Updated: 11 September 2017

Print version

CEE 577: Surface Water Quality Modeling

Lecture #3

(Rivers & Streams)

Chapra, L14

Watershed & Hydrogeometric Parameters

- Geometry
  - Width and Depth
  - Slope
- Hydrology
  - Velocity and Flow
  - Mixing characteristics (dispersion)
- Drainage Area
- Dams, Reservoirs & flow diversions
- Geographical location of basin

Assessing Hydrogeometry

- Point Estimates vs. Reach Estimates
- Flow
  - often requires velocity
  - May use stage
    - USGS gaging stations

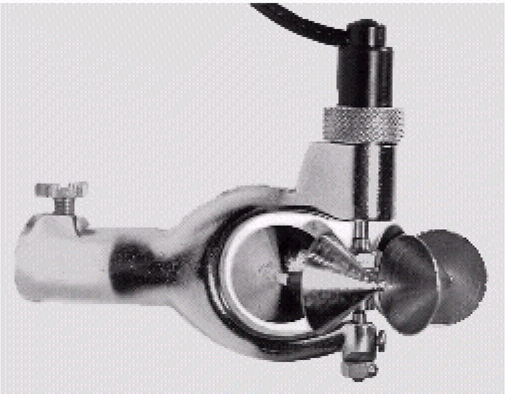
$$Q = UA_c$$

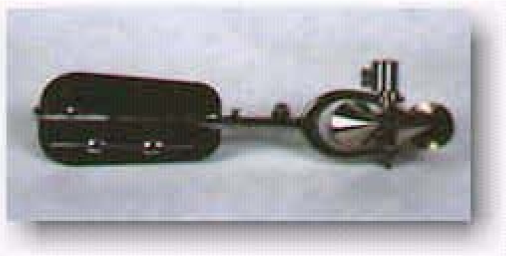
$$U = \frac{Q}{A_c}$$

- Velocity
  - Current Meter
  - Weighted Markers or Dye

Current Meters

- Price
- Pygmy





http://advmnc.com/Rickly/currmet.htm
http://www.swoffer.com/2200.htm

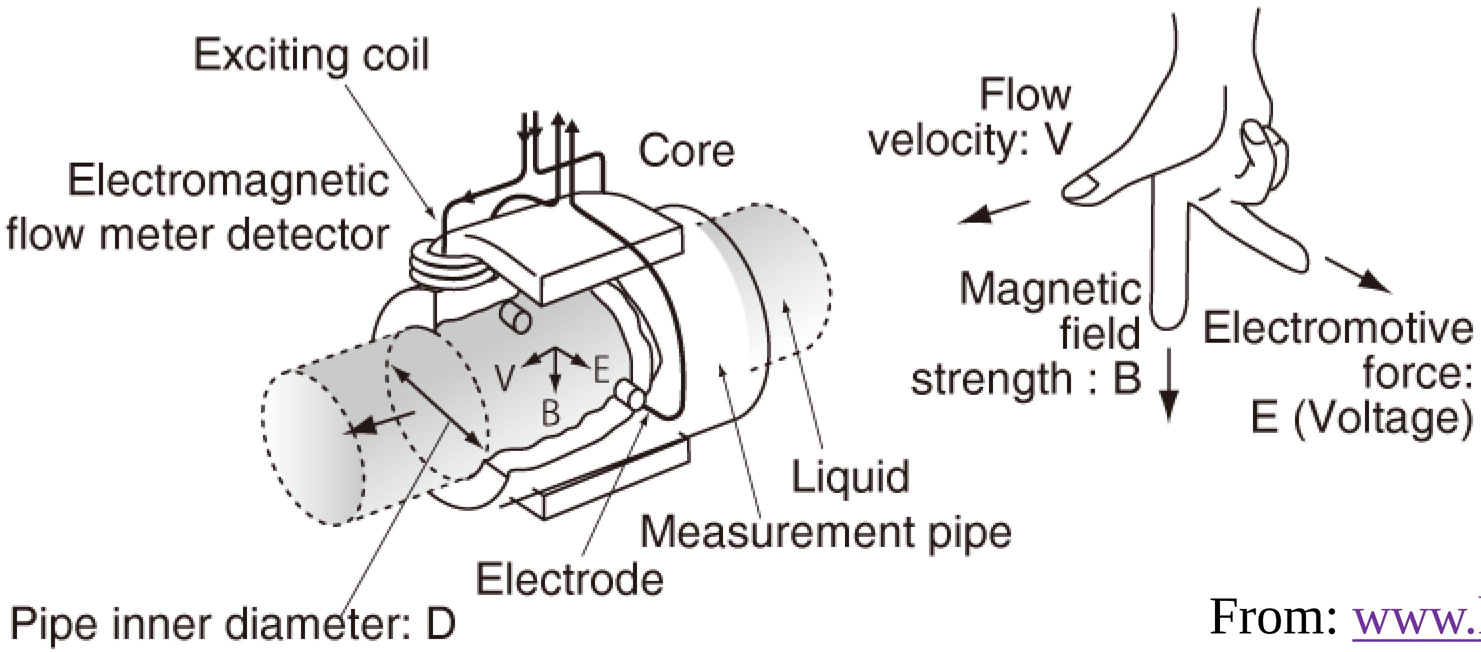
Electromagnetic sensors

- Hach FH950 flow meter

Images: www.hach.com

Principles of electromagnetic sensing

- Under Faraday's law of induction, moving conductive liquids inside of a magnetic field generates an electromotive force (voltage) in which the pipe inner diameter, magnetic field strength, and average flow velocity are all proportional. In other words, the flow velocity of liquid moving in a magnetic field is converted into electricity. (E is proportional to $V \times B \times D$)



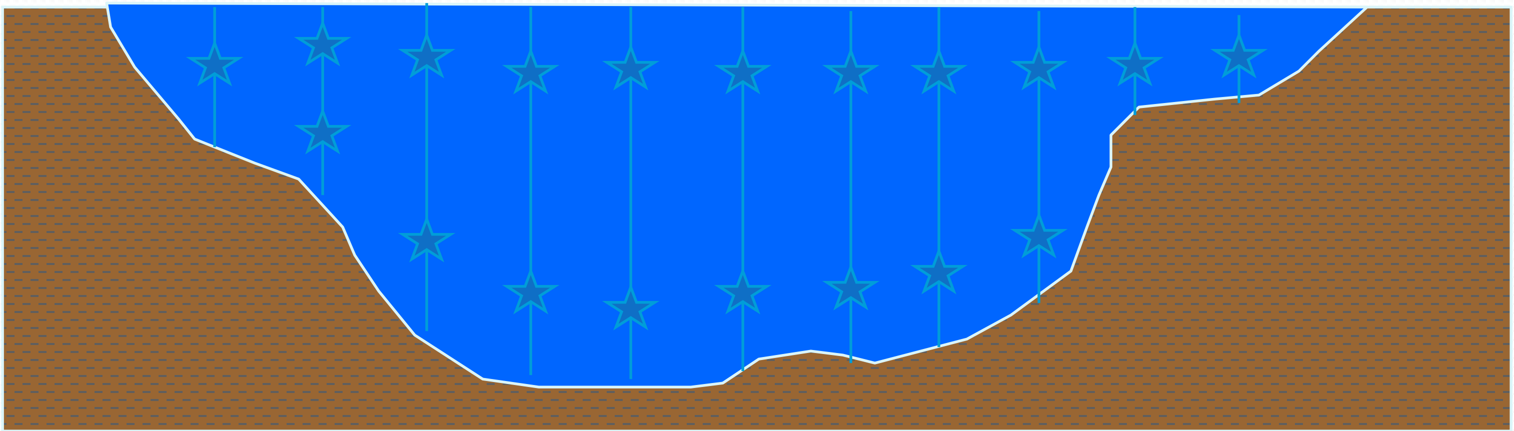
From: www.keyance.com

Current Meter Deployment

- Current meter and weight suspended from a bridge crane
- Wading rod and current meter used for measuring the discharge of a river

Current Meter Method

- Divide stream cross section into transects
- Measure velocity in each with meter
  - at 60% depth in shallow water (<2ft)
  - or 20% and 80% depth in deep water



Deployment cont.

- Crane, current meter, and weight used for measuring the discharge of a river from a bridge

From: U.S. GEOLOGICAL SURVEY CIRCULAR 1123; on the www at:

http://h2o.usgs.gov/public/pubs/circ1123/index.html

Moving Marker Methods

- Best for low velocity (<0.2 ft/s)
- Several types
  - Drogues (current at depth)
  - Dye (mixing too)
  - Surface objects (Oranges, Frisbees)
- Velocity from change in location with time

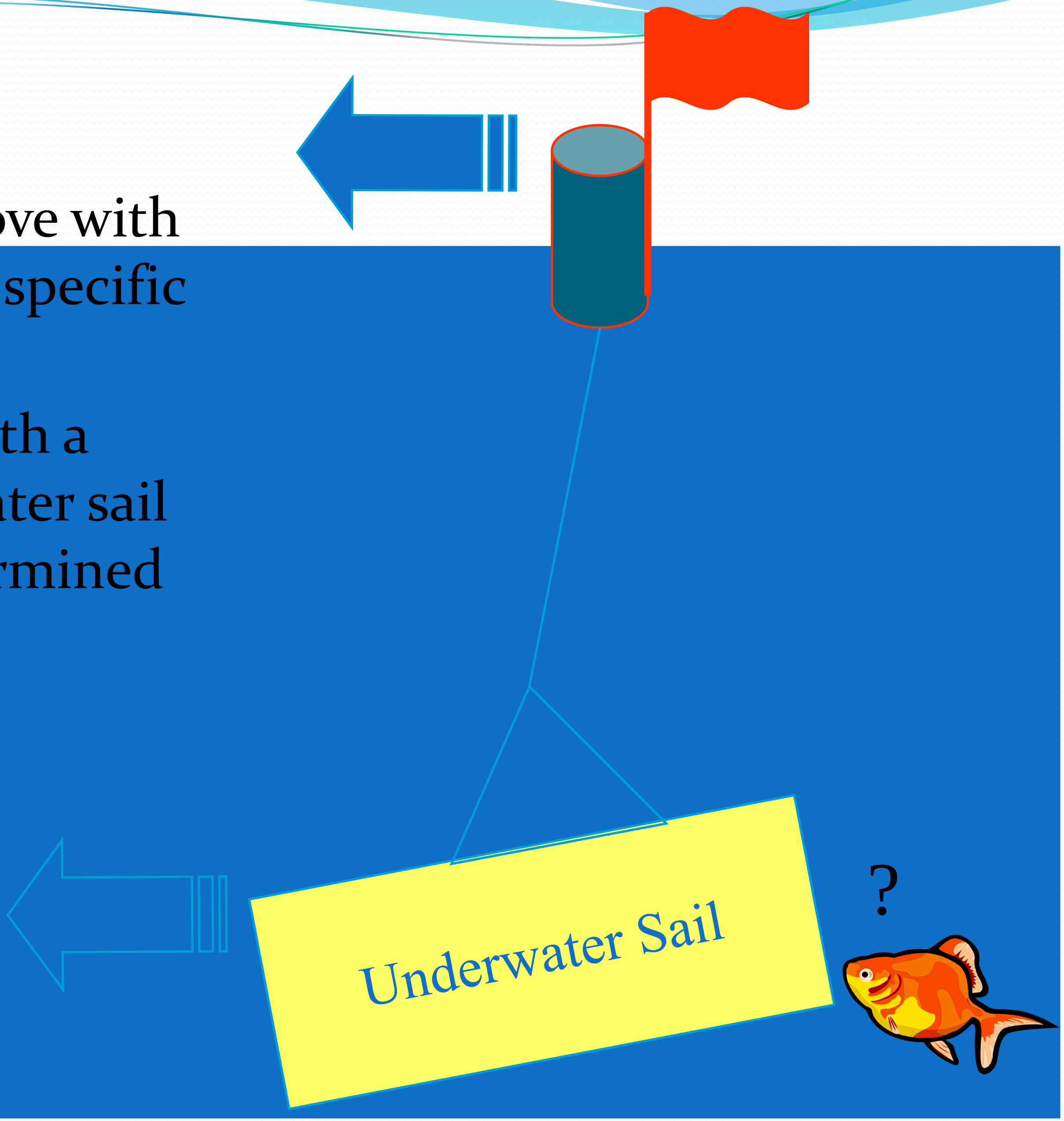
$$U_{avg} = \frac{\Delta x}{t^*}$$

Time of travel

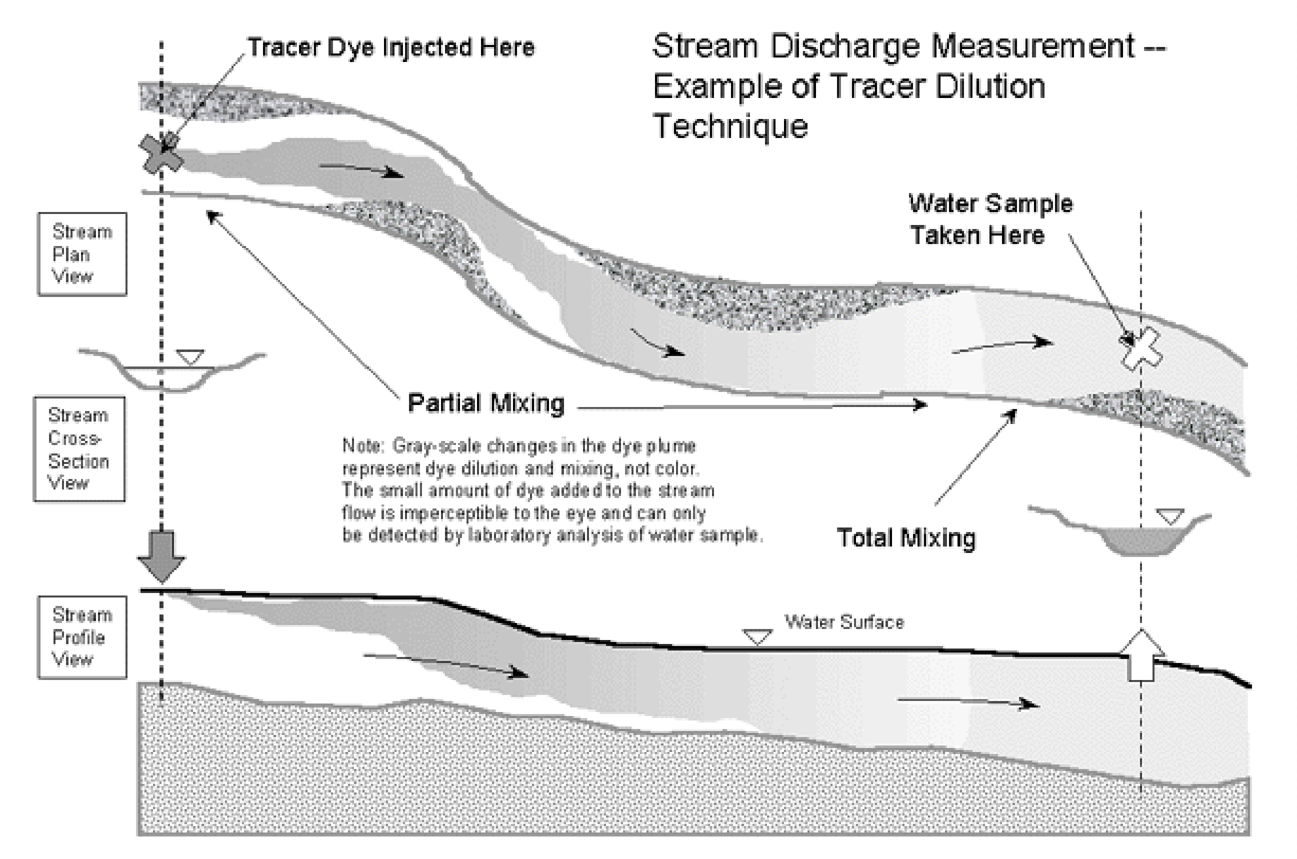
$$Q_{avg} = U_{avg}\left(\frac{A_1 + A_2}{2}\right)$$

Drogues

- Designed to move with the current at a specific depth
- Surface float with a plastic underwater sail set at a predetermined depth



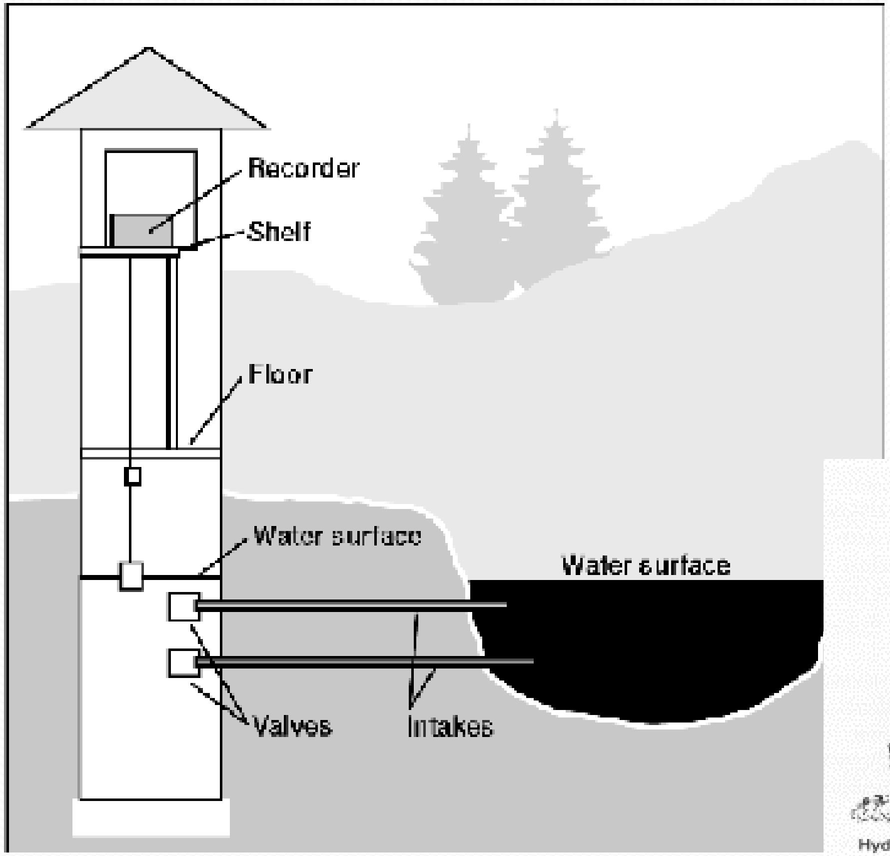
Dye studies

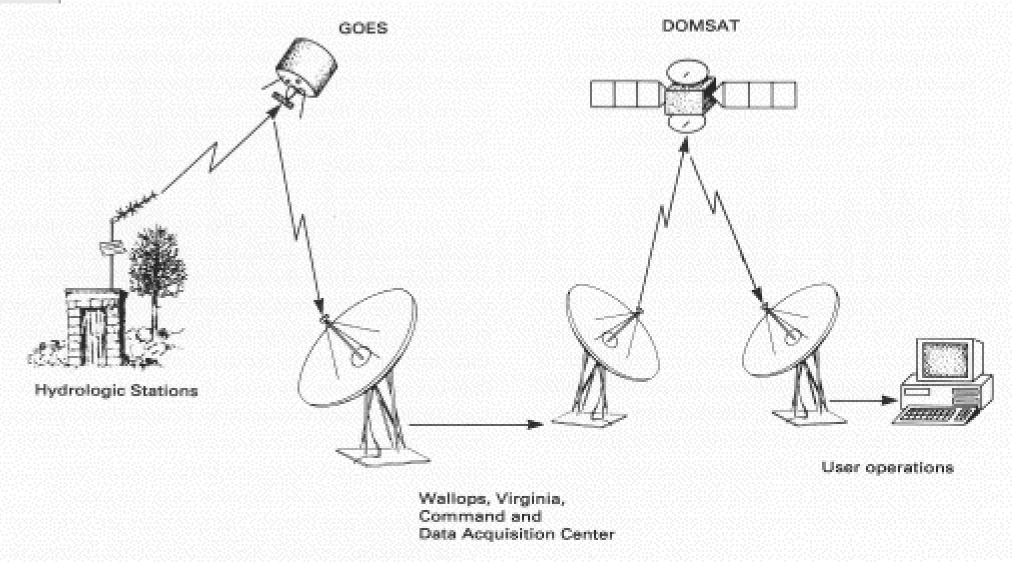


Drawing courtesy of R. D. Mac Nish, University of Arizona, Tucson (http://www.tucson.ars.ag.gov/salsa/research/research_1997/AMS_Posters/gw-sw_interactions/gw-sw_f1.html)

USGS Gaging Stations

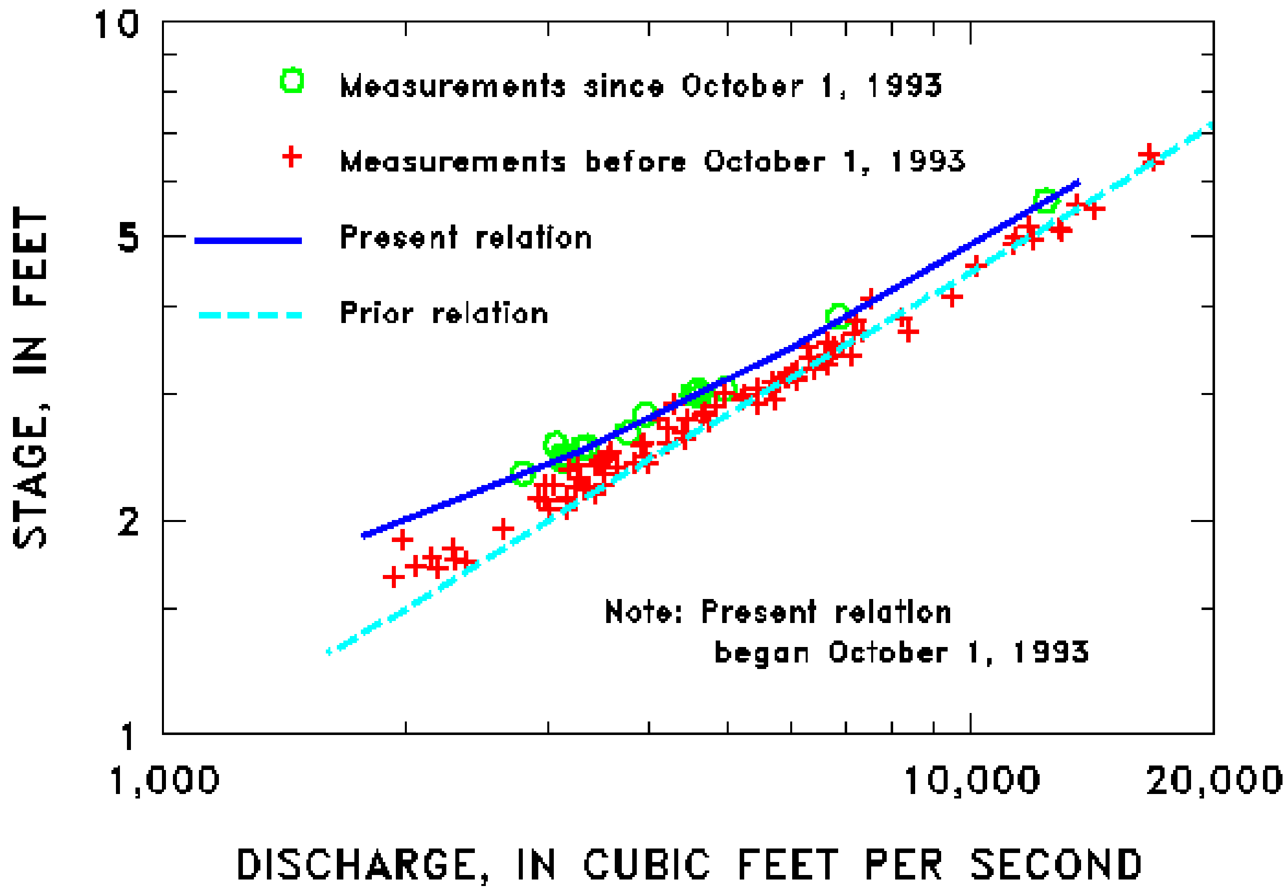
- Hardware & telemetry

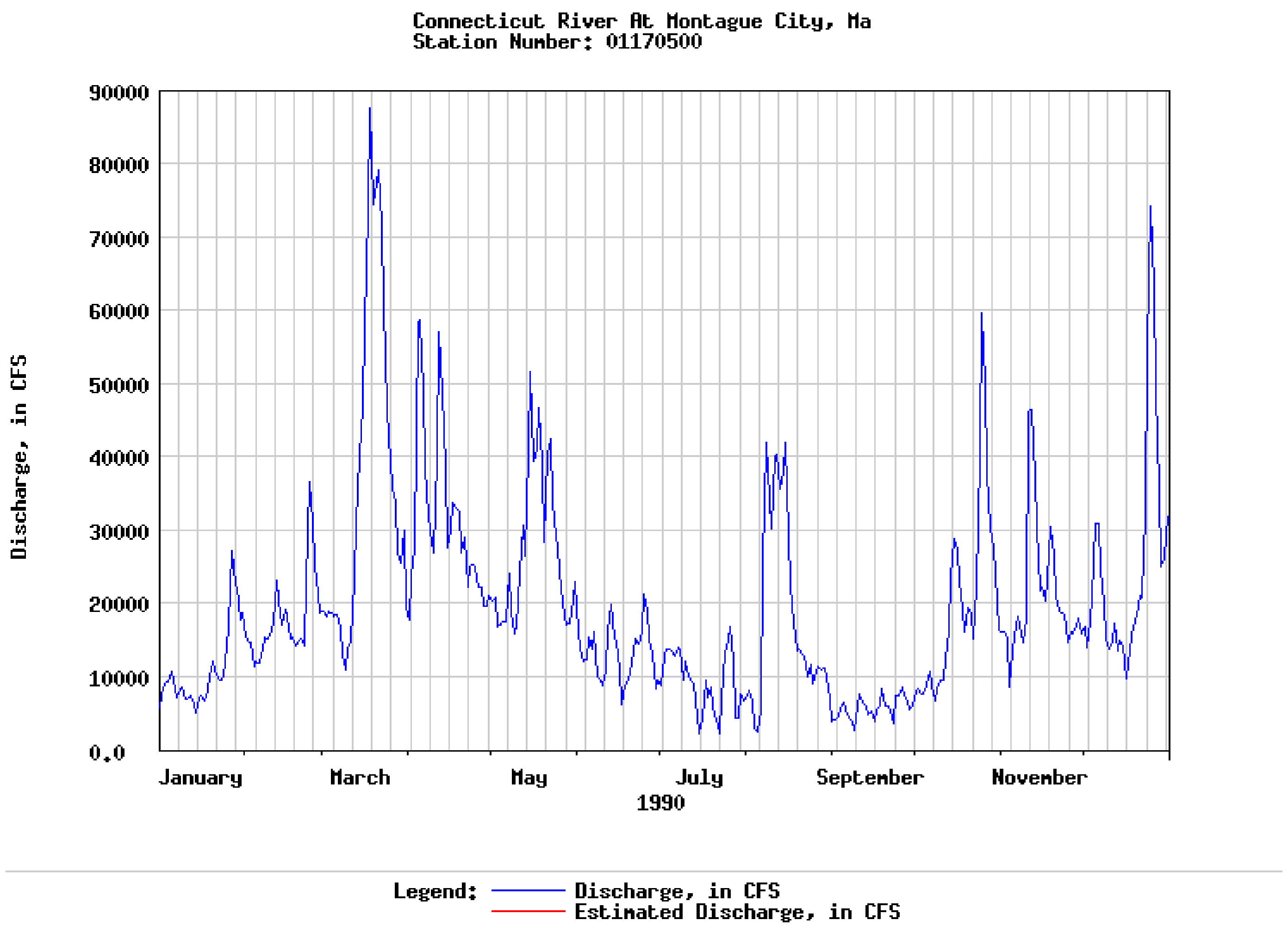




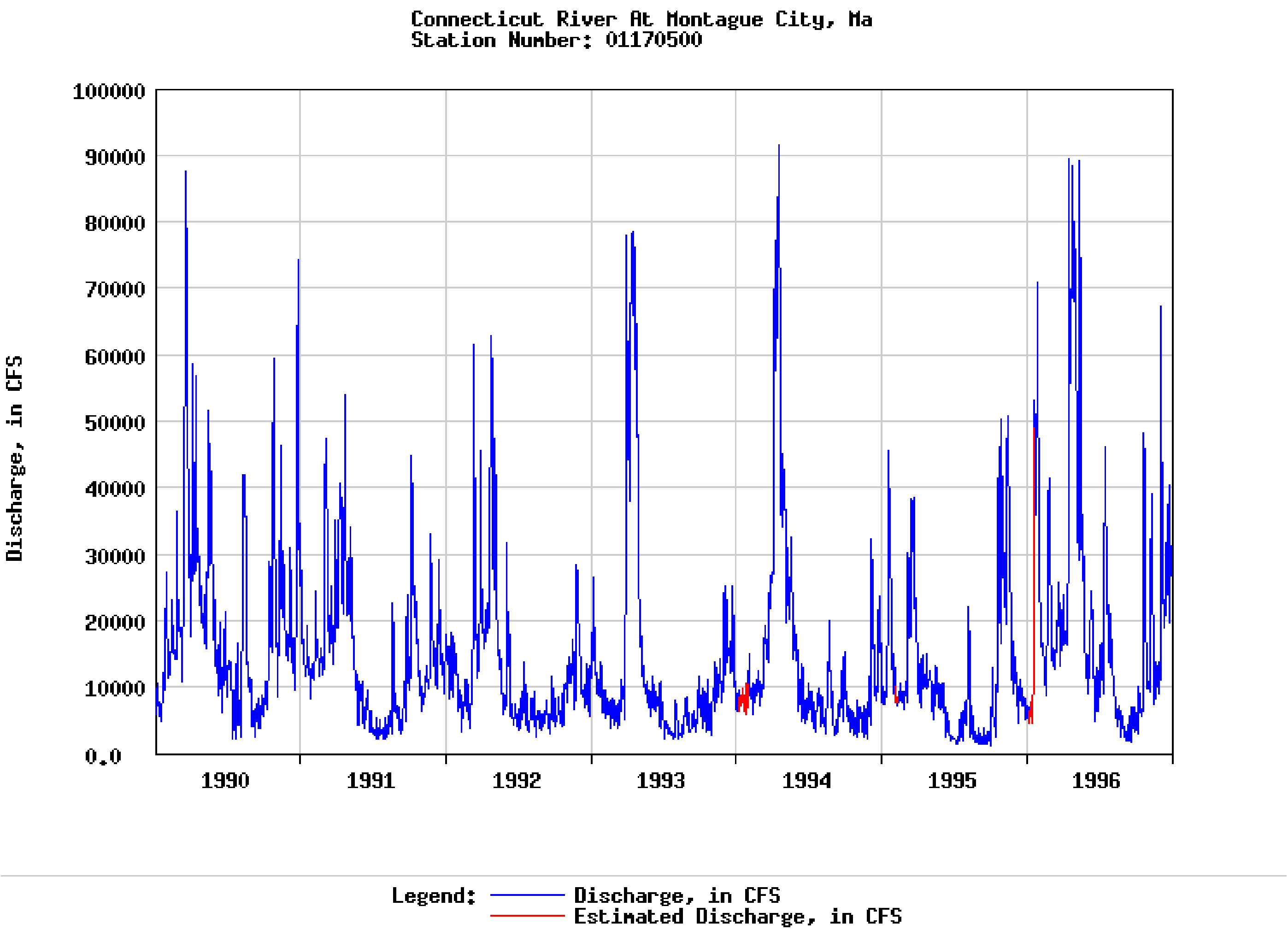
Stage vs Discharge

- Sections of stage-discharge relations for the Colorado River at the Colorado--Utah State line



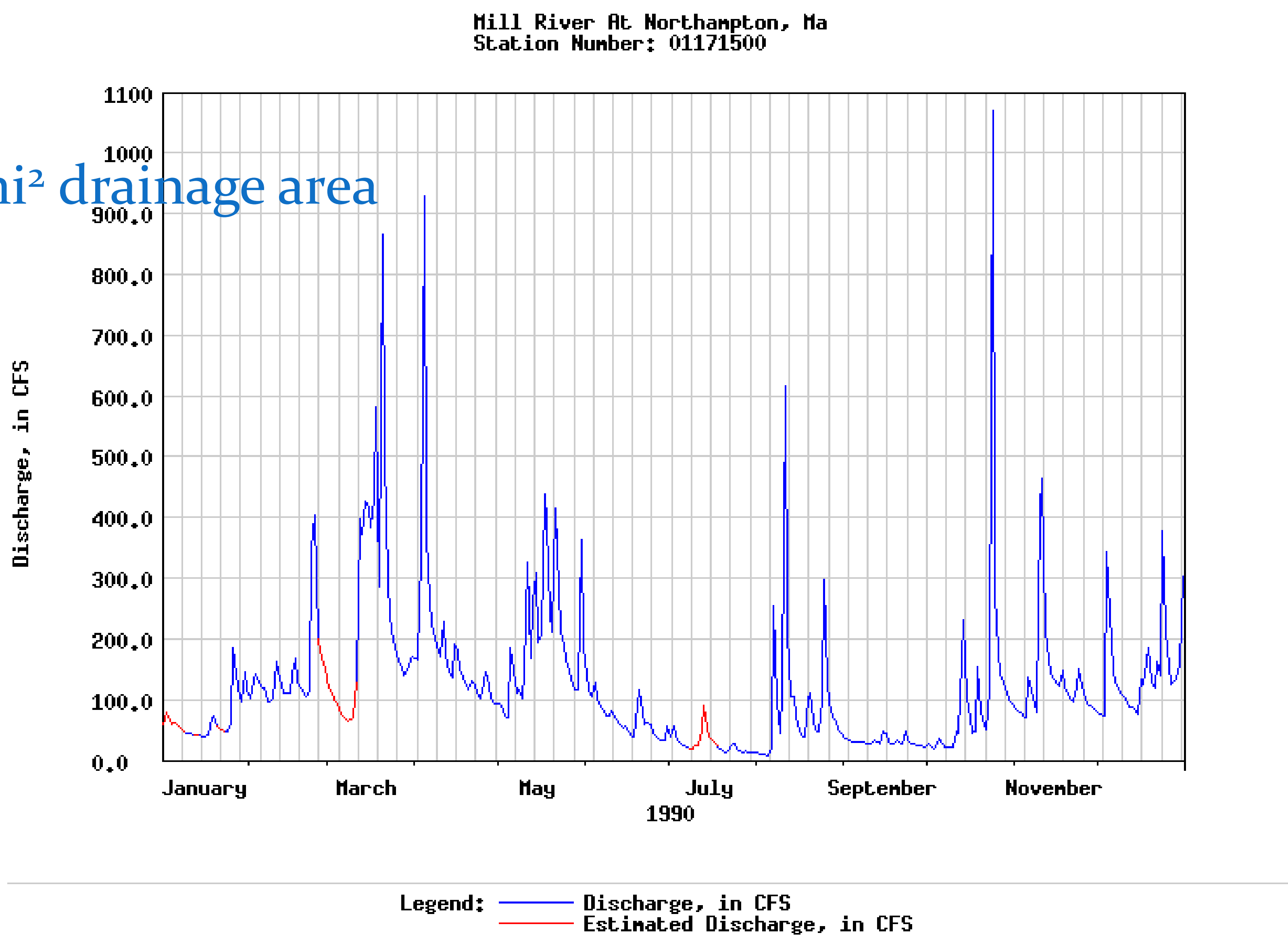

Connecticut River At Montague City, Ma
Station Number: 01170500
90000
80000
70000
60000
50000
40000
30000
20000
10000
0.0
Discharge, in CFS
January
March
May
July
September
November
1990
Legend:
Discharge, in CFS
Estimated Discharge, in CFS

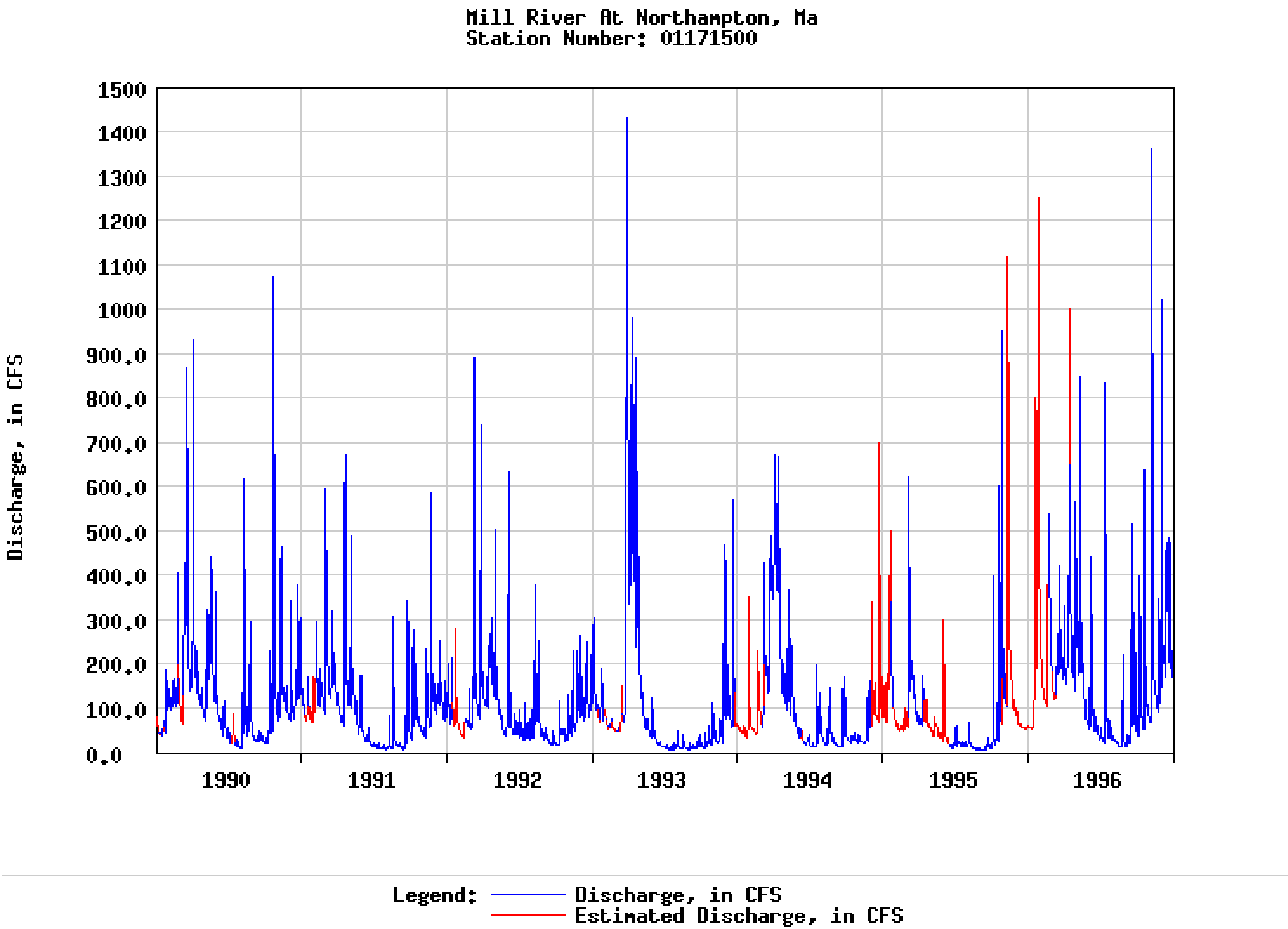
Annual Hydrograph



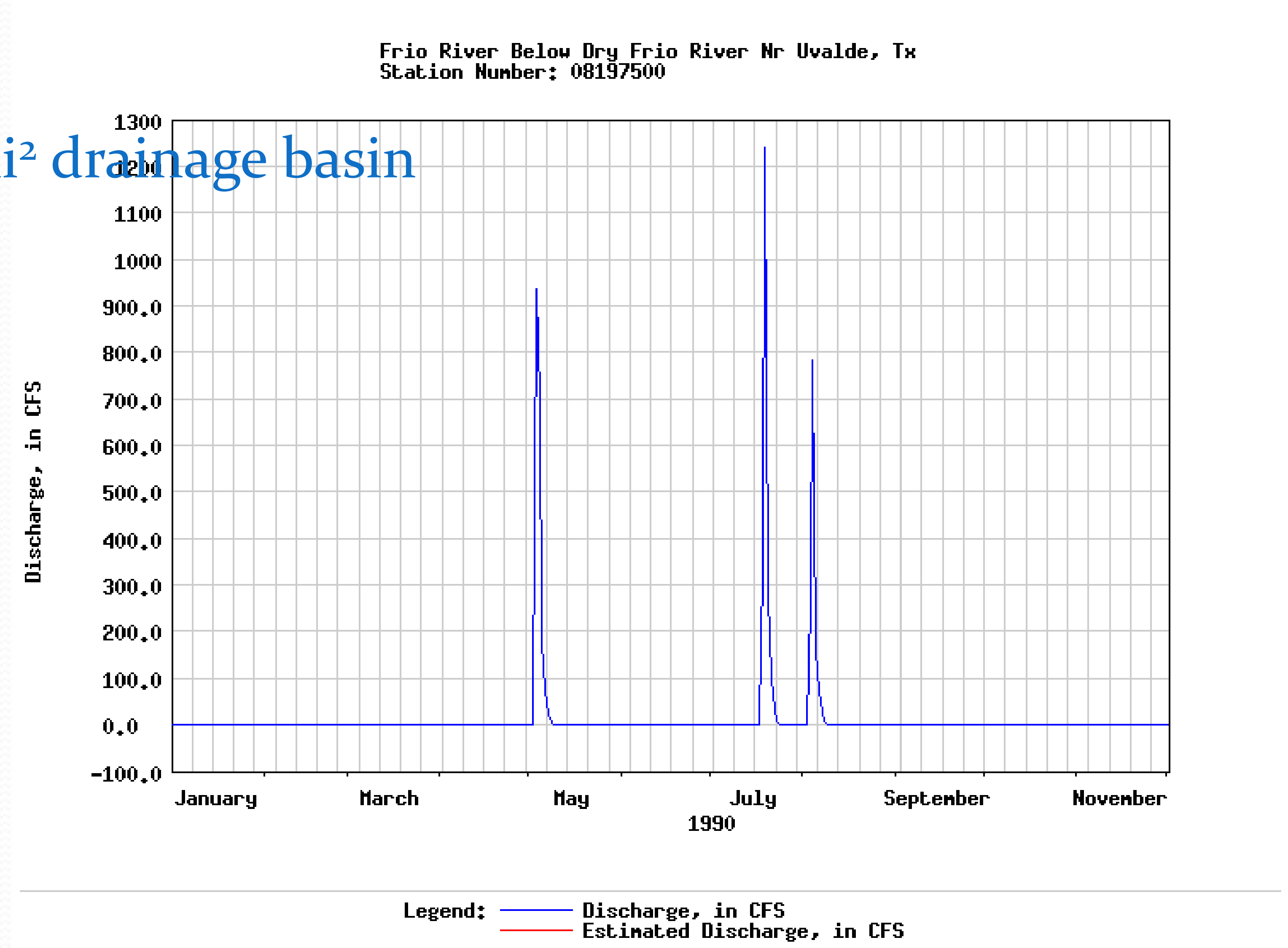
Perennial flow regime

- 52 mi² drainage area

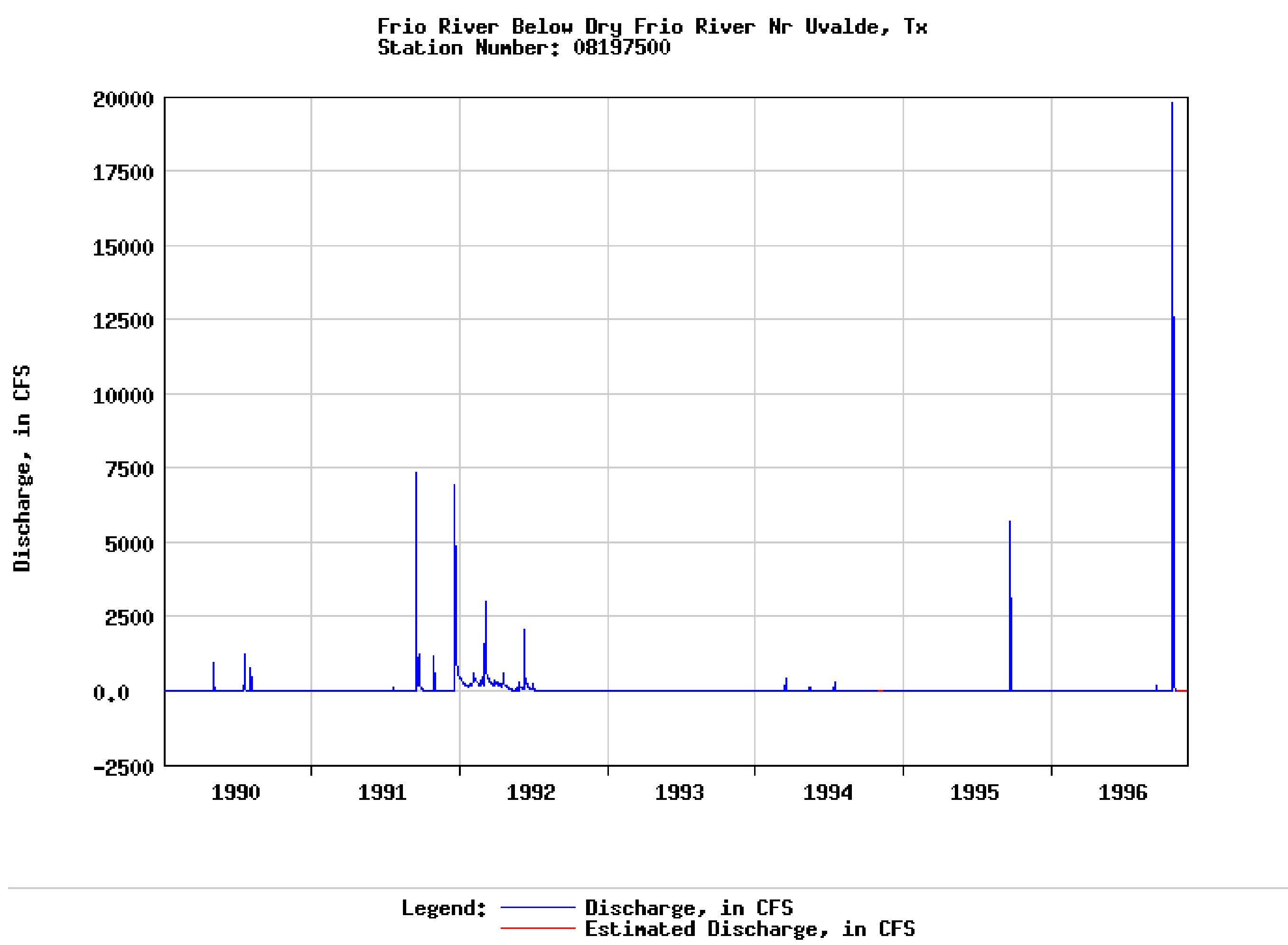



Mill River At Northampton, Ma
Station Number: 01171500
Discharge, in CFS
1500
1400
1300
1200
1100
1000
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
1990
1991
1992
1993
1994
1995
1996
Legend:
Discharge, in CFS
Estimated Discharge, in CFS

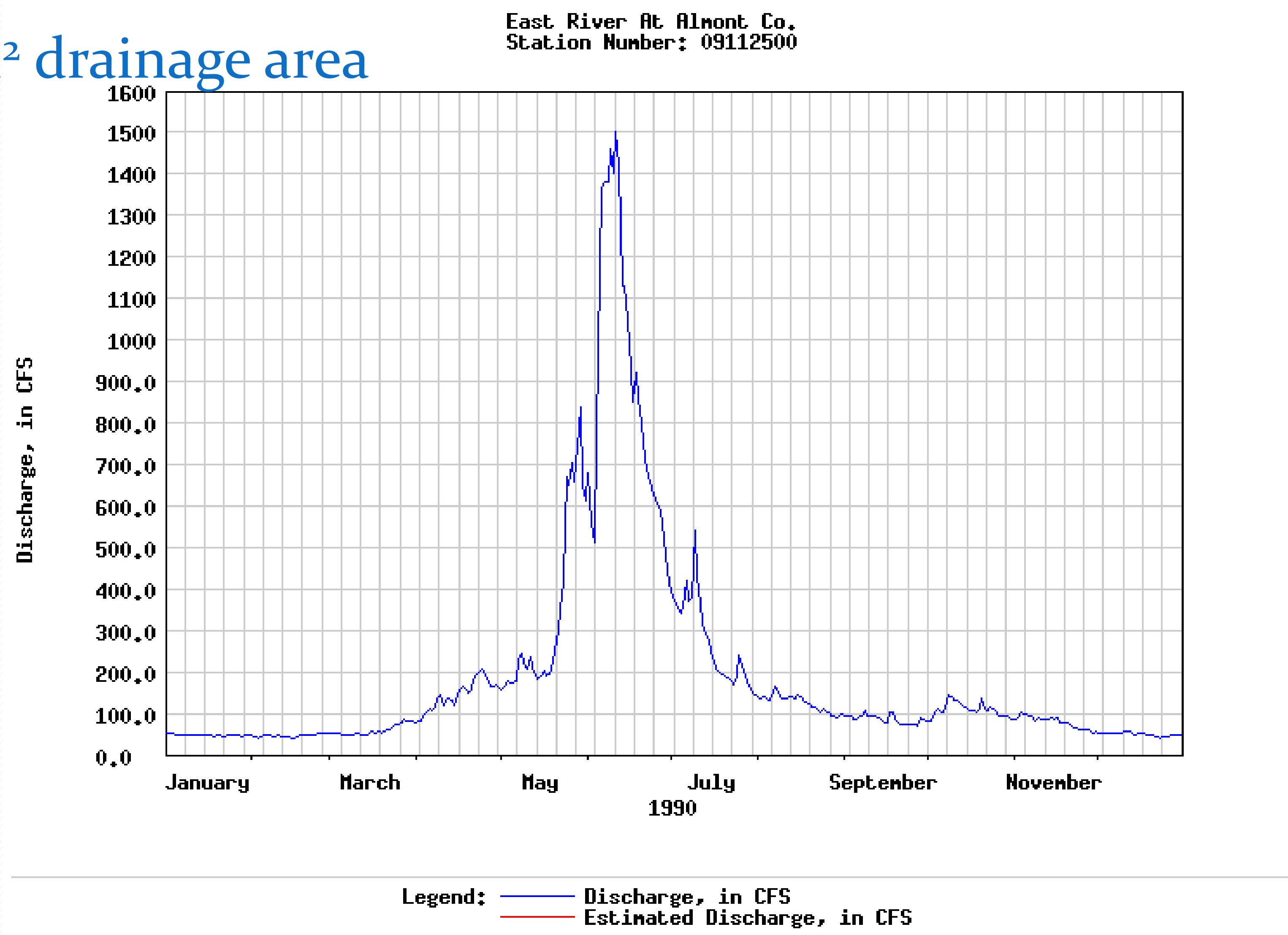
- 631 mi² drainage basin



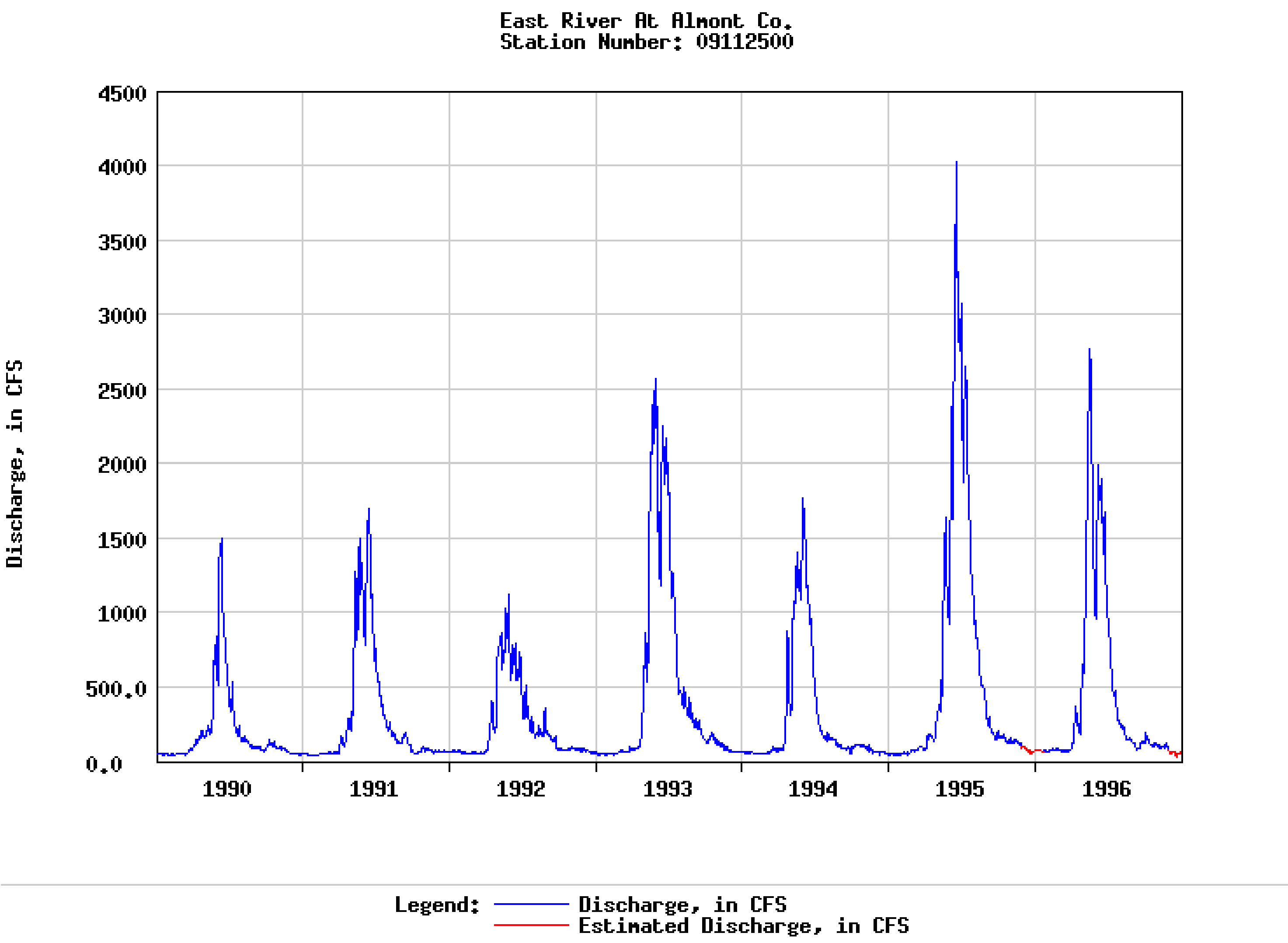
Ephemeral River



* 289 mi² drainage area

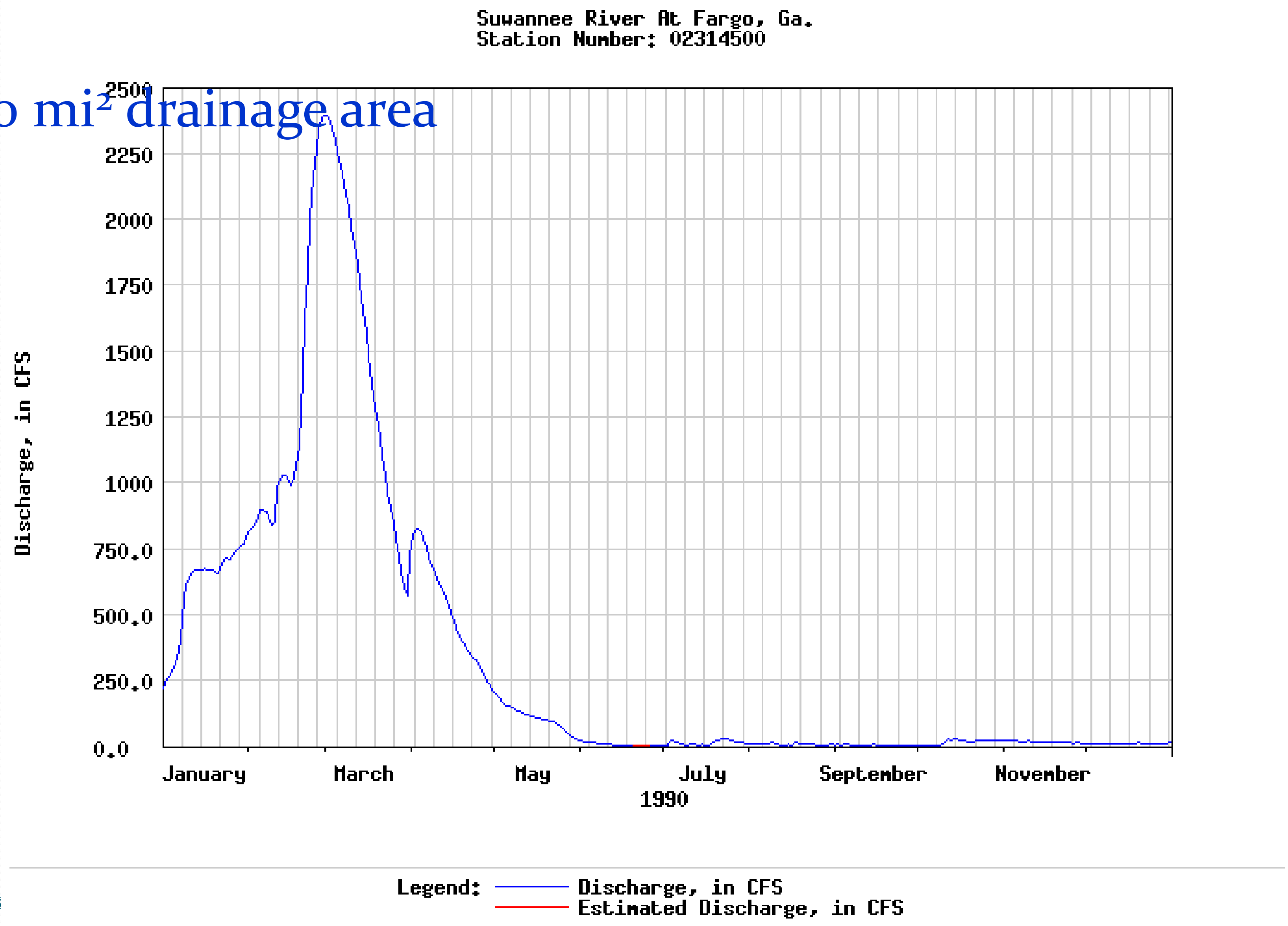


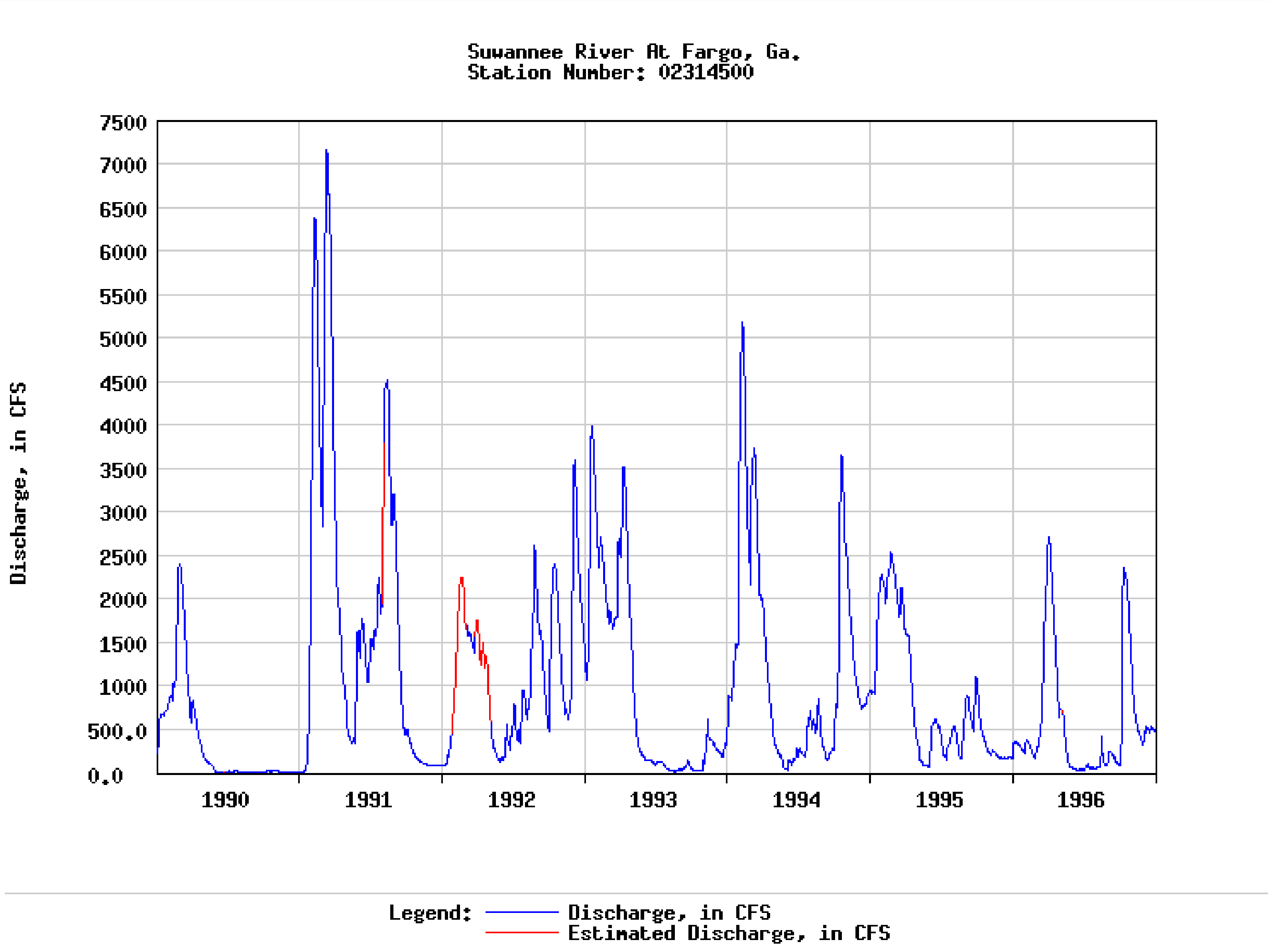
Snow melt



East River At Almont Co.
Station Number: 09112500
4500
4000
3500
3000
2500
2000
1500
1000
500.0
0.0
Discharge, in CFS
1990
1991
1992
1993
1994
1995
1996
Legend:
Discharge, in CFS
Estimated Discharge, in CFS

- 1260 mi^2 drainage area

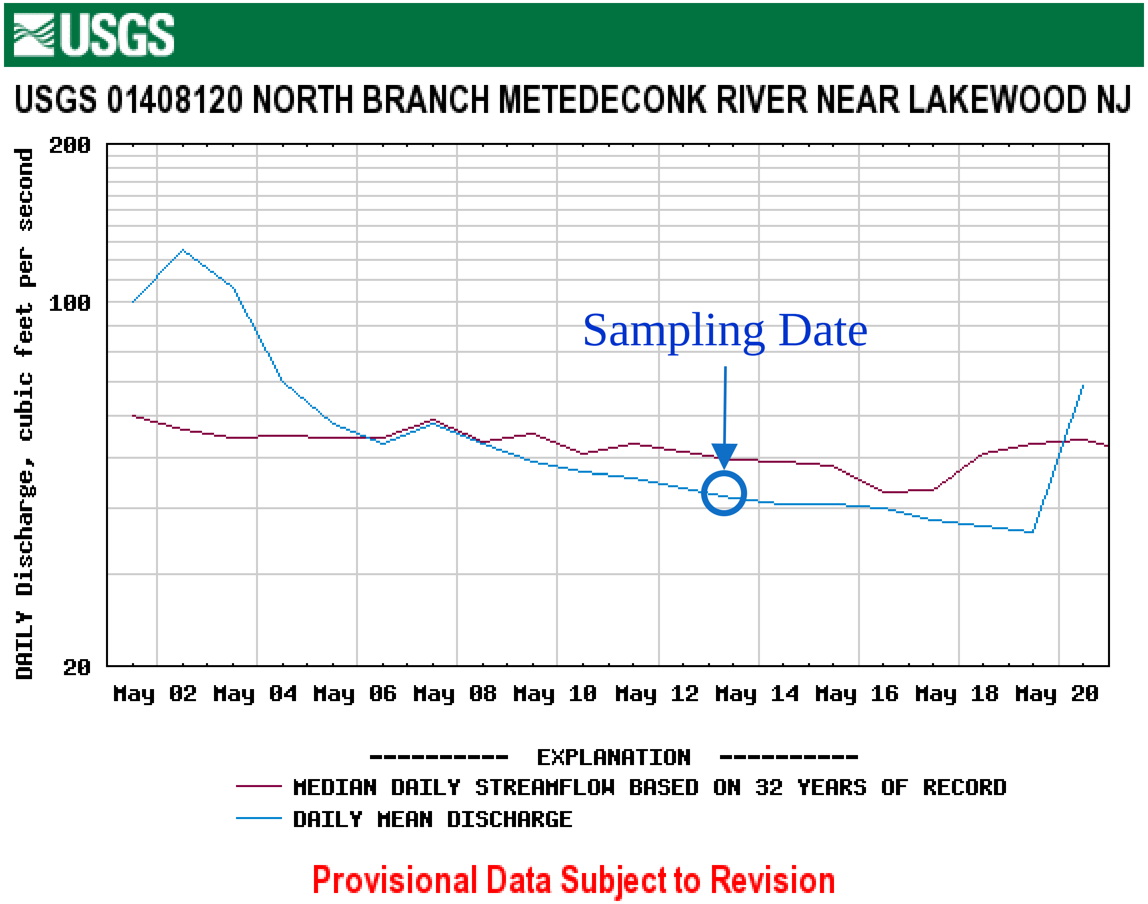


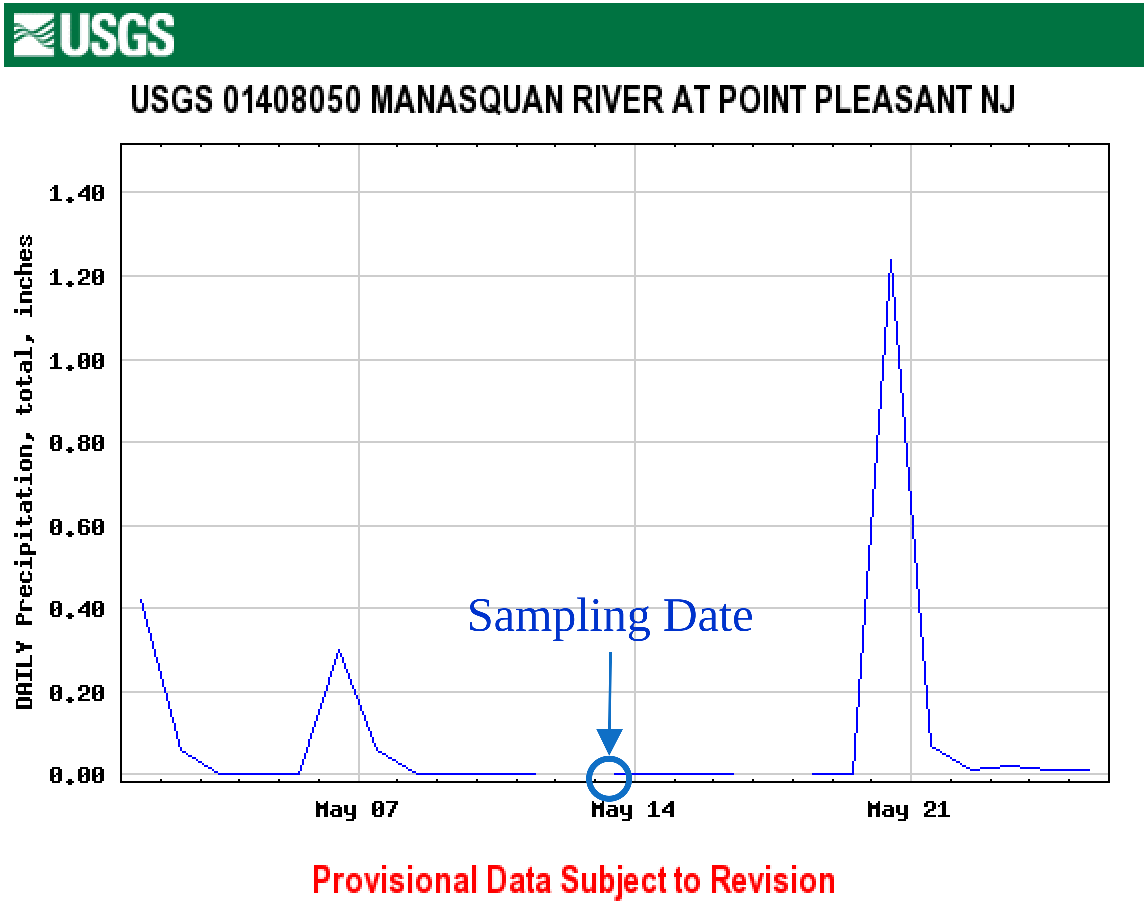


Suwannee River At Fargo, Ga.
Station Number: 02314500
Discharge, in CFS
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500.0
0.0
1990
1991
1992
1993
1994
1995
1996
Legend:
Discharge, in CFS
Estimated Discharge, in CFS

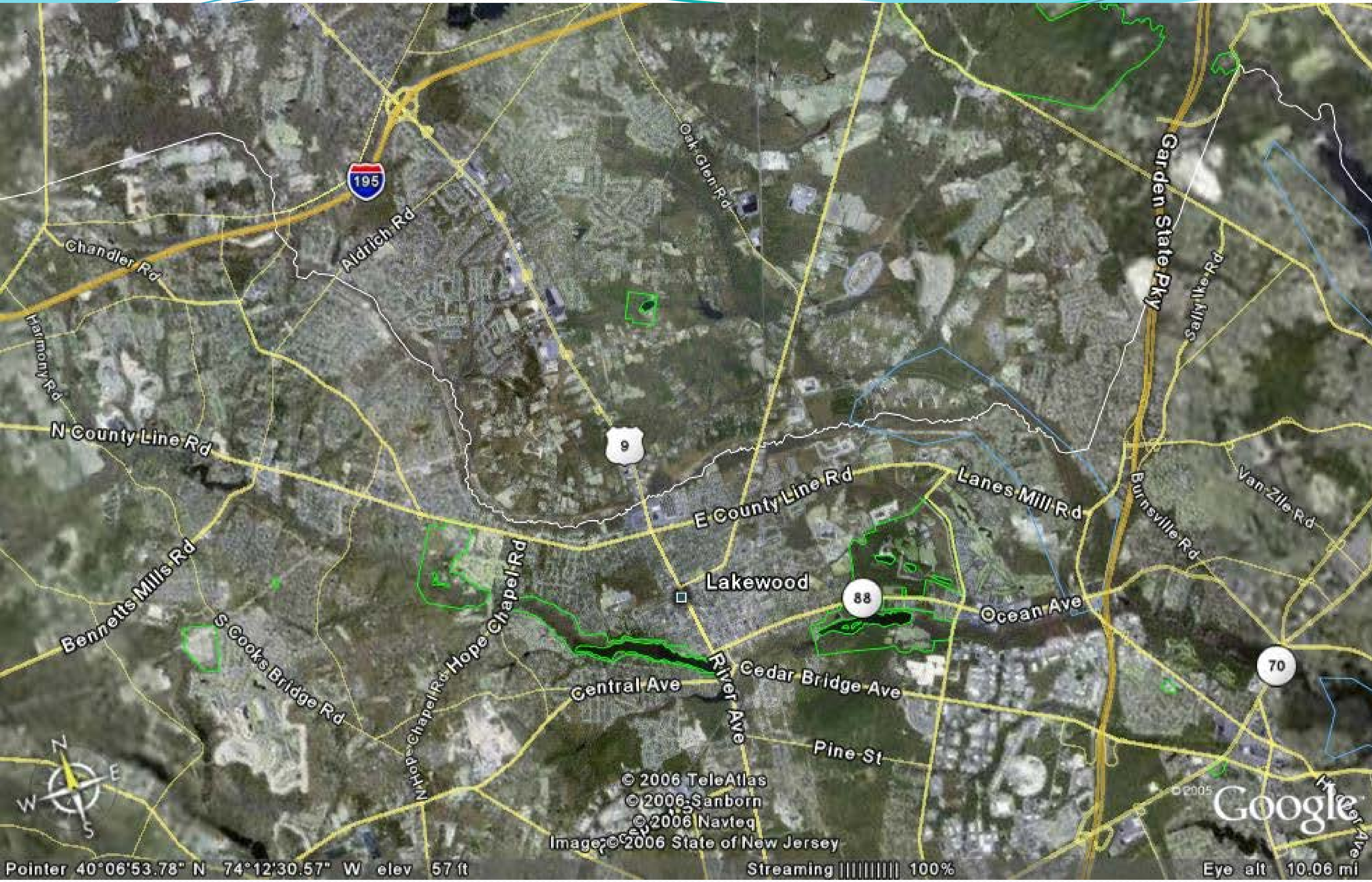
USGS Data Sources

- For “real time” data see:
  - http://water.usgs.gov/public/realtime.html
- For “historical” data see:
  - http://waterdata.usgs.gov/usa/nwis/


USGS
USGS 01408120 NORTH BRANCH METEDECONK RIVER NEAR LAKEWOOD NJ
DAILY Discharge, cubic feet per second
200
100
20
Sampling Date
May 02 May 04 May 06 May 08 May 10 May 12 May 14 May 16 May 18 May 20
---------- EXPLANATION ----------
MEDIAN DAILY STREAMFLOW BASED ON 32 YEARS OF RECORD
DAILY MEAN DISCHARGE
Provisional Data Subject to Revision


USGS
USGS 01408050 MANASQUAN RIVER AT POINT PLEASANT NJ
DAILY Precipitation, total, inches
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Sampling Date
May 07
May 14
May 21
Provisional Data Subject to Revision


Lanes Mill Rd
Van Zile Rd
Clay Cir
Blake Cir
Central Blvd
Forest Ave
Cedar Ave
Pine Ave
Burnsville Rd
Lake Rd
Cleveland Av
Worth St
Cherie Dr
Joe Parker Rd
Park Ave
Clay Ave
Jack Martin Blvd
Pinewood Dr
Laurel Brook Dr
Walter Rd
John St
Fort St
Edge St
Pinehurst Dr
Ocean Ave
W Princeton Ave
70
88
Princeton Ave
Division St
Garden State Pky
Chambers Bridge Rd
Forge Pond
Swarthmore Ave
Oberlin Ave N
BIRCHWOOD PARK
Cedar Bridge Ave
© 2006 TeleAtlas
© 2006 Sanborn
© 2006 Navteq
Image © 2006 State of New Jersey
Google
Pointer 40°04'49.28" N 74°09'08.97" W elev 0 ft
Streaming 100%
Eye alt 15335 ft


195
Chandler Rd
Aldrich Rd
Oak Glen Rd
Garden State Pky
Sally Ike Rd
Harmony Rd
N County Line Rd
9
E County Line Rd
Lanes Mill Rd
Burnsville Rd
Van Zile Rd
Bennetts Mills Rd
Hope Chapel Rd
Lakewood
88
Ocean Ave
70
S Cooks Bridge Rd
Central Ave
River Ave
Cedar Bridge Ave
Pine St
N Hope Chapel Rd
© 2006 TeleAtlas
© 2006 Sanborn
© 2006 Navteq
Image © 2006 State of New Jersey
© 2005 Google
Pointer 40°06'53.78" N 74°12'30.57" W elev 57 ft
Streaming 100%
Eye alt 10.06 mi

Other resources

- **There are two WQN publications available from the USGS:**
  - The CD-ROMs are published in a 2-disc set as USGS Digital Data Series DDS-37, entitled "Data from Selected U.S. Geological Survey National Stream Water-Quality Monitoring Networks (WQN)" by R.B. Alexander, J.R. Slack, A.S. Ludtke, K.K. Fitzgerald, and T.L. Schertz.
The cost is $42 plus shipping and handling costs.
  - Copies of Open-File Report 96-337, entitled "Data from Selected U.S. Geological Survey National Stream Water-Quality Monitoring Networks (WQN) on CD-ROM" by R.B. Alexander, A.S. Ludtke, K.K. Fitzgerald, and T.L. Schertz, are available for $12.75 in paper or $4.00 on microfiche. DDS-37 contains an electronic ASCII version of the text with GIF and PostScript illustrations and an HTML version accessible with Web browser.
- **To order, write or call:**
- U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, Colorado 80225-0286
1-800-435-7627

Summary

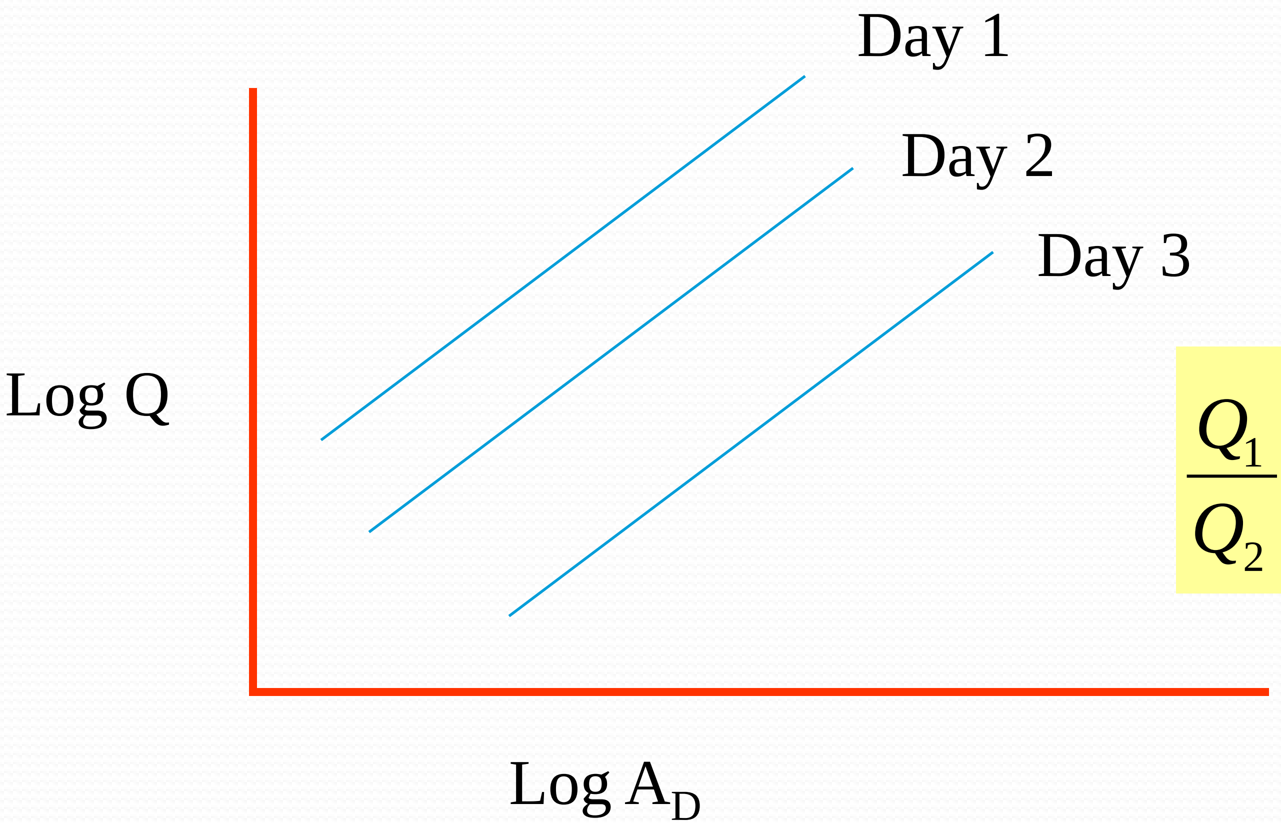
- Natural conditions that affect hydrograph
- Anthropogenic factors
  - impoundments
  - urbanization and channelization
    - quick runoff
  - human water use

Other uses and calculations

- Interpolation between measurement sites
- Dispersion, longitudinal and lateral
  - Driven by flow velocity and stream geometry
  - Determines distance to complete mixing
- Low flow analysis
  - Important for "design conditions"

Interpolating Flow Measurements

- For estimating flow between gaging stations
- Develop log-log relationship



$$\frac{Q_1}{Q_2} = \left(\frac{A_{D1}}{A_{D2}} \right)^y$$

Longitudinal Dispersion

- From Fischer et al., 1979

m/s

m^2s^{-1}

Width (m)

$$E = 0.011\frac{U^2 B^2}{HU^*}$$

Mean depth (m)

Where the Shear Velocity is:

$$U^* = \sqrt{gHS}$$

Lateral Mixing

- Lateral or transverse dispersion coefficient for a stream:

Mean depth

$$E_{lat} = 0.6HU^*$$

Shear velocity

- Length required for complete mixing:

Side discharge:

$$L_m = 0.40U \frac{B^2}{E_{lat}}$$

Center discharge:

$$L_m = 0.10U \frac{B^2}{E_{lat}}$$

Width

Low Flow Analysis

- Generally the design condition
- 7Q10 = minimum 7-day flow that would be expected to occur every 10 years.
- Calculation
  - determine the minimum 7-day flow for each year of record (usually summer period)
  - list years in ascending order, assigning a rank (m)
  - Then probability or occurrence is:
  - Determine 10% probability flow from graph on probability paper

$$p = \frac{m}{N+1}$$

Low Flow Analysis: Data Table

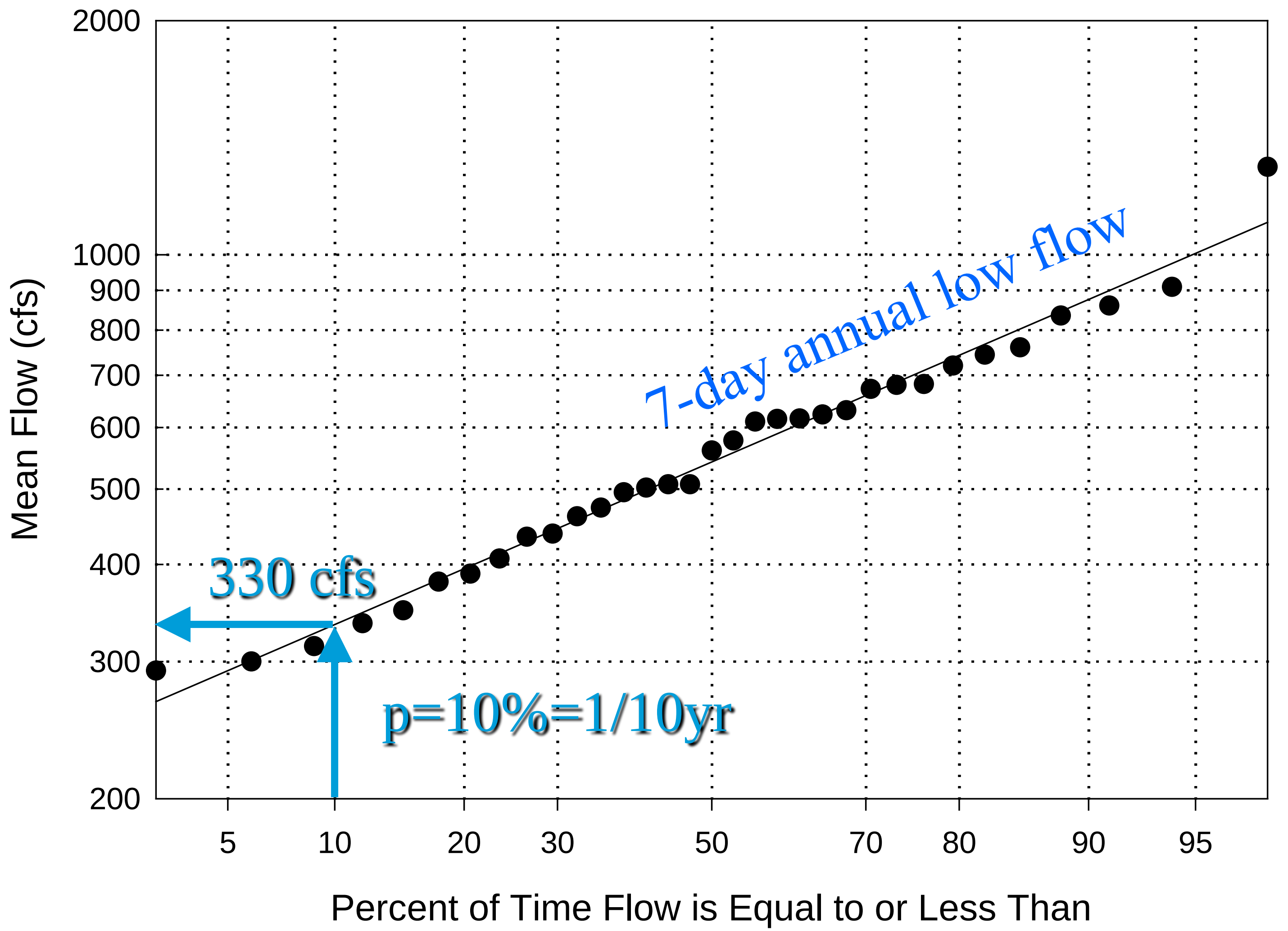
- 33 years of data from: Schuylkill River @ Philadelphia

Rank	p	Q (cfs)
1	2.94	292
2	5.88	300
3	8.82	314
4	11.76	336
5	14.71	349
6	17.65	380
7	20.59	389
8	23.53	407
9	26.47	434
10	29.41	438
11	32.35	461
12	35.29	473
13	38.24	495
14	41.18	502
15	44.12	507
16	47.06	507
17	50.00	560

Rank	p	Q (cfs)
18	52.94	577
19	55.88	610
20	58.82	615
21	61.76	616
22	64.71	623
23	67.65	631
24	70.59	672
25	73.53	680
26	76.47	682
27	79.41	720
28	82.35	744
29	85.29	760
30	88.24	835
31	91.18	860
32	94.12	909
33	97.06	1297

Low Flow Analysis: Graph

- 7Q10 Graphical Solution: Schuylkill River @ Philadelphia



- Thomann & Mueller, pg. 39-40
- Chapra, pg. 243-244

- To next lecture