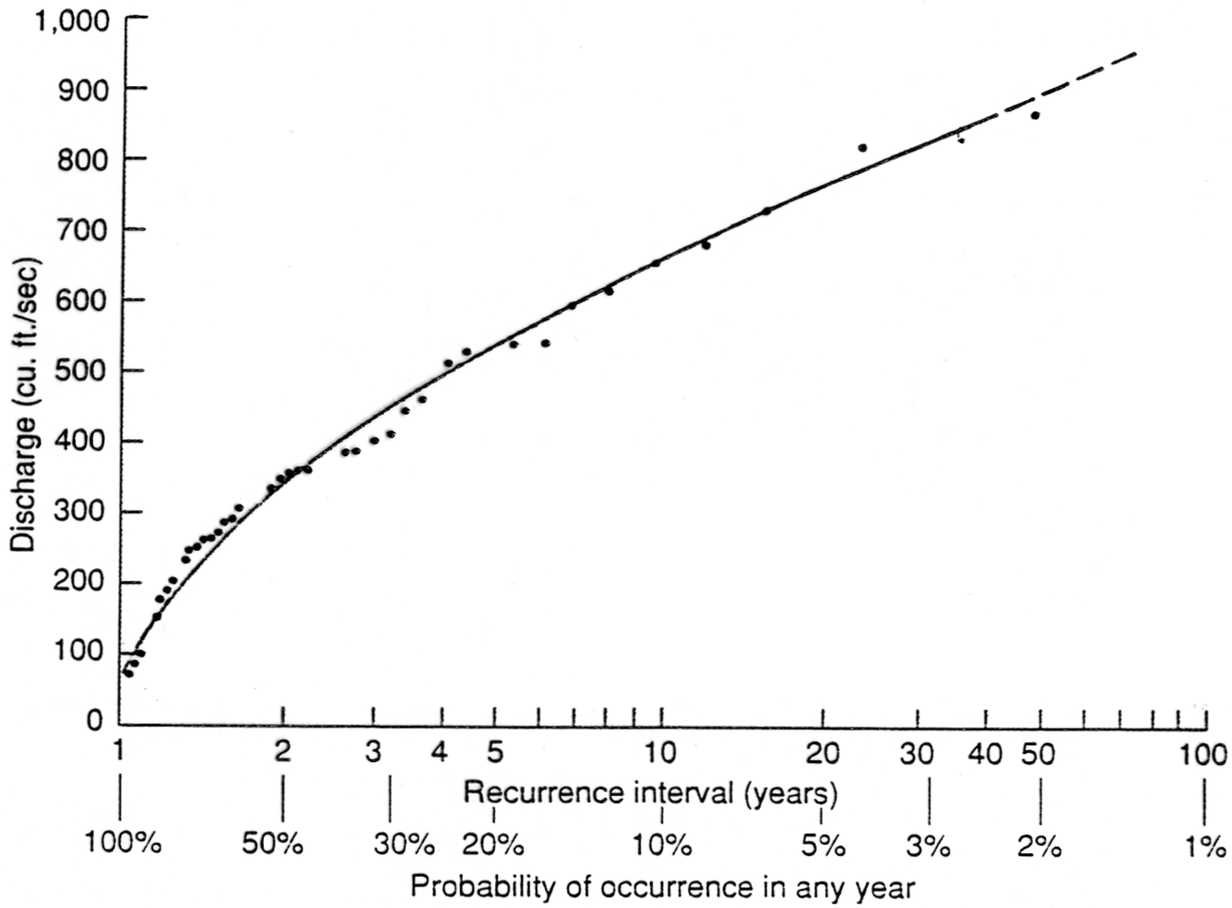
flow duration curve



Flow duration curve for the Powder River near Arvada, Wyo., 1917–1950.
(Leopold and Maddock 1953)

River Processes

Another common approach to finding the frequency-magnitude relationship is to consider only peak discharge during the year.



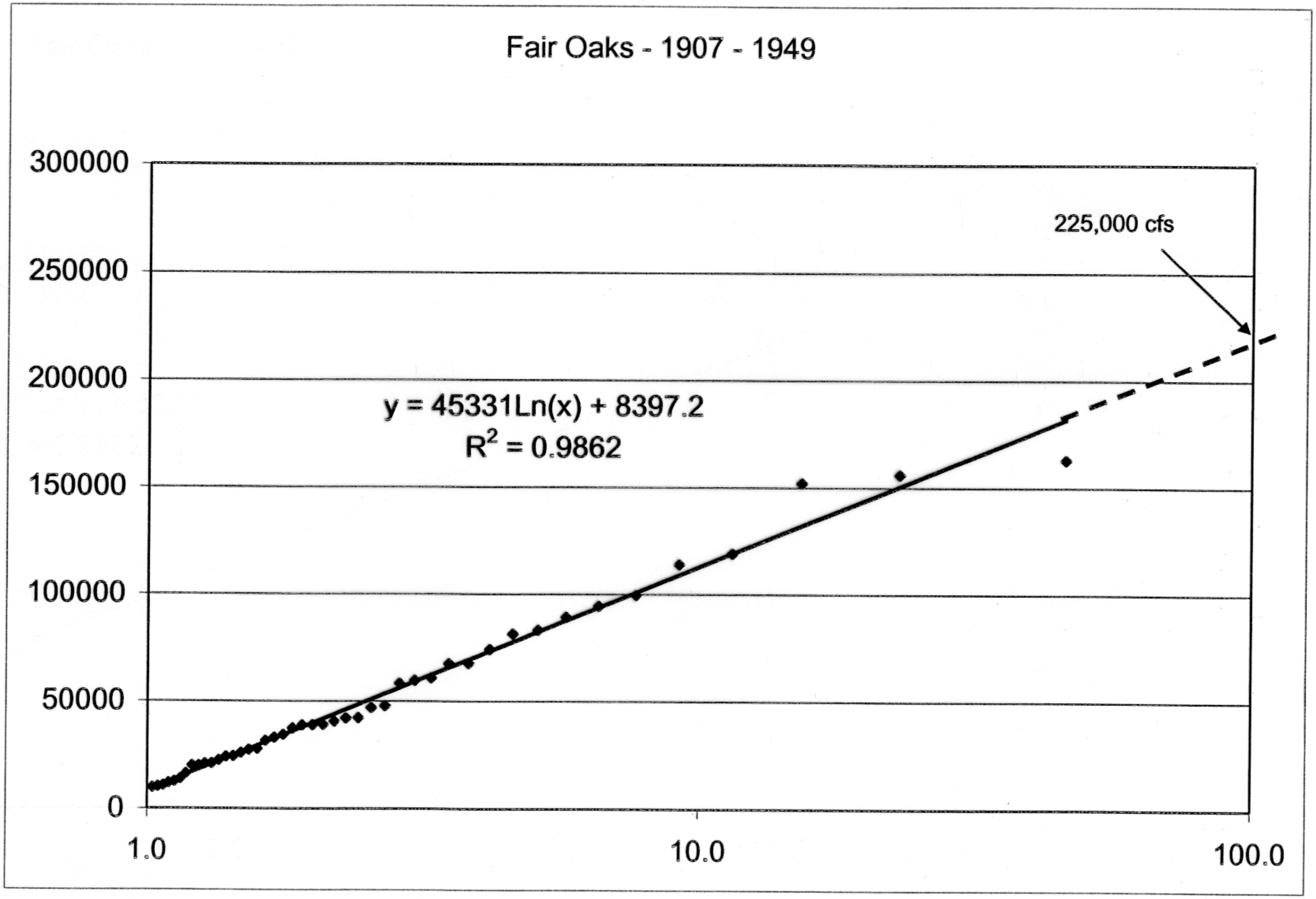
River Processes

The ***recurrence interval (R)*** is the average time between flow events of equal or larger magnitude and is calculated as:

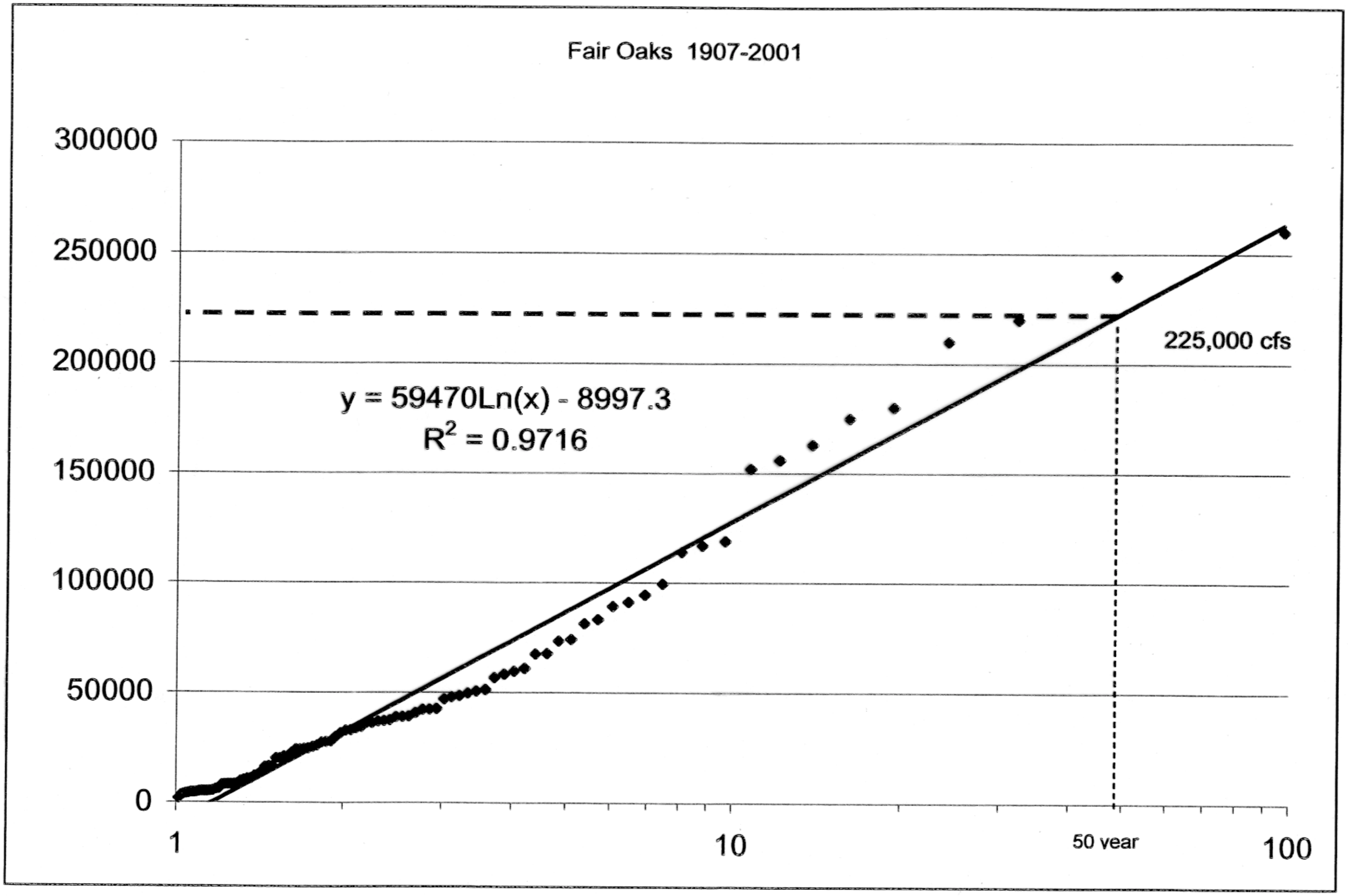
$$R = (n + 1) / m$$

where:
n – total number of discharge values in the sample, and
m – the rank of the given flow

River Processes

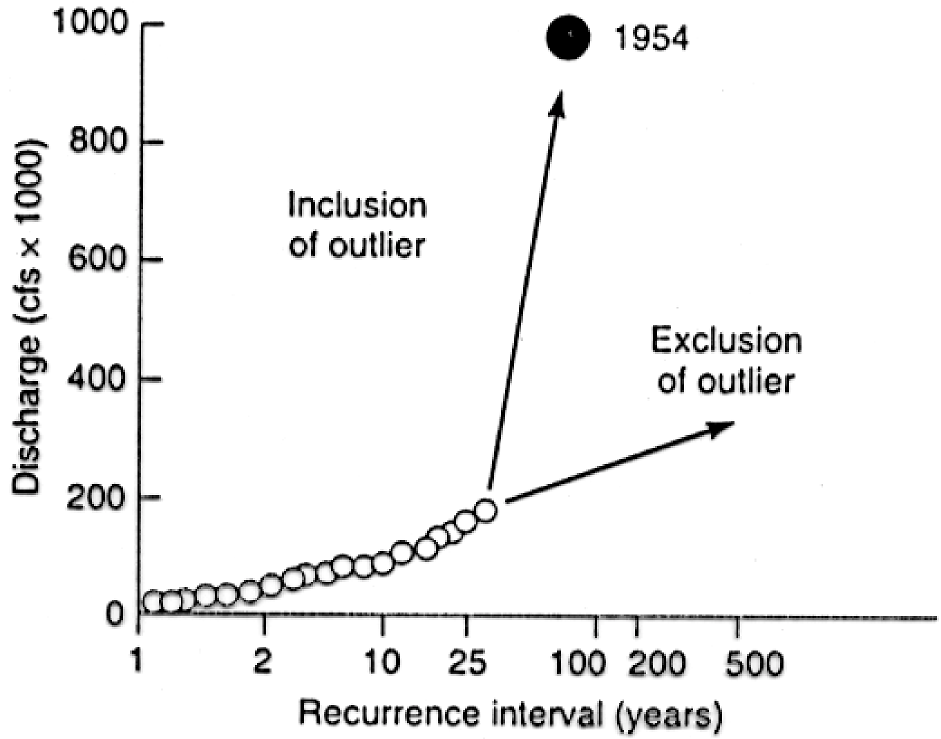


River Processes



River Processes

Sometimes the data sets are less than clear in how events should be considered. Statistical outliers often orient the direction of data trends.



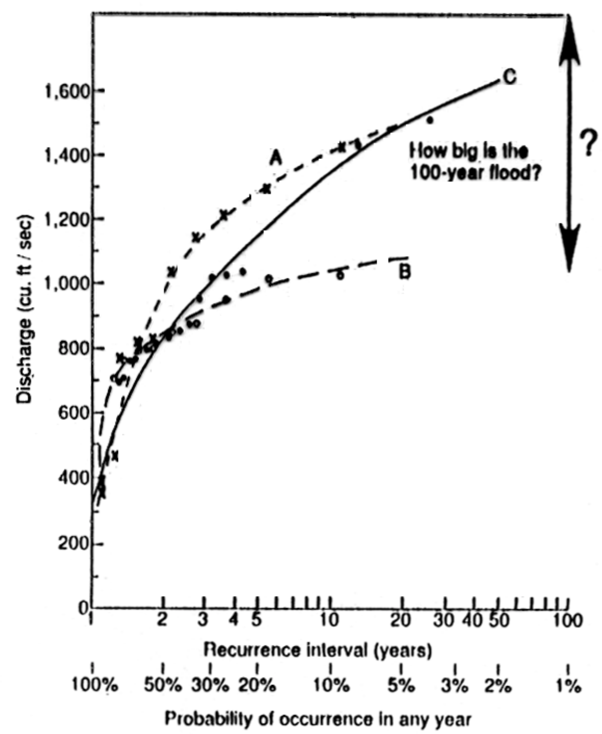
River Processes

Sometimes the data sets are less than clear in how events should be considered.

Which one is right?

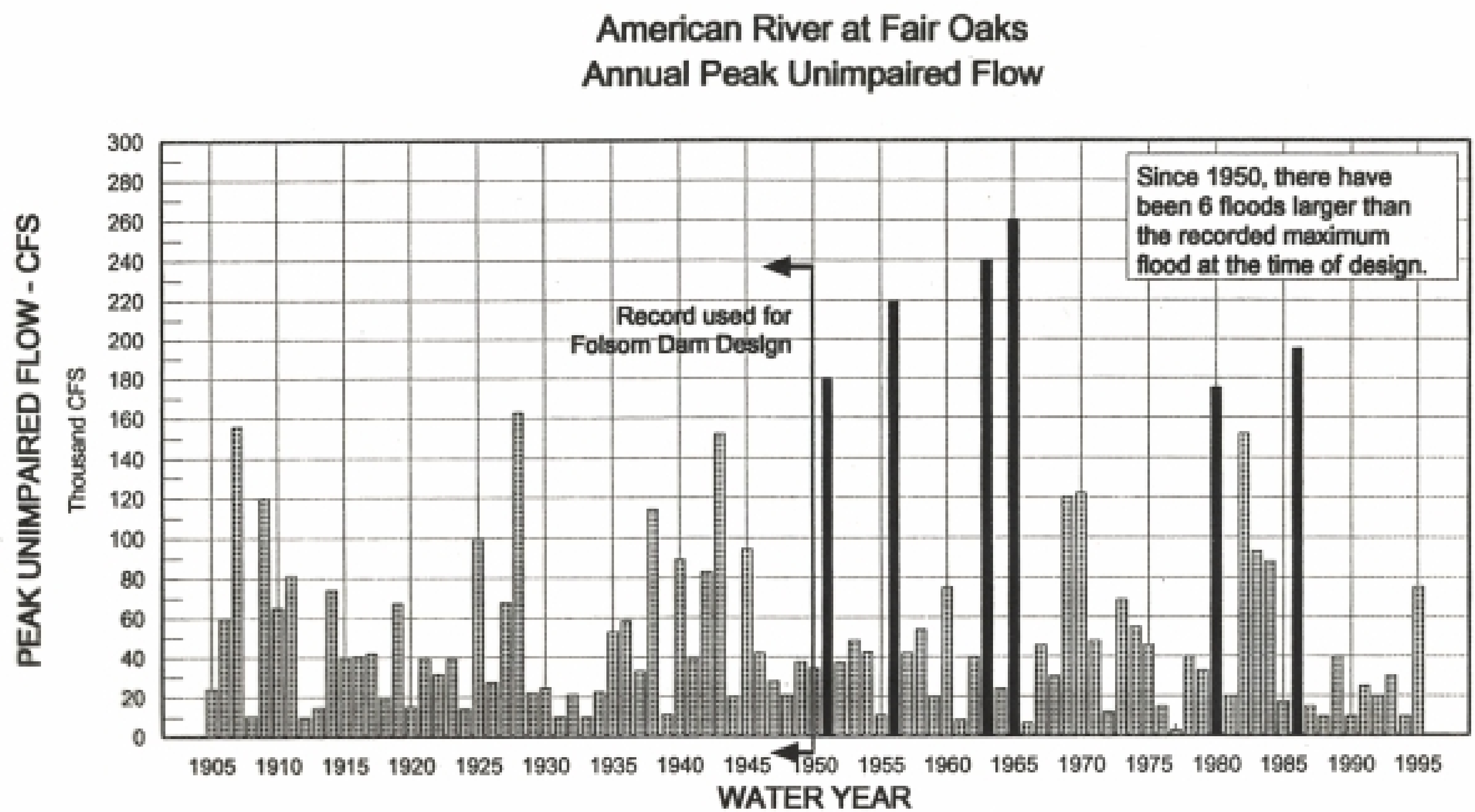
Year	Maximum mean one-day discharge (cu. ft. / sec.)	For twenty-five-year record		For ten-year record	
		M (rank)	R (years)	M (rank)	R (years)
1951	1,220	4	6.50	3	3.67
1952	1,310	3	8.67	2	5.50
1953	1,150	5	5.20	4	2.75
1954	346	25	1.04	10	1.10
1955	470	23	1.13	9	1.22
1956	830	13	2.00	6	1.83
1957	1,440	2	13.0	1	11.0
1958	1,040	6	4.33	5	2.20
1959	816	14	1.86	7	1.57
1960	769	17	1.53	8	1.38
1961	836	12	2.17		
1962	709	19	1.37		
1963	692	21	1.23		
1964	481	22	1.18		
1965	1,520	1	26.0		
1966	368	24	1.08	10	1.10
1967	698	20	1.30	9	1.22
1968	764	18	1.44	8	1.38
1969	878	10	2.60	4	2.75
1970	950	9	2.89	3	3.67
1971	1,030	7	3.71	1	11.0
1972	857	11	2.36	5	2.20
1973	1,020	8	3.25	2	5.50
1974	796	15	1.73	6	1.83
1975	793	16	1.62	7	1.57

Source: Data from U.S. Geological Survey Open-File Report 79–681.



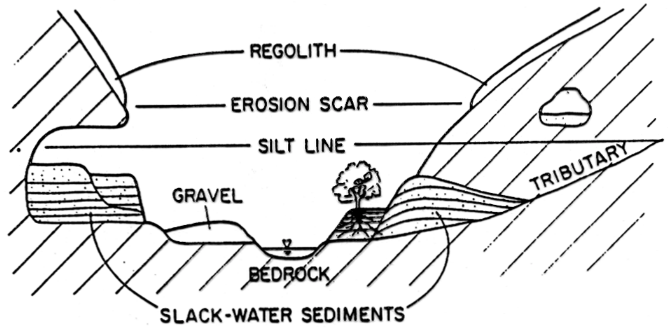
River Processes

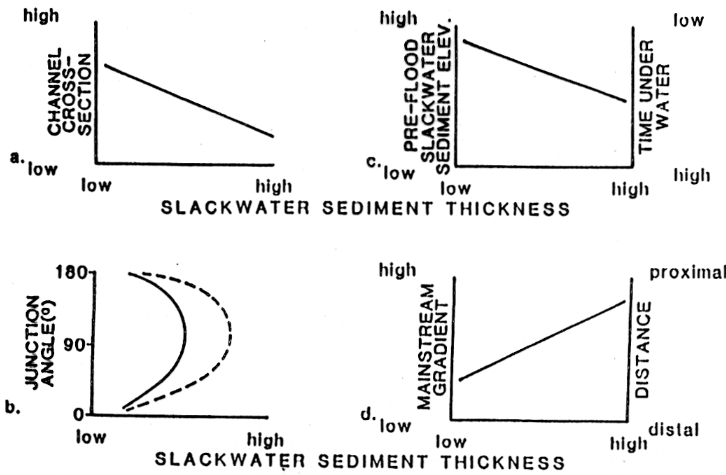
Folsom Dam, Sacramento, California



River Processes

One of the more promising techniques used to extend the curves seems to be ***Paleohydrology*** which uses Holocene stratigraphic records – specifically ***slack water sediments***.



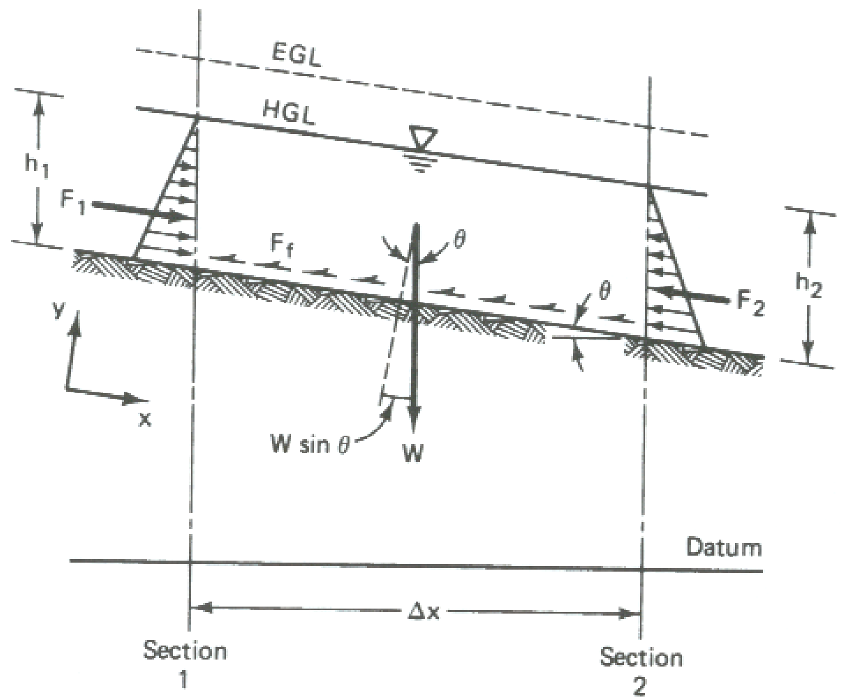


River Processes

Using a more sophisticated version of Q = V * A, flood hydrologists reconstruct the discharge that likely occurred to occupy the cross-sectional area of the channel defined by the slack water sediments.

Using the continuity equation (Q = V * A) the discharge is given by:

$$Q = (1.49 / n)\ A * R^{2/3} * S^{1/2}$$



River Processes

Applicability

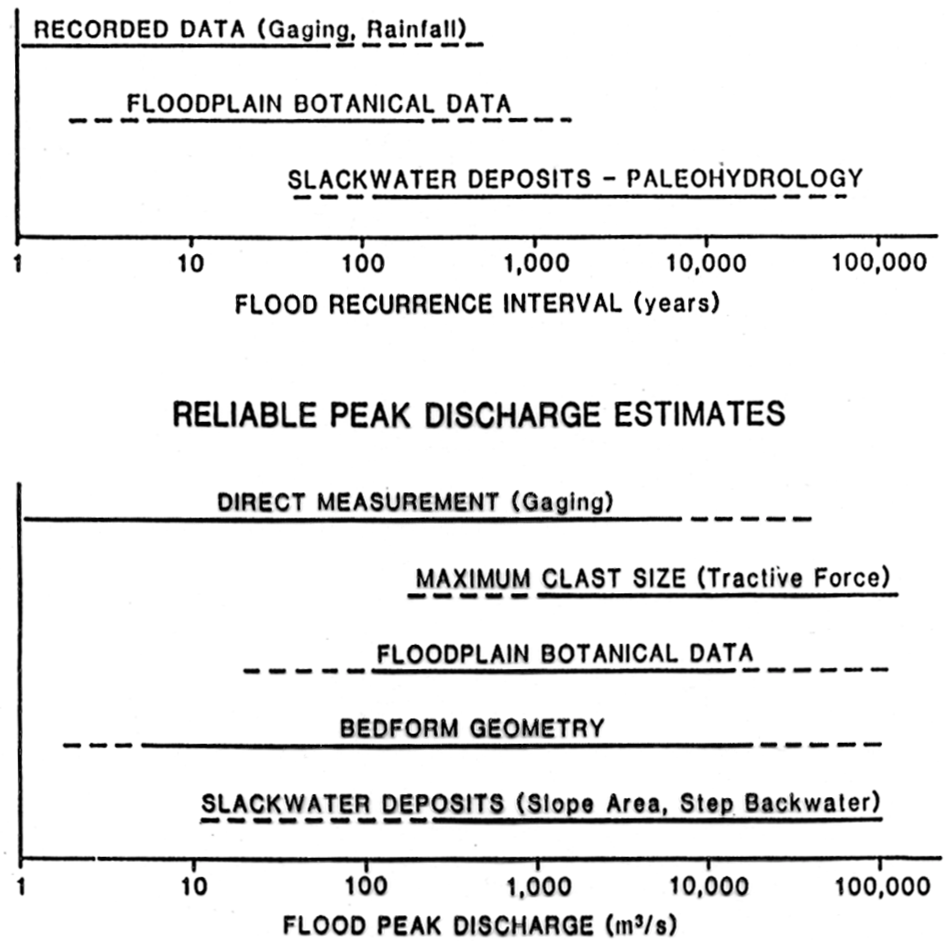
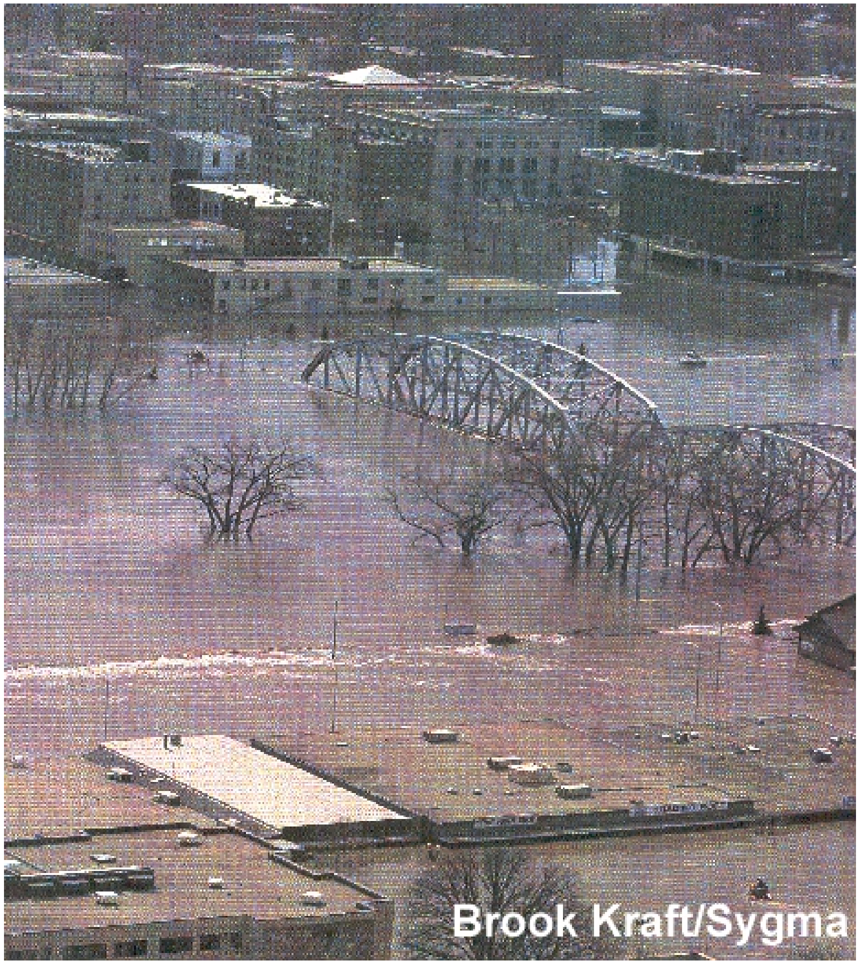


FIGURE 12. Range of applicability and reliability of various historical and paleoflood techniques for estimating paleoflood discharge and frequency.

River Processes

Flooding

A **flood** is defined as any relatively high stream flow that spills out of a stream's channel onto the valley floor.



River Processes

Flooding

River Processes

Flooding

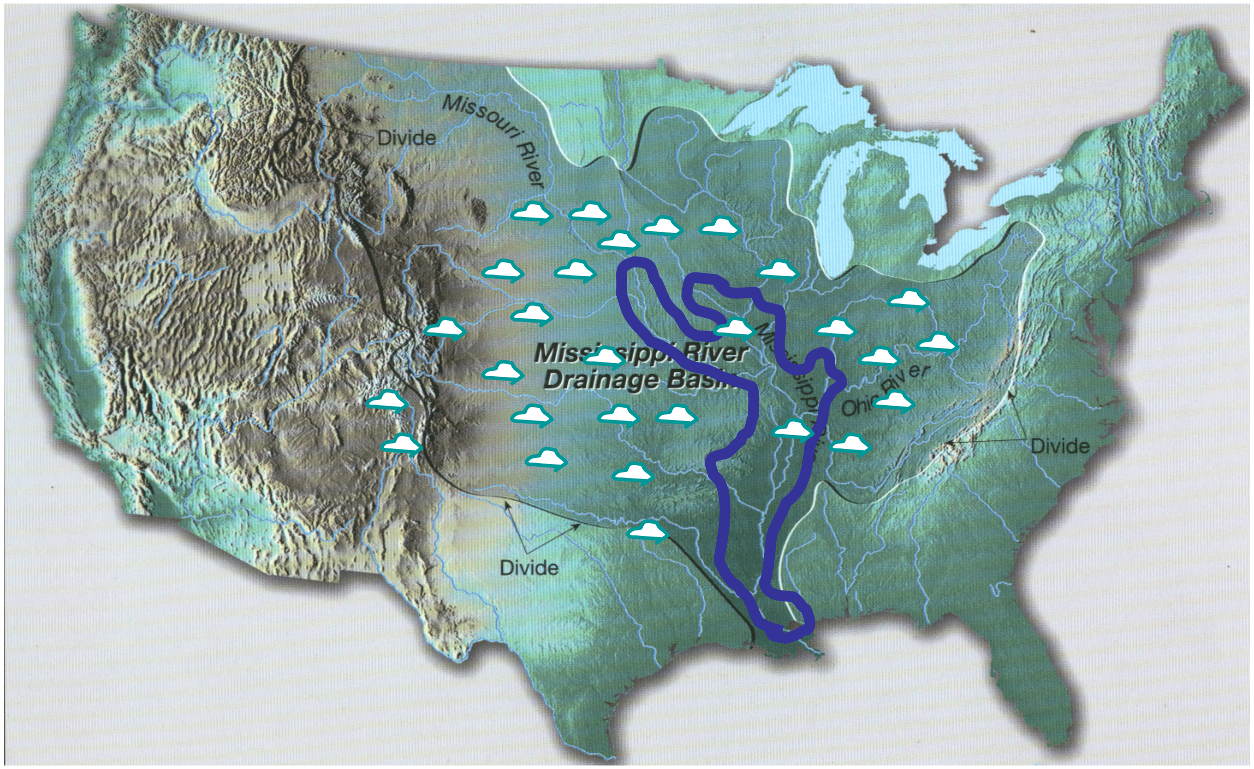
Upstream floods

River Processes

Flooding

Downstream floods

downstream flood



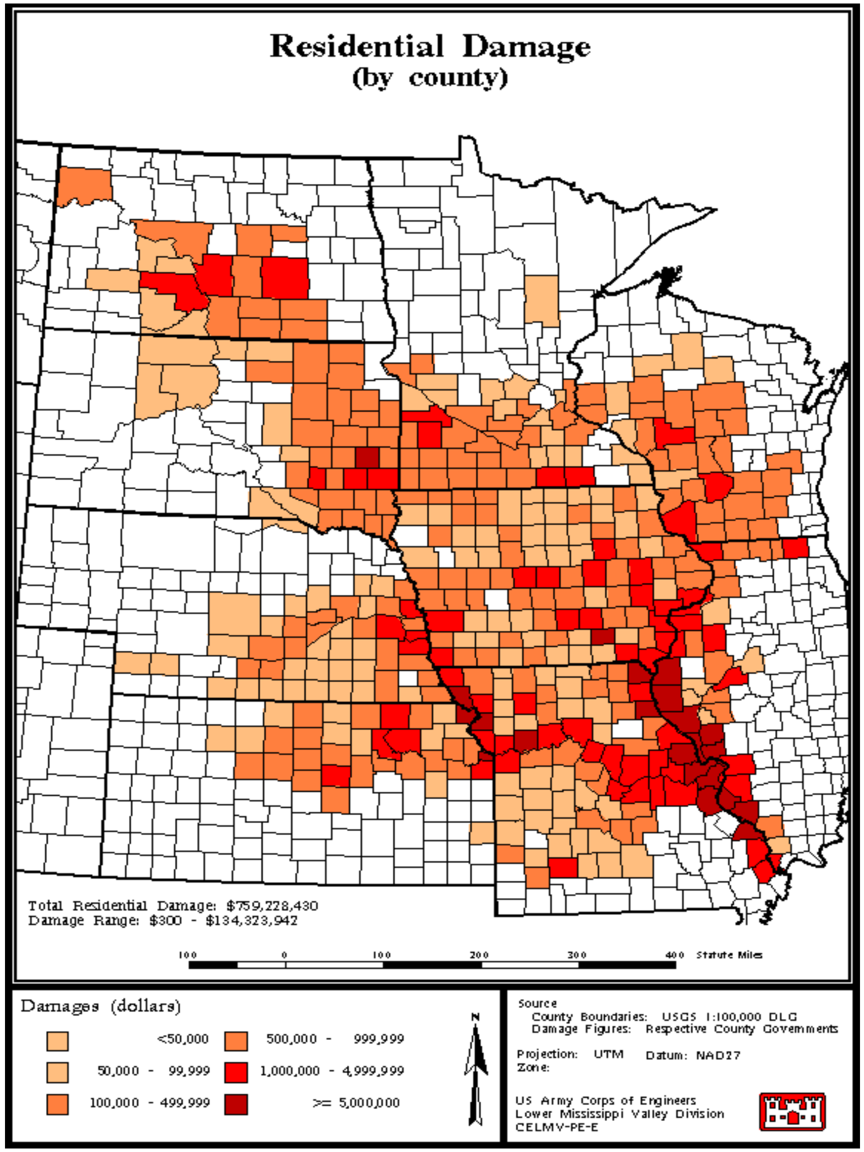
River Processes

Flooding

Mississippi River Flood of 1993.

River Processes

Flooding



Mississippi River Flood of 1993.

River Processes

The River Channel

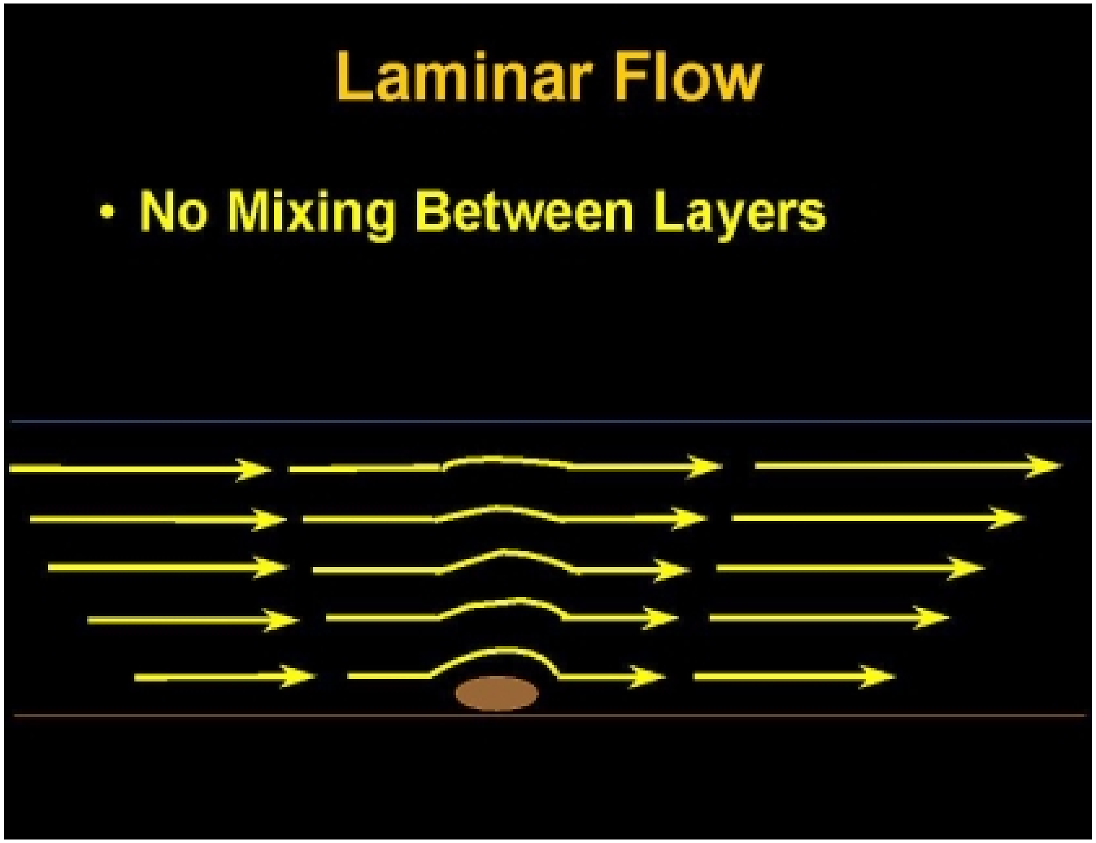
River Processes

The River Channel

Resistance is spread through the water by viscous or turbulent processes.

River Processes

The River Channel
Laminar vs. turbulent flow



River Processes

The River Channel

When laminar flow changes to turbulent can be predicted:

$$RE = (V * R * \rho) / u$$

where V is the mean velocity,
R is the hydraulic radius,
ρ is the density, and
u is the molecular viscosity.

The hydraulic radius R is determined by the relationship:

$$R = A / P$$

where A is the cross-sectional area of the channel and
P is the wetted perimeter

River Processes

Flow equations and resisting factors
Chezy equation

$$V = C * (R * S)^{1/2}$$

The **Manning number**, defined as :

$$V = (1.49 / n) * R^{2/3} * S^{1/2}$$

so

$$C (R S)^{1/2} = (1.49 / n) * R^{2/3} * S^{1/2}$$

then

$$C = 1.49 (R^{1/6} / n)$$