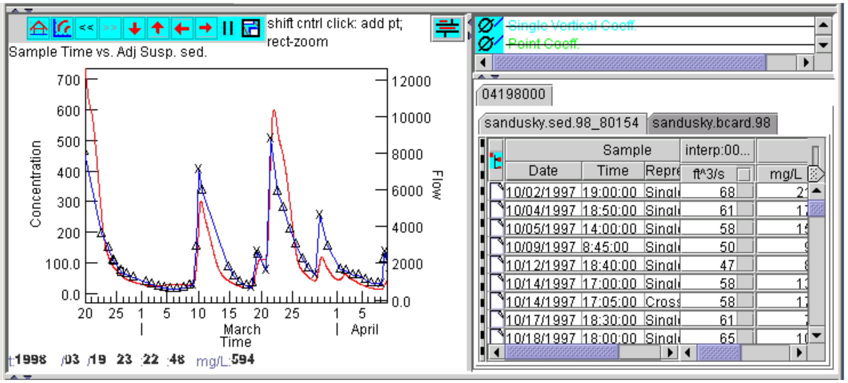
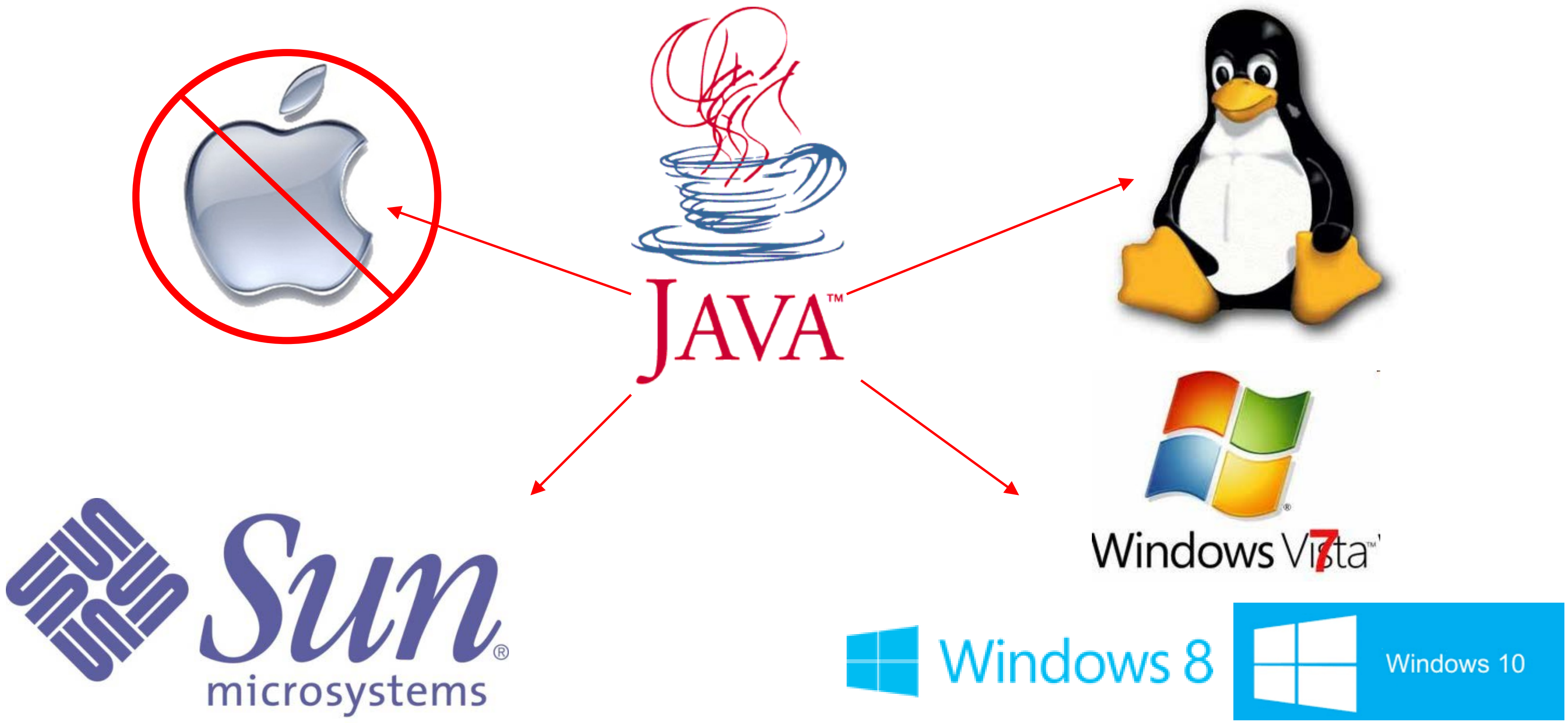
Graphical Constituent Loading Analysis System (GCLAS)

- Initial release in 2001
- GCLAS can compute discharges/loads and time-weighted mean concentrations of water-quality constituents at about any time scale (typically daily)
- Requires concentration data at a high enough frequency to reasonably define the chemograph

GCLAS



Runs on …

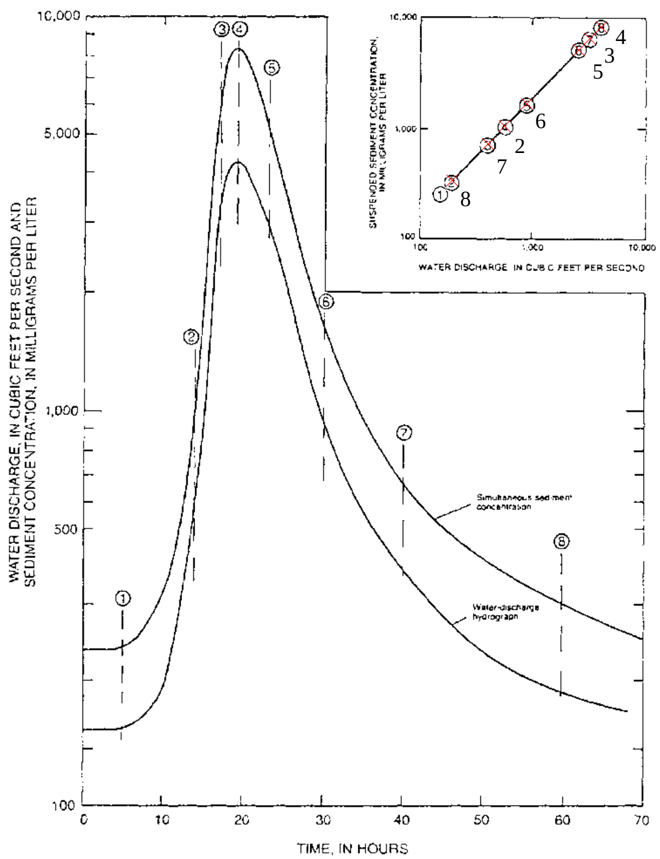


USGS

Why use GCLAS?

- Provides a uniform set of tools for constituent loading computations
- Speeds record computation/recomputation
- Enhances ability to perform certain exploratory analyses (e.g. assessment of cross-section coefficients)
- Enhances ability to archive and restore data for later analyses and(or) review
- Not dependent on statistical assumptions or having a good surrogate for the constituent of interest

Is flow a good surrogate for concentration?



Modified from Glysson, 1987

Is flow a good surrogate for concentration?

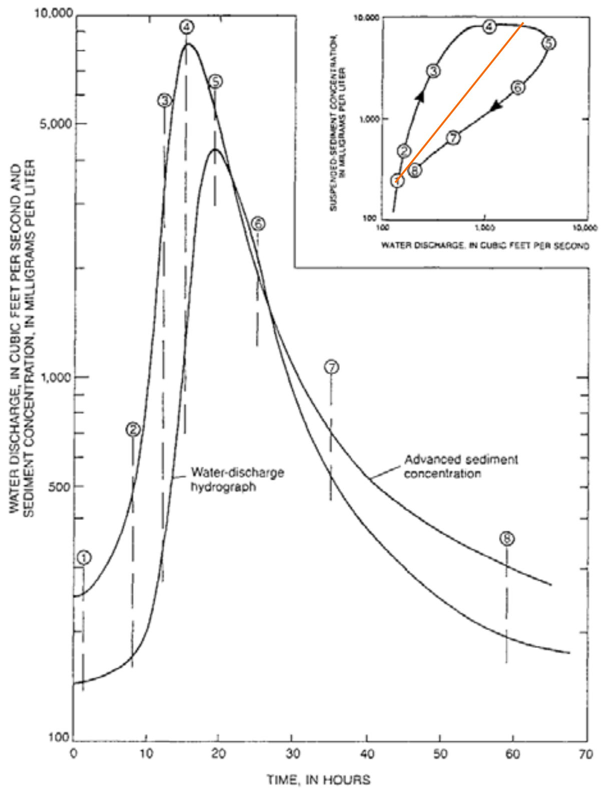


Figure 5.--Sediment concentration peak preceding the water discharge peak.

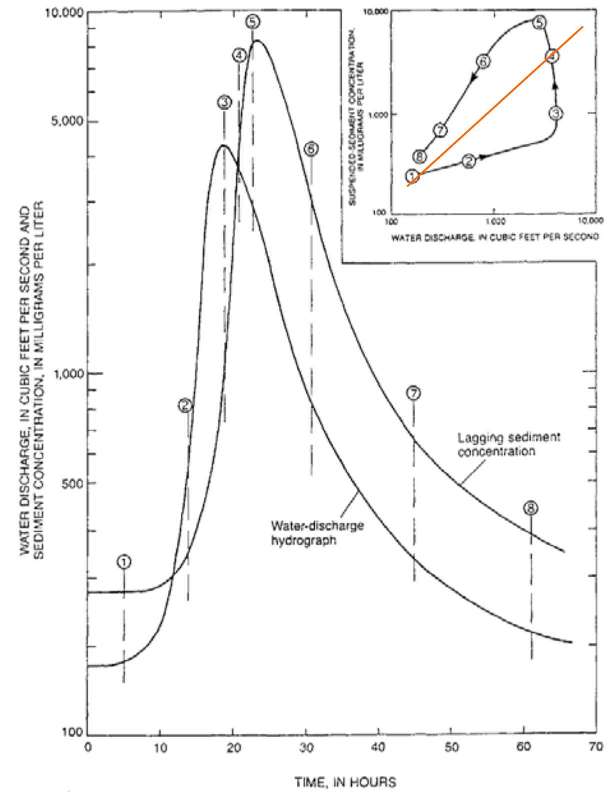
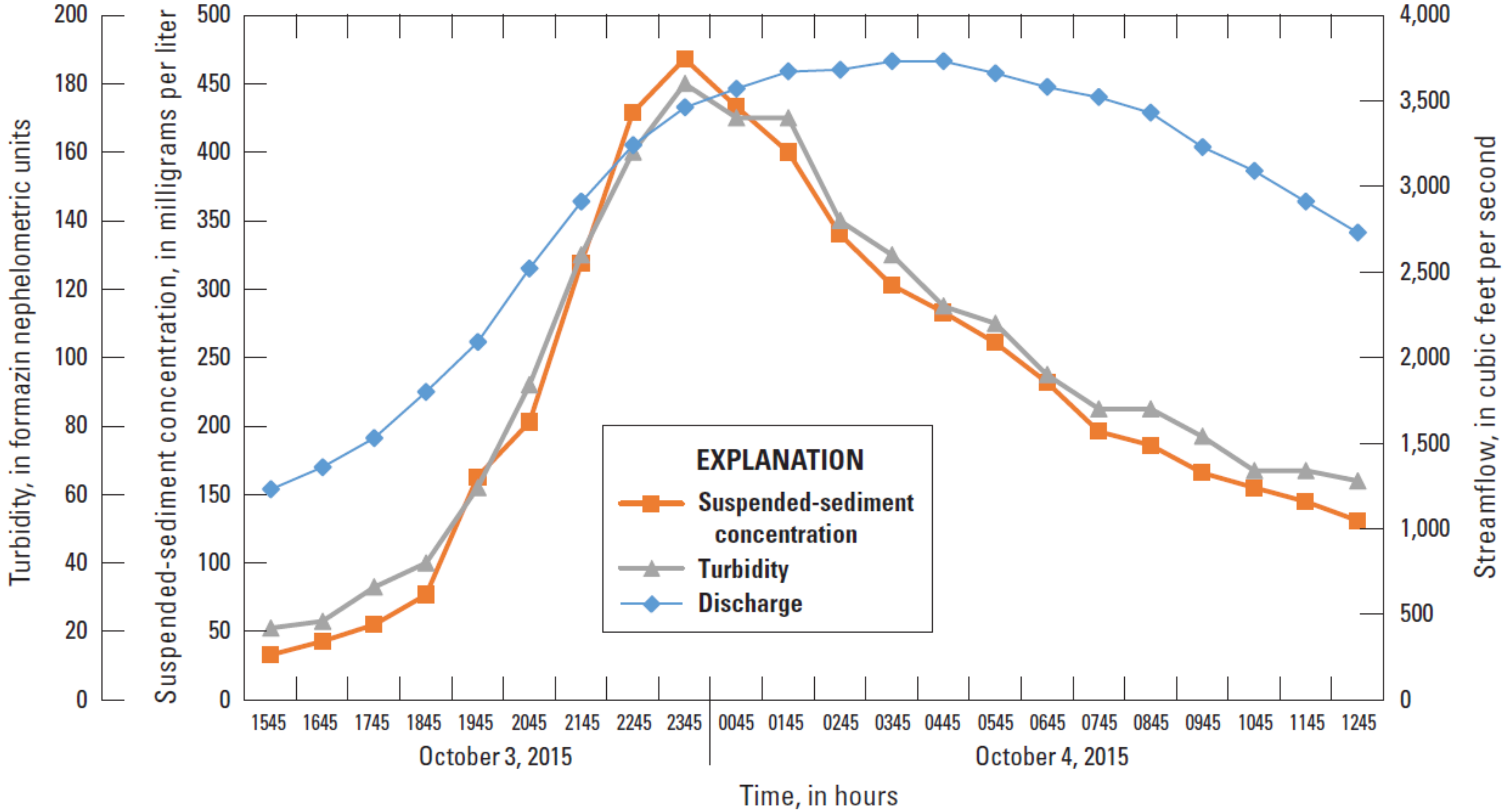


Figure 6.--Sediment concentration peak lagging the water discharge peak.

USGS

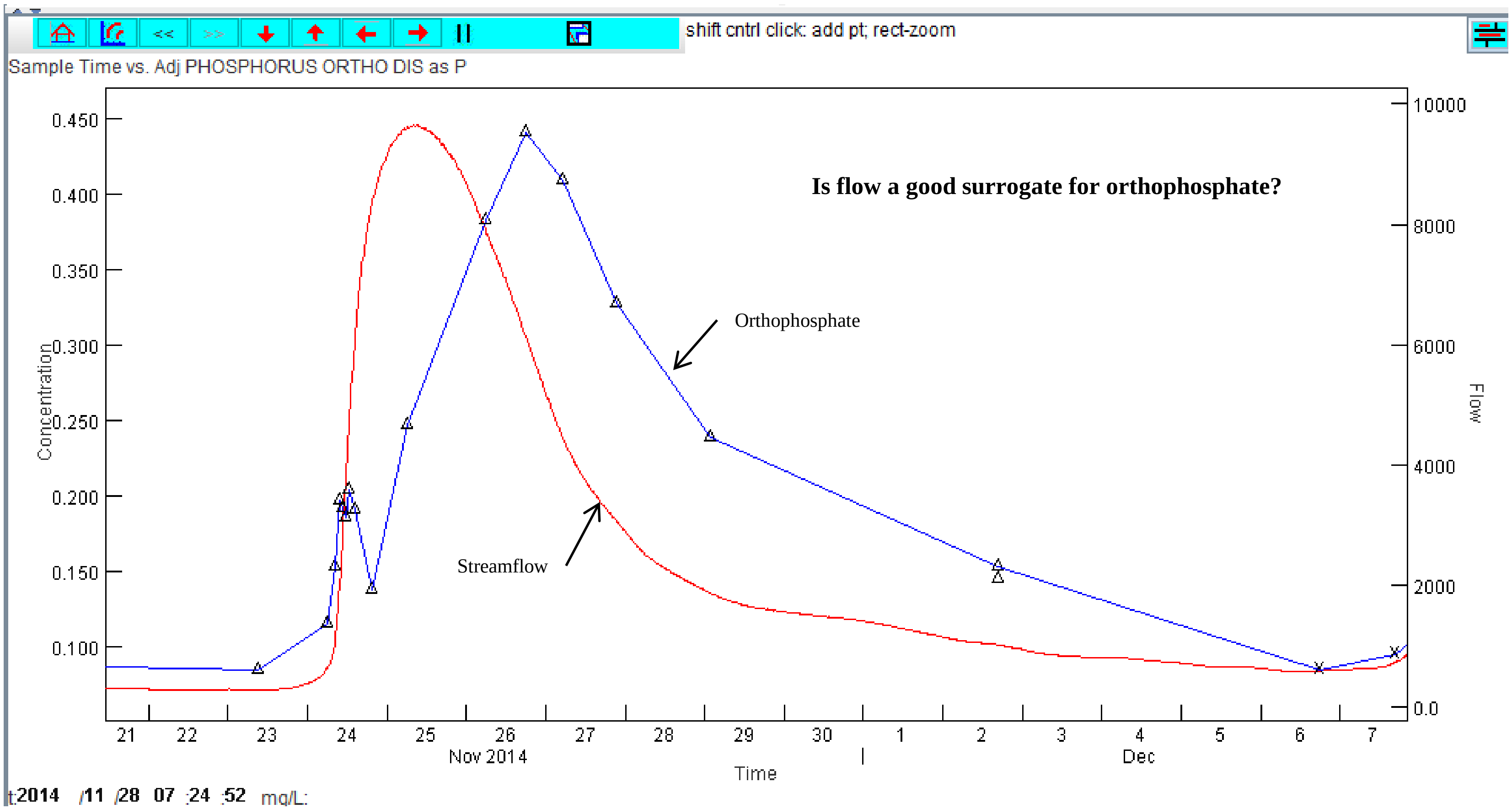
Modified from Glysson, 1987

Sometimes surrogates other than flow work well



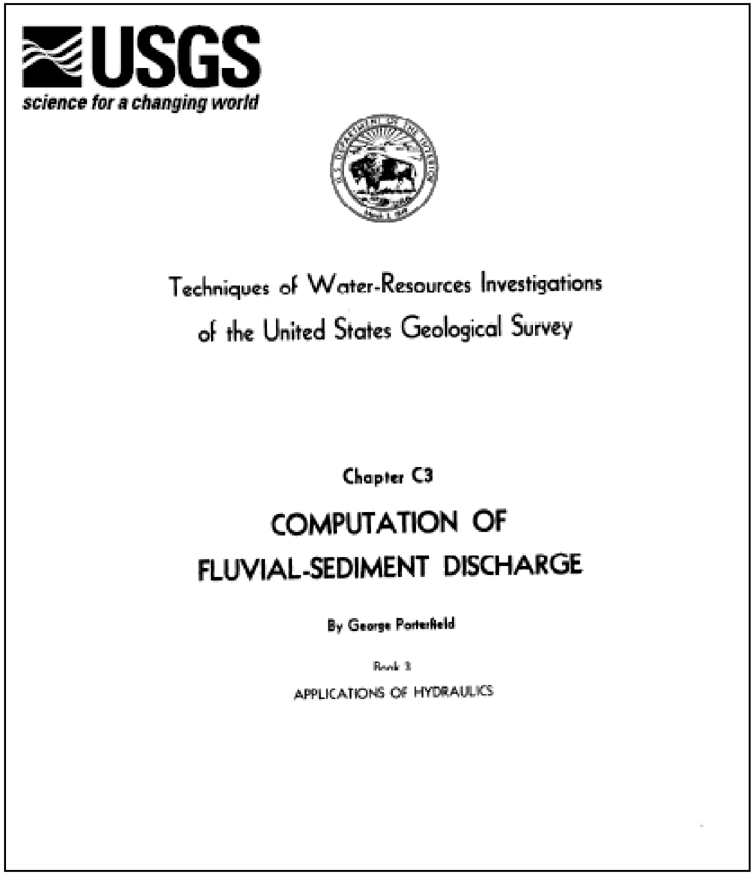
USGS

Sometimes there are no good surrogates



USGS

Computations based on methods described by Porterfield



science for a changing world

Techniques of Water-Resources Investigations of the United States Geological Survey

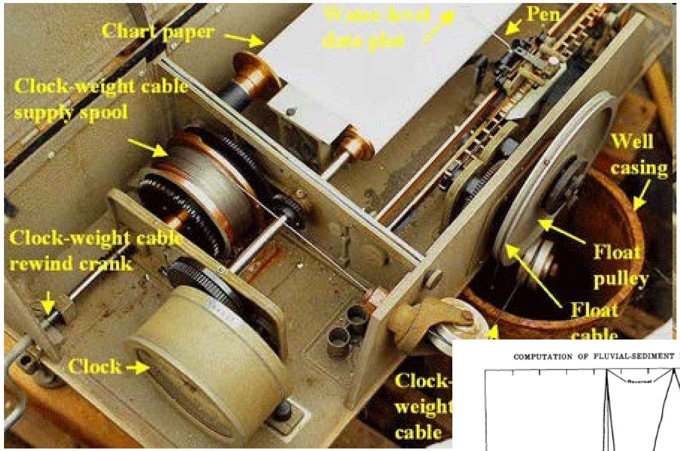
Chapter C3

COMPUTATION OF FLUVIAL-SEDIMENT DISCHARGE

By George Porterfield

Book 3

APPLICATIONS OF HYDRAULICS



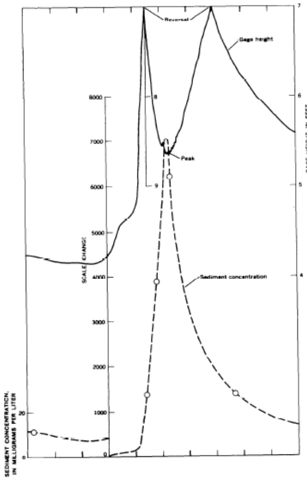


Figure 37.—Gage height and sediment concentration for a subdivided day.

Midinterval Method

Table 4.—Computation of subdivided day, midinterval method

Clock time (col. 1): The actual time, given in 24-hour time, for which values are tabulated. Sufficient values must be chosen to assure that the maximum change in successive values of water discharge and sediment concentration is within the limits specified by the allowable range in stage and by the guide to subdivision (fig. 36).

Time interval (col. 2): The sum of one-half the time back to the preceding clock time and one-half the time to the following clock time. The first interval, of 2.5 hours, is one-half the time from midnight (0000 hrs) and 5 a.m. (0500 hrs). The second interval, of 3.5 hours, is one-half the time from midnight to 5 a.m. (2.5 hrs) plus one-half the time from 5 a.m. to 7 a.m. (1 hr). This may also be computed by taking one-half the difference of alternate hours (except the first and last) as follows:

First interval: $\frac{0500-0000}{2} = 2.5$

Second interval: $\frac{0700-0000}{2} = 3.5$

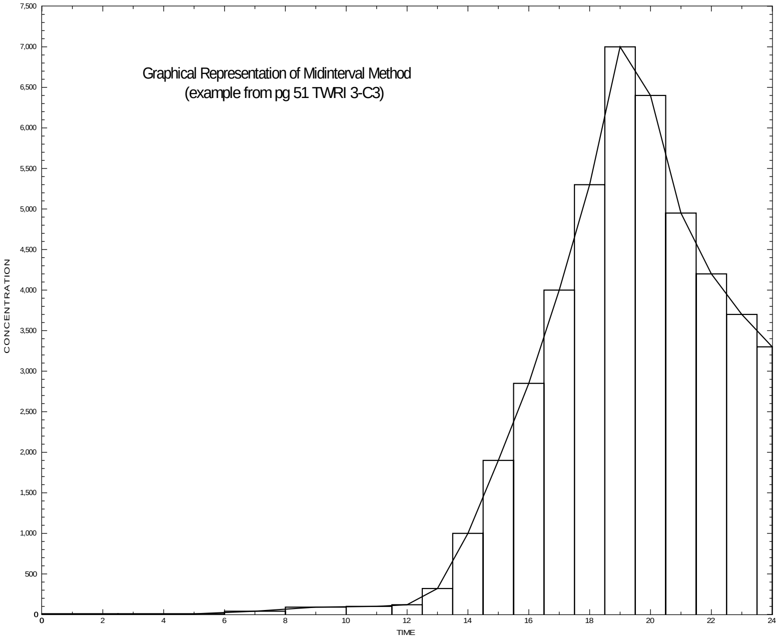
Third interval: $\frac{0900-0500}{2} = 2.0$

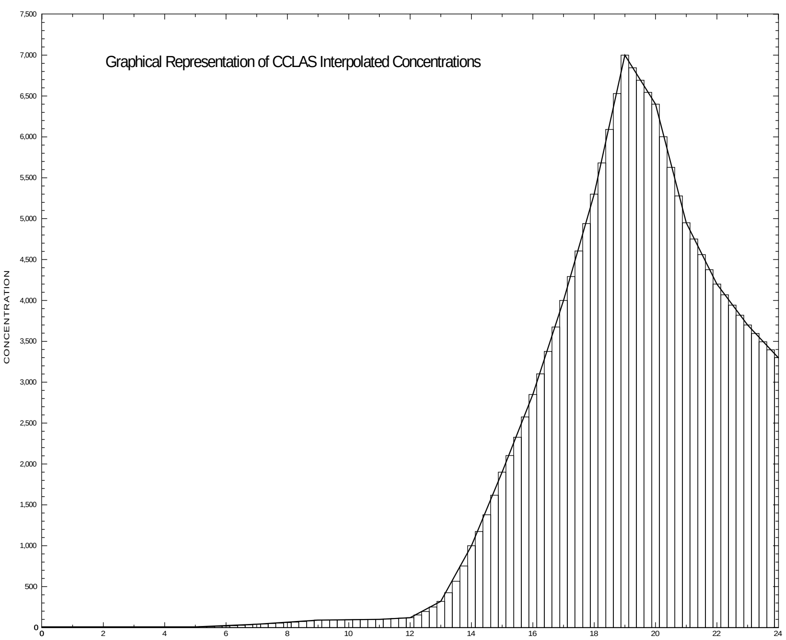
Cols. 3-6: See explanation for columns 2-5, table 3.

Interval × concentration (col. 7): See explanation for column 6, table 3.

	Clock time (hrs) (1)	Time interval, t (hrs) (2)	Gage height (ft) (3)	Shift correction (ft) (4)	Water discharge, q (cfs) (5)	Sediment concentration, c (mg/l) (6)	Interval × concentration, tc (col. 2 × col. 6) (7)
	0000	2.5	4.17	0	174	8	20
	0500	3.5	4.19	0	182	8	28
	0700	2.0	4.32	0	234	40	80
	0900	2.0	4.60	0	370	90	180
	1100	1.5	4.67	0	408	100	150
	1200	1.0	4.73	0	442	120	120
	1300	1.0	5.22	0	744	320	320
	1400	1.0	6.22	0	1,740	1,000	1,000
	1500	1.0	7.20	0	3,120	1,900	1,900
	1600	1.0	7.83	0	4,220	2,850	2,850
	1700	1.0	8.26	0	5,090	4,000	4,000
	1800	1.0	8.50	0	5,620	5,300	5,300
	1900	1.0	8.56	0	5,750	7,000	7,000
	2000	1.0	8.60	0	5,840	6,400	6,400
	2100	1.0	8.54	0	5,710	4,950	4,950
	2200	1.0	8.41	0	5,420	4,200	4,200
	2300	1.0	8.31	0	5,200	3,700	3,700
	2400	.5	8.10	0	4,760	3,300	1,650
Total	—	24	144.365	—	54,168	—	43,848
Weighted mean	—	—	6.02	—	2,260	—	1,830

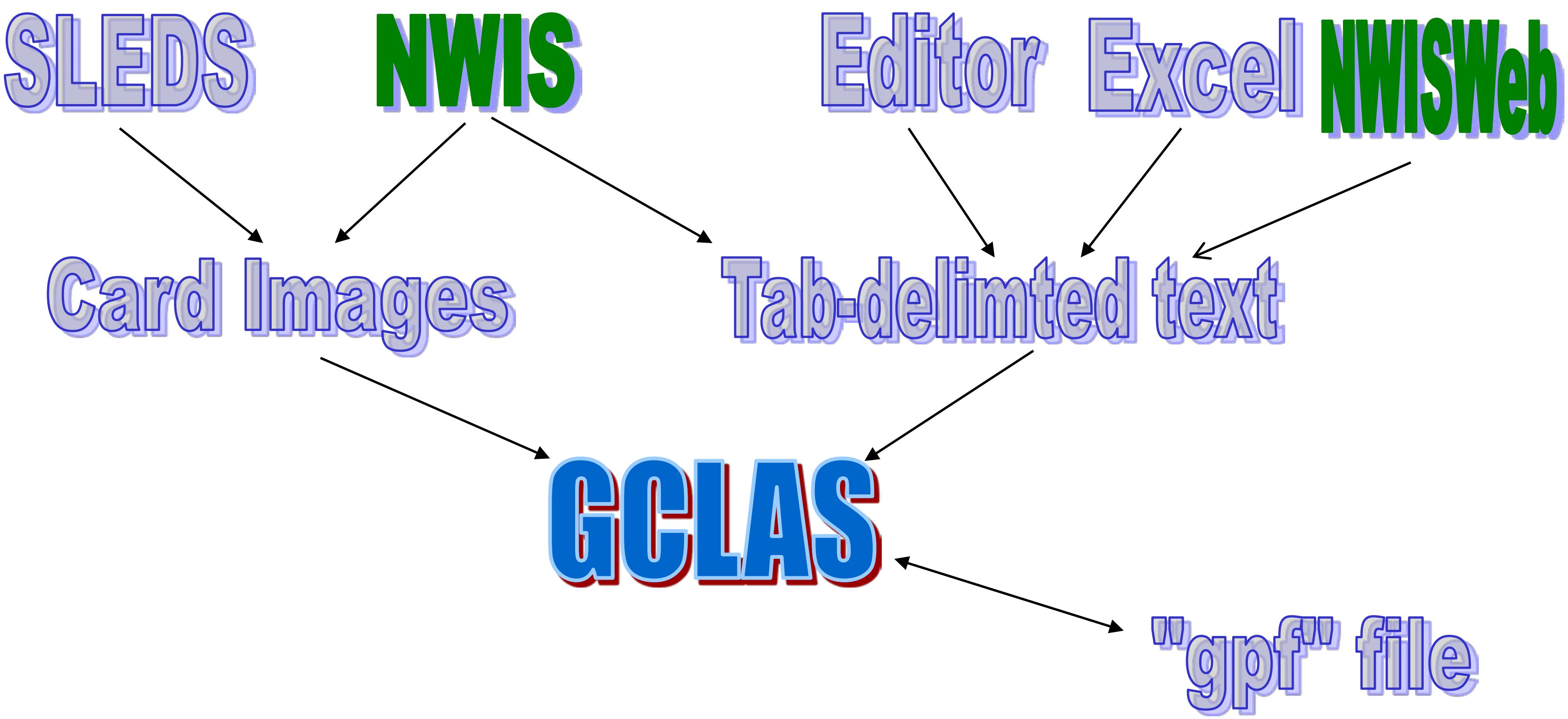
- In GCLAS, concentrations interpolated to times of unit streamflow values
- Computations done at same time step as streamflow



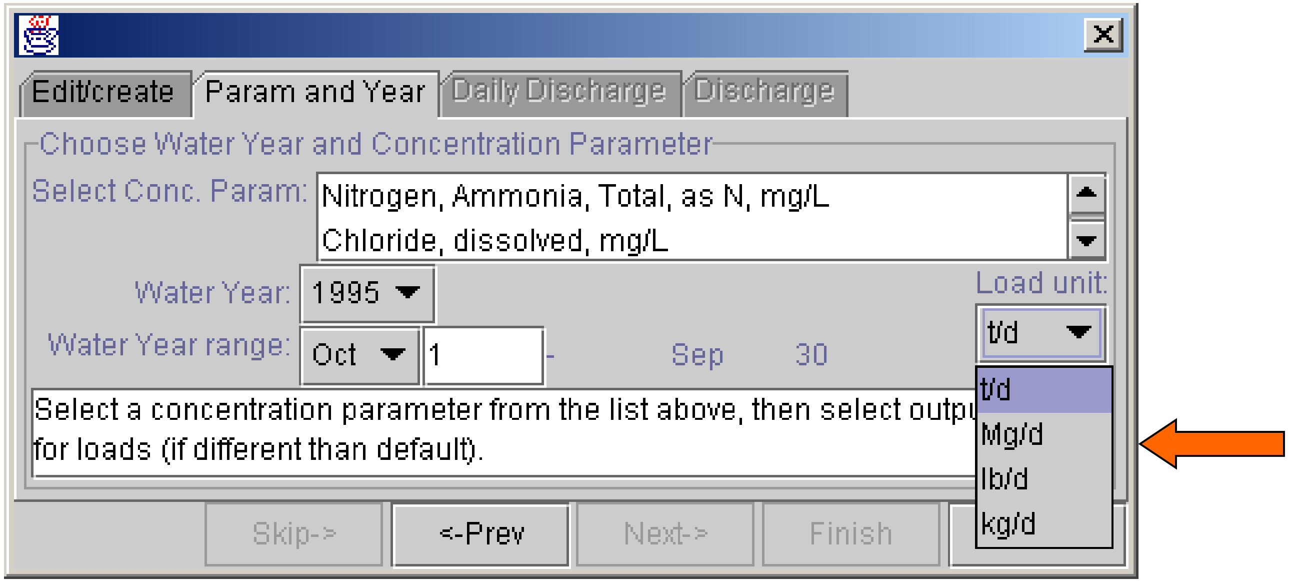


GCLAS Features

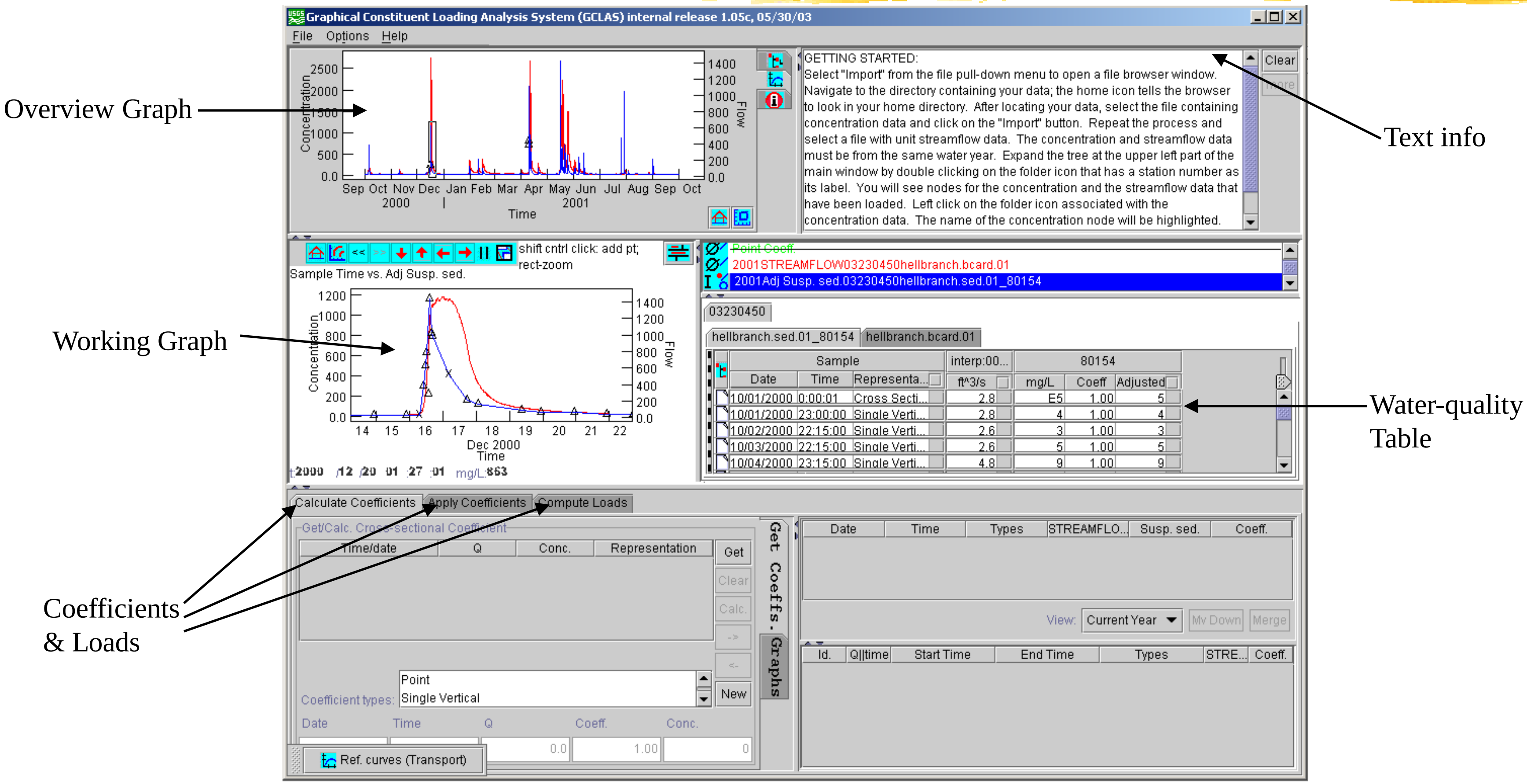
Multiple Input Formats



Flexible Input/Output Units



Multiple Concurrent Views of Data



Metadata (if needed)

Normal View

03230450

hellbranch.sed.01_80154 | hellbranch.bcard.01

Sample			interp:00...	80154		
Date	Time	Representation	ft^3/s	mg/L	Coeff	Adjusted
10/01/2000	0:00:01	Cross Section	2.8	E5	1.00	5
10/01/2000	23:00:00	Single Vertical	2.8	4	1.00	4
10/02/2000	22:15:00	Single Vertical	2.6	3	1.00	3
10/03/2000	22:15:00	Single Vertical	2.6	5	1.00	5
10/04/2000	23:15:00	Single Vertical	4.8	9	1.00	9

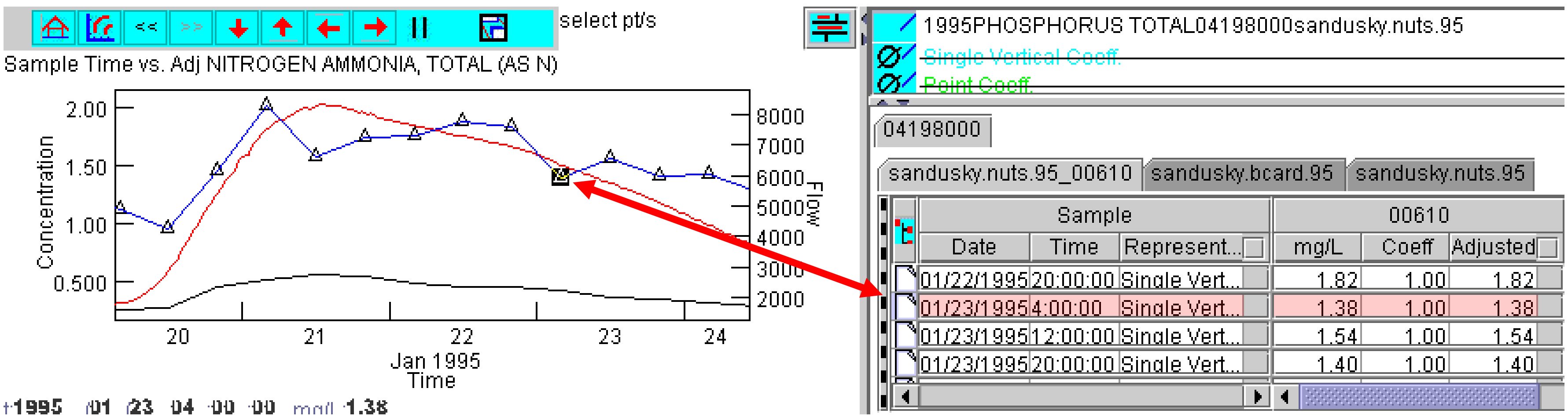
Expanded View

03230450

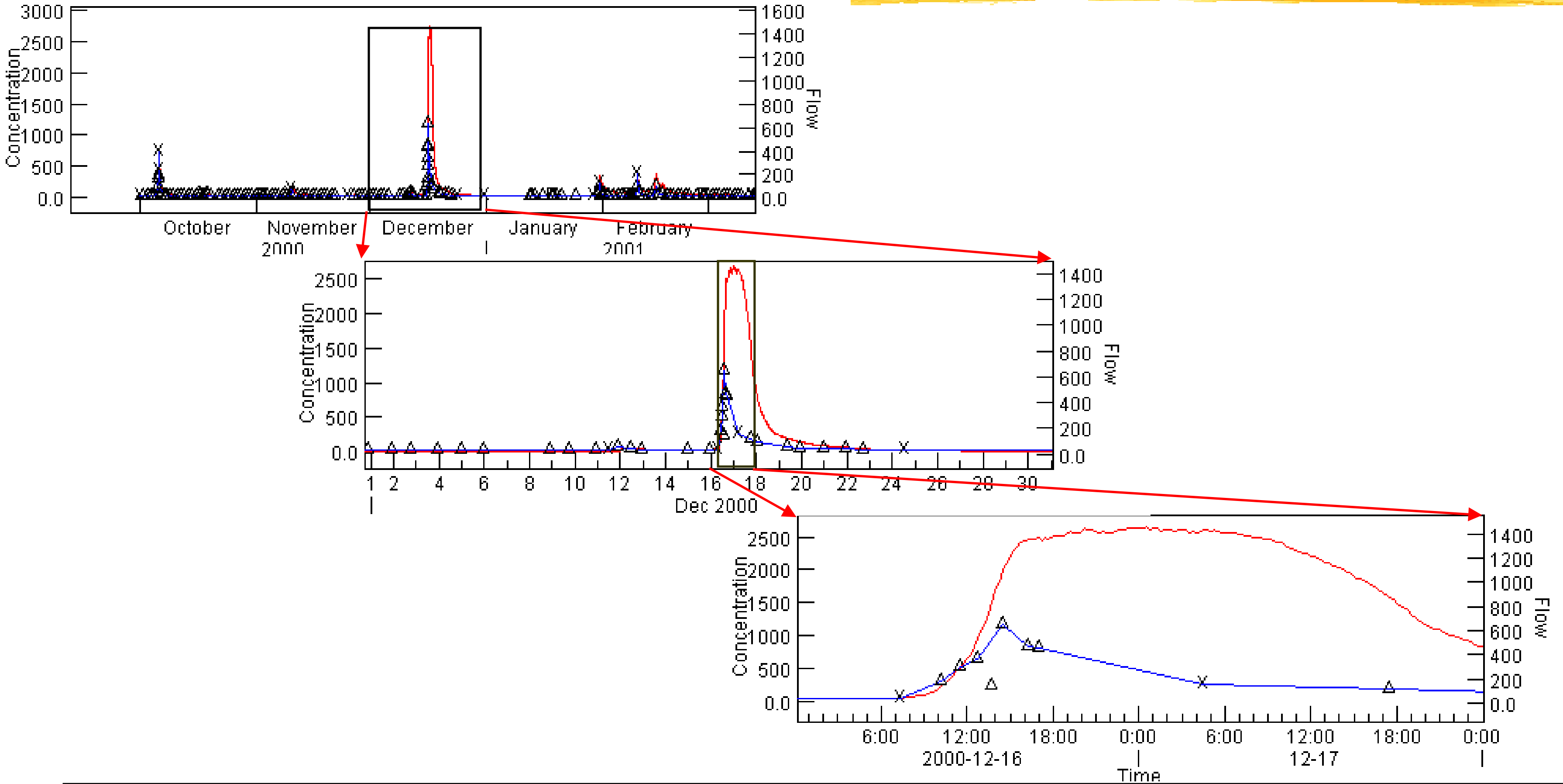
hellbranch.sed.01_80154 | hellbranch.bcard.01

Sample								interp:00...	80154		
Date	Time	Representation	Hydro Cond	Collector	Hydro Event	Method	QA Type	ft^3/s	mg/L	Coeff	Adjusted
10/01/2000	0:00:01	Cross Section	Stable, normal stage	Unspecified	Routine Sample	None	Regular	2.8	E5	1.00	5
10/01/2000	23:00:00	Single Vertical	Stable, normal stage	Unspecified	Routine Sample	Unspecified	Regular	2.8	4	1.00	4
10/02/2000	22:15:00	Single Vertical	Stable, normal stage	Unspecified	Routine Sample	Unspecified	Regular	2.6	3	1.00	3
10/03/2000	22:15:00	Single Vertical	Stable, normal stage	Unspecified	Routine Sample	Unspecified	Regular	2.6	5	1.00	5
10/04/2000	23:15:00	Single Vertical	Stable, normal stage	Unspecified	Routine Sample	Unspecified	Regular	4.8	9	1.00	9

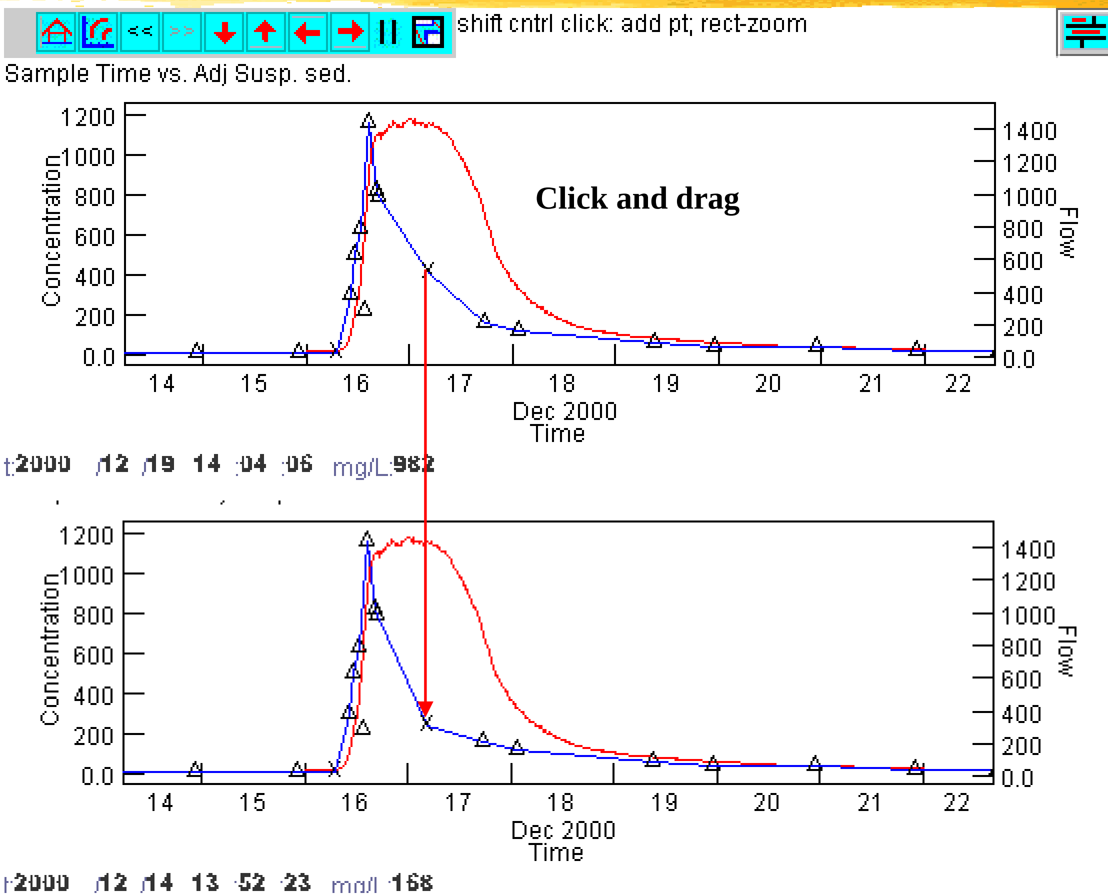
Dynamically Linked Views



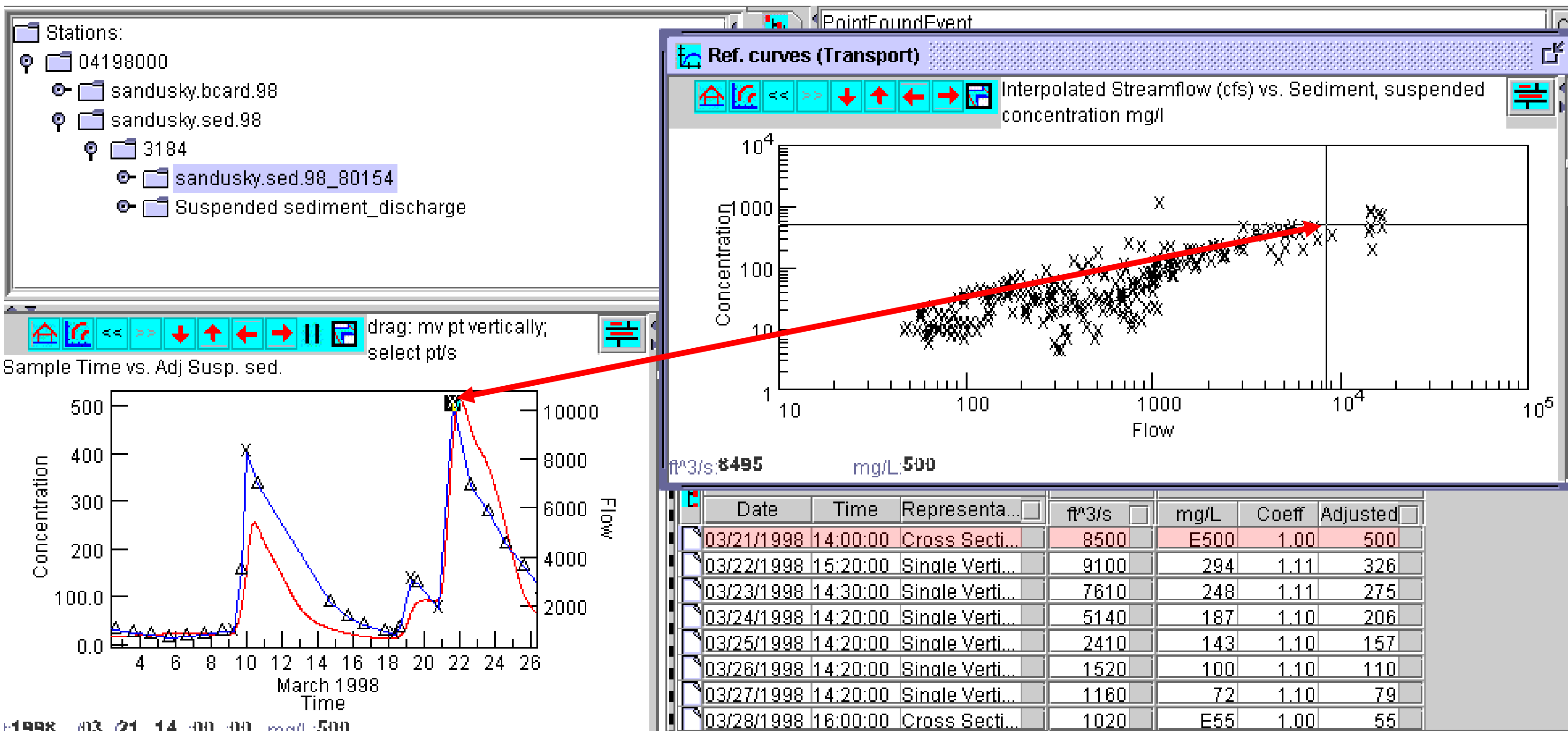
Drill Down for Detail



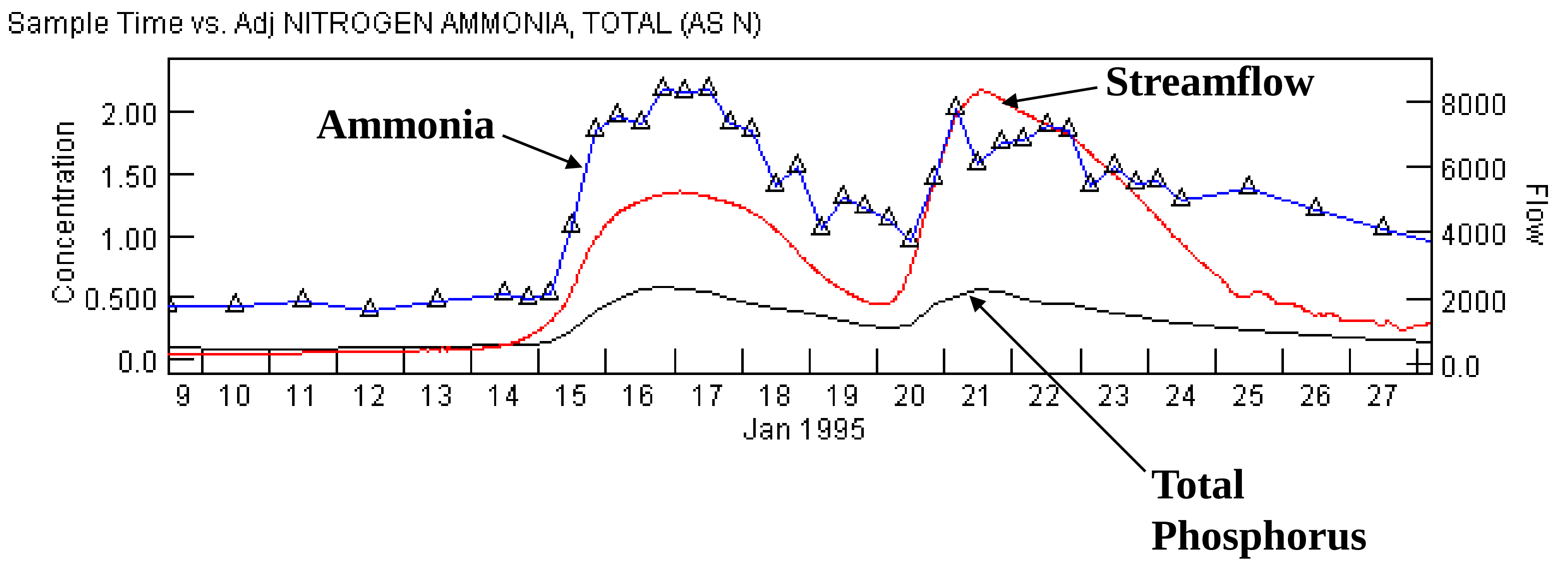
Graphically Add/Edit Estimates



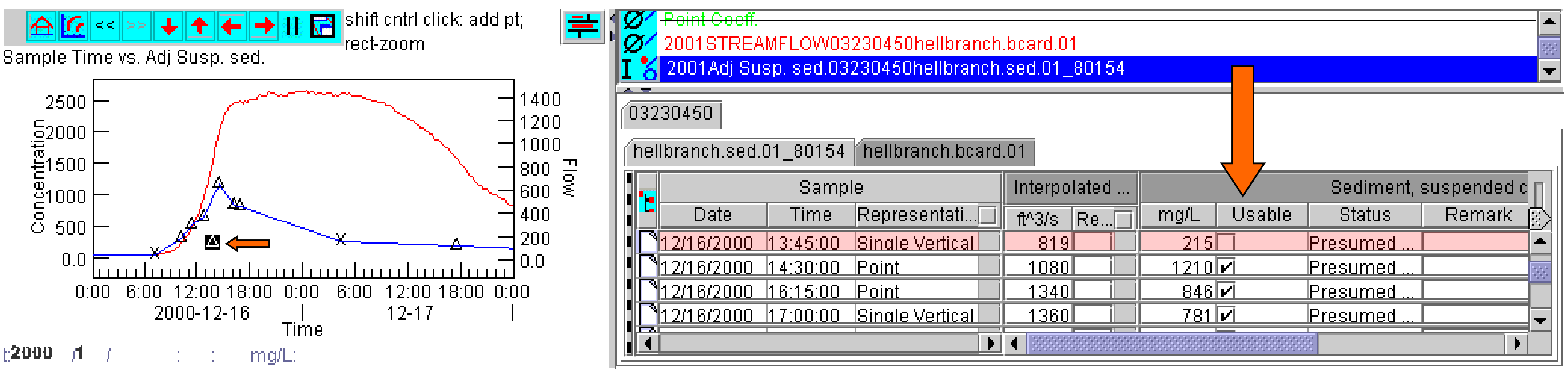
Linked Transport Plot to Aid Estimation



Reference Curves

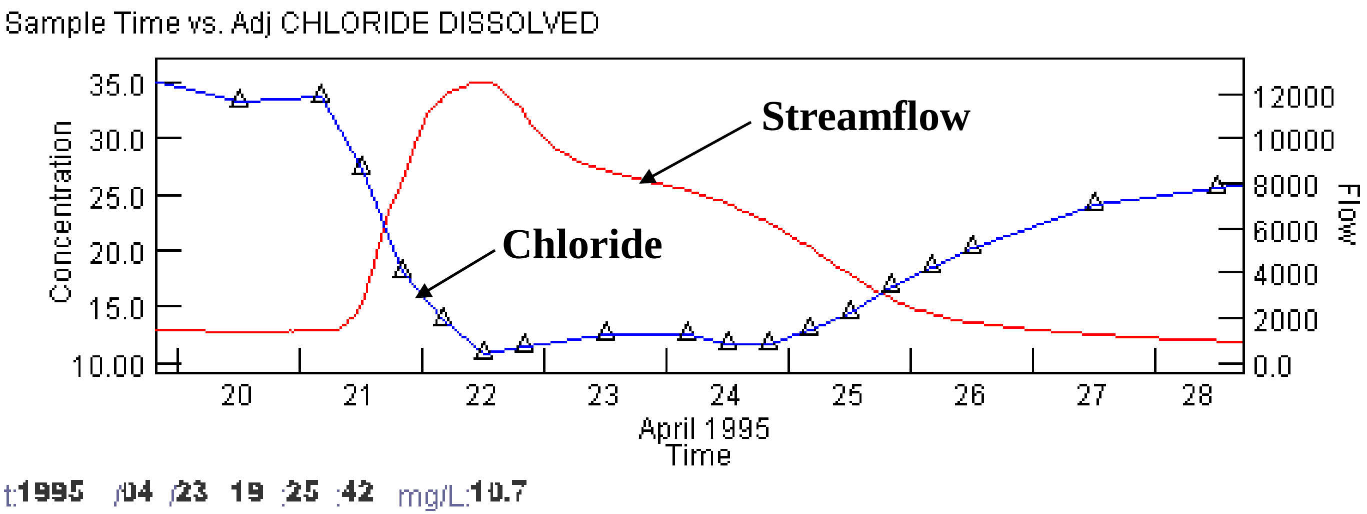


“Usable” Values

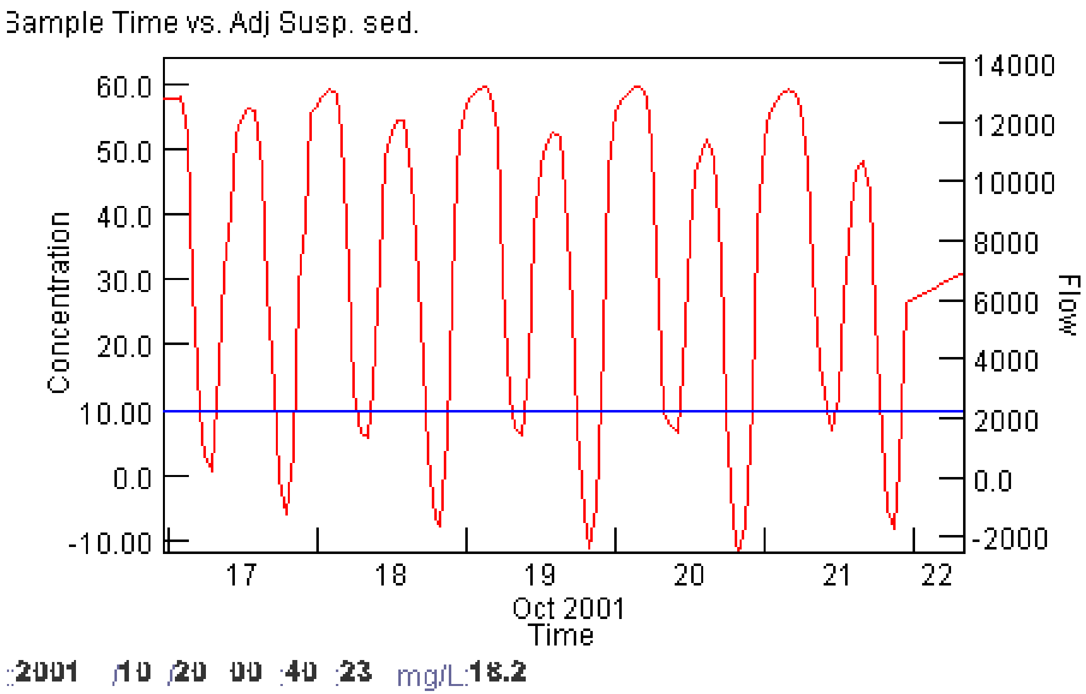


Used to ignore erroneous values and individual values used to compute averages

Compute Loads of Any Constituent

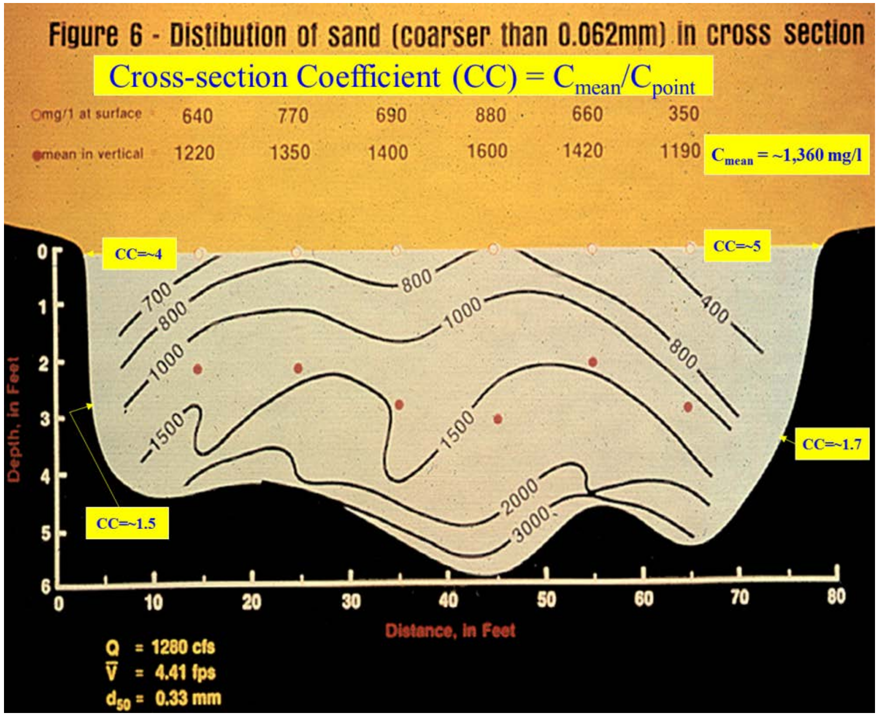


Can Calculate Loads for Periods of Zero and Reverse Flow



Cross-section coefficients

- Used to adjust concentrations from point or single-vertical (SV) samples to be more representative of cross-section mean
- Based on comparisons between concurrent point/SV concentrations and depth & width integrated concentrations (e.g. EDI/EWI)



USGS

Cross-section Coefficients

Concentration at:

Point

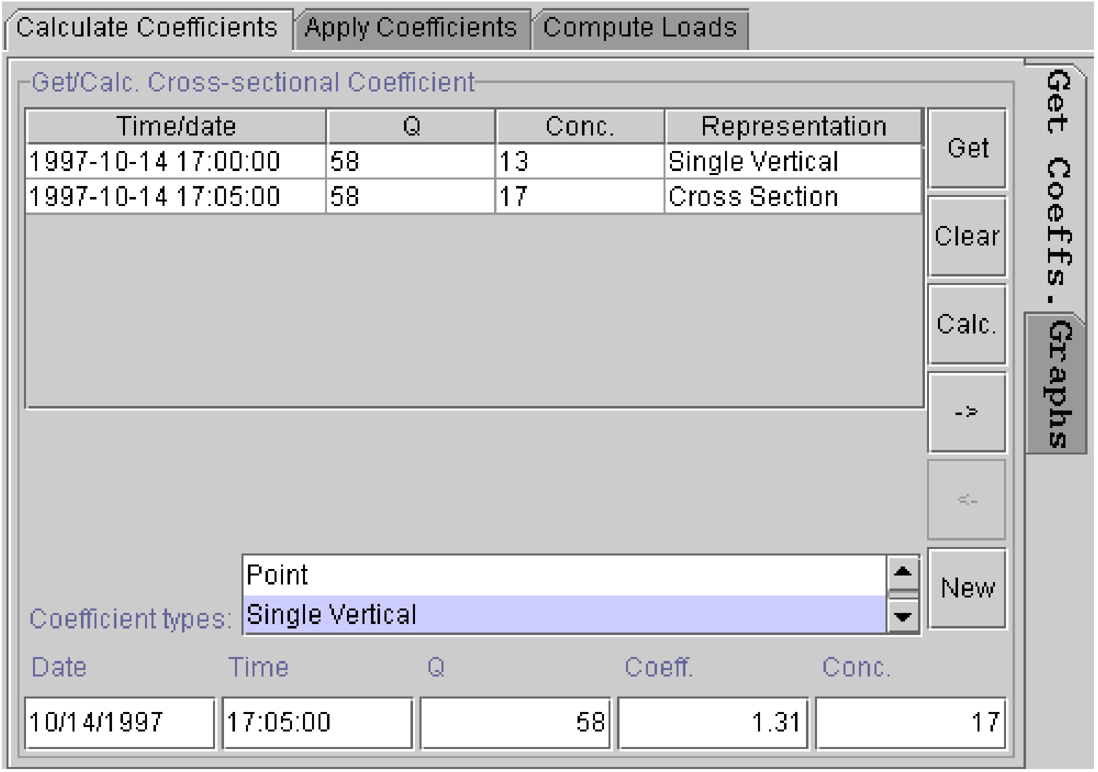
Single Vertical

Coefficient Relation

Mean Concentration

USGS

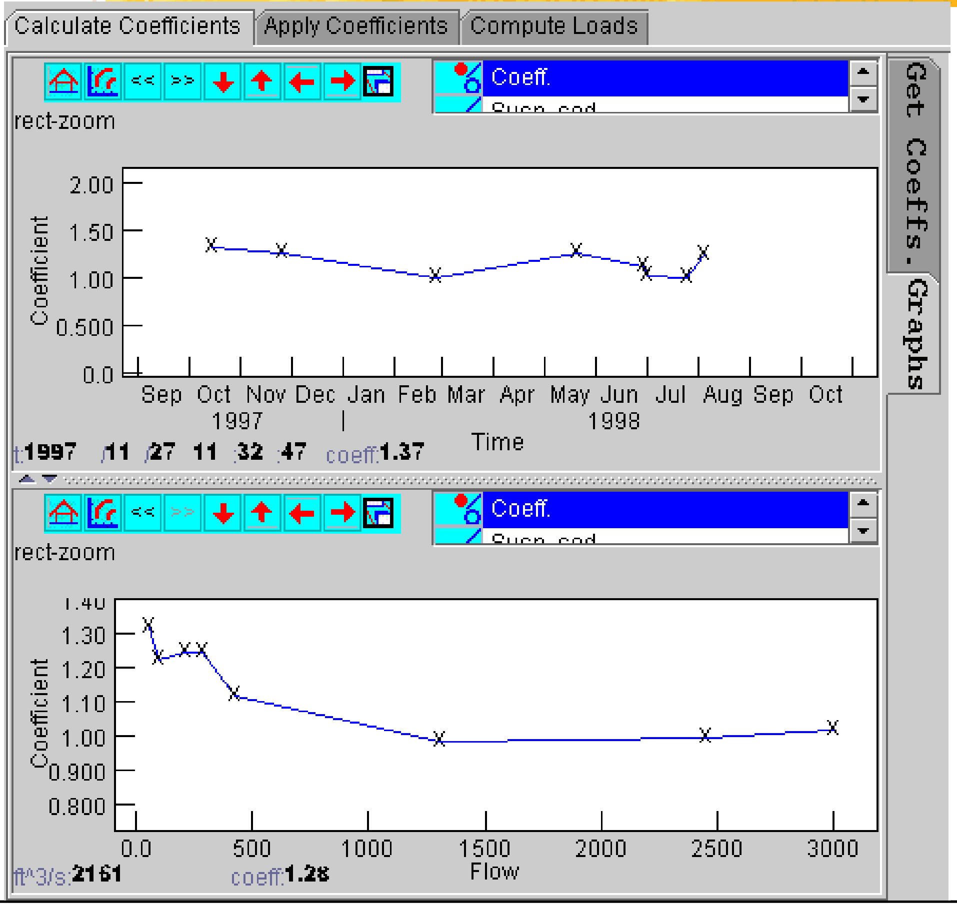
Coefficient Calculation Tool



Visualization of Coefficient Trends

Coeff. vs Time

Coeff. vs Flow

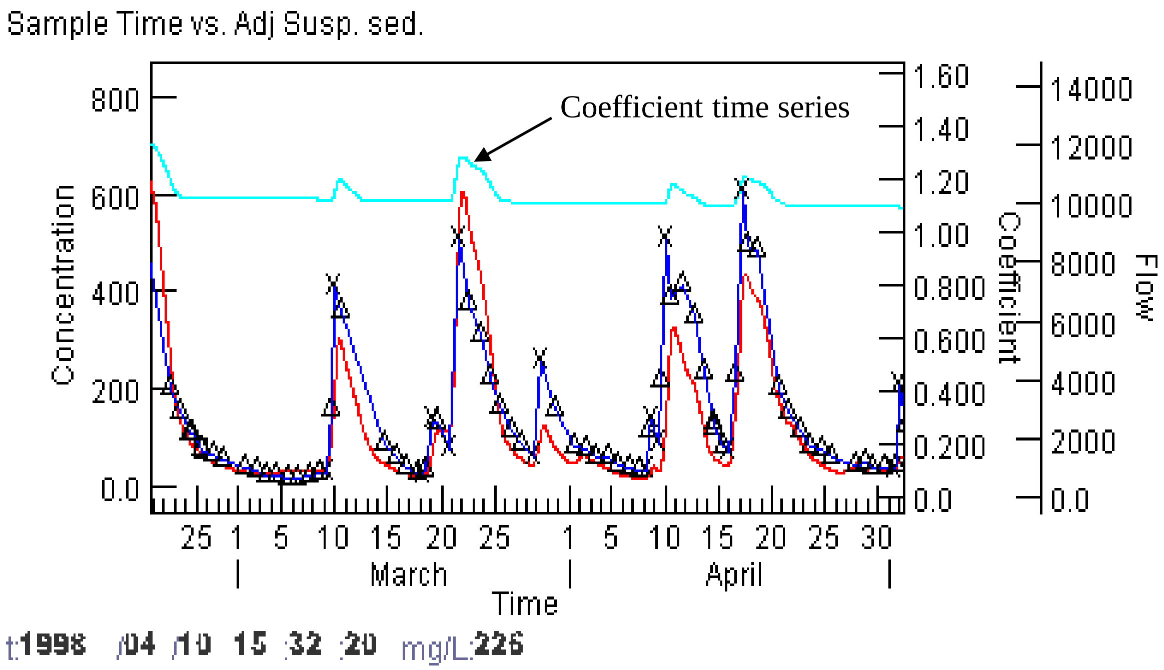


Cross-section Coefficients

Can be applied as:

- Constant
- Vary as a function of time
- Vary as a function of streamflow
- Vary as a function of time and streamflow

Visualization of Coefficient Time Series



Compute Loads for Any Period Less Than or Equal to a Water Year

Calculate Coefficients | Apply Coefficients | Compute Loads

Day	October			November			December		
	Q	Conc.	Load	Q	Conc.	Load	Q	Conc.	Load
18	65	11	1.9	86	8	1.9	397	30	32
19	65	9	1.6	87	9	2.1	353	25	24
20	65	7	1.3	92	8	2.1	313	21	17
21	64	6	1.1	98	7	1.9	288	17	13
22	59	7	1.2	151	12	5.5	287	15	11
23	58	9	1.4	244	17	11	538	59	92
24	58	10	1.6	272	14	10	872	82	193
25	60	11	1.8	218	16	9.3	2720	342	3080
26	71	12	2.4	178	15	7.5	4020	381	4260
27	116	13	4.1	156	12	5.0	2980	250	2030
28	132	14	4.9	241	39	28	1830	191	954
29	142	12	4.7	466	84	107	1120	133	407
30	119	10	3.3	618	63	105	797	101	219
31	100	12	3.3	--	--	--	581	78	122
Month	2010	12	66	4200	18	343	31500	89	15900
Annu...	474000	92	367000	--	--	--	--	--	--

Options | Summary

Linear

Load Unit: t/d

Num. Months: 3

Start: 10/01/1997 00:00:00

End: 09/30/1998 23:59:59

reset time | compute w/UV | compute

USGS

Create Daily-Value Outputs

Calculate Coefficients | Apply Coefficients | Compute Loads

Day	October Q	October Conc.	October Load	November Q	November Conc.	November Load	December Q	December Conc.	December Load
20	65								
21	64	6	1.1	98	7				
22	59	7	1.2	151	12				
23	58	9	1.4	244	17				
24	58	10	1.6	272	14	10	872	82	193
25	60	11	1.8	218	16	9.3	2720	342	3080
26	71	12	2.4	178	15	7.5	4020	381	4260
27	116	13	4.1	156	12	5.0	2980	250	2030
28	132	14	4.9	241	39	28	1830	191	954
29	142	12	4.7	466	84	107	1120	133	407
30	119	10	3.3	618	63	105	797	101	219
31	100	12	3.3	--	--	--	581	78	122
Month	2010	12	66	4200	18	343	31500	89	15900
Annu...	474000	92	367000	--	--	--	--	--	--

Reports
- cardExports
  - Daily Loads (rounded)
  - Daily Loads (unRounded)
  - Daily Mean Concentration (rounded)
  - Daily Mean Concentration (unRounded)
- Print Daily Load Report

```
# ------------ GCLAS output --------------
#
# site 04198000
# parmcode 80155
agency_cd           site_no datetime         00_80155
5s        15s       20d     14n
USGS      04198000          1997-10-03       0.0
USGS      04198000          1997-10-04       0.69
USGS      04198000          1997-10-05       2.9
USGS      04198000          1997-10-06       2.5
USGS      04198000          1997-10-07       2.2
USGS      04198000          1997-10-08       2.0
```

USGS

Create Unit-Value Outputs

Calculate Coefficients | Apply Coefficients | Compute Loads

Day	March			April			May		
	Q	Conc.	Load	Q	Conc.	Load	Q	Conc.	Load
1	18000	38	1840	17000	36	1630	12000	27	869
2	17900	34	1660	16500	37	1630	11300	25	773
3	18500	31	1540	16700	34	1510	11500	23	719
4	18300	27	1350	17100	30	1370	10900	21	623
5	17900	24	1150	16700	26	1150	10300	19	532
6	18000	31	1490	16100	22	949	9640	17	445
7	19700	30	1580	16000	21	923	10100	15	410
8	23800	29	1880	15700	22	931	9950	14	363
9	26100	49	3430	16200	22	980	9990	15	412
10	27400	48	3580	16400	23	1030	9830	18	469
11	27900	42	3180	16100	26	1140	9620	20	520
12	28800	36	2830	16100	27	1180	9850	22	597
13	27800	36	2680	16000	27	1180	9660	25	643

Options | Summary

Linear

Load Unit: t/d

Num. Months: 3

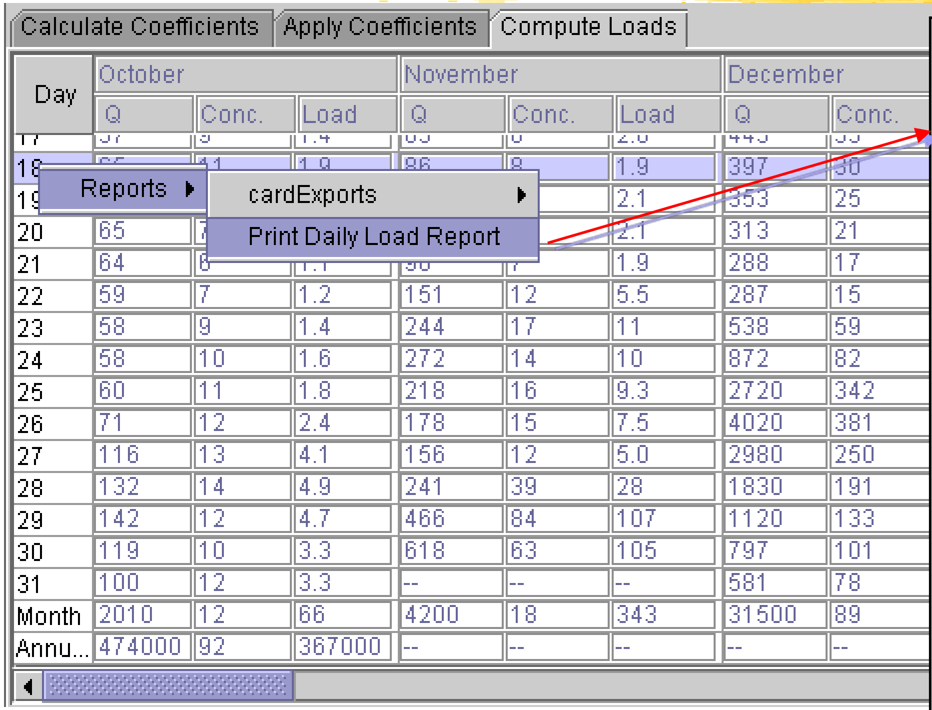
Start: 10/01/2001 00:00:00

End: 09/30/2002 23:59:59

reset time | compute w/UV | compute

```
# ------------ GCLAS output --------------
#
# site 04198000
# parmcode 80155
agency_cd       site_no datetime        tz_cd   00_80155
5s      15s     20d     6s      14n
USGS    04198000        1997-10-02 19:00        USP     3.84987
USGS    04198000        1997-10-02 19:30        USP     3.84221
USGS    04198000        1997-10-02 20:00        USP     3.83454
USGS    04198000        1997-10-02 20:30        USP     3.63846
USGS    04198000        1997-10-02 21:00        USP     3.63117
USGS    04198000        1997-10-02 21:30        USP     3.62389
```

Create Printable Loading Report



Day	October Q	Conc.	Load	November Q	Conc.	Load	December Q	Conc.
18		11	1.9	86	8	1.9	397	30
19						2.1	353	25
20	65					2.1	313	21
21	64	6				1.9	288	17
22	59	7	1.2	151	12	5.5	287	15
23	58	9	1.4	244	17	11	538	59
24	58	10	1.6	272	14	10	872	82
25	60	11	1.8	218	16	9.3	2720	342
26	71	12	2.4	178	15	7.5	4020	381
27	116	13	4.1	156	12	5.0	2980	250
28	132	14	4.9	241	39	28	1830	191
29	142	12	4.7	466	84	107	1120	133
30	119	10	3.3	618	63	105	797	101
31	100	12	3.3	--	--	--	581	78
Month	2010	12	66	4200	18	343	31500	89
Annu...	474000	92	367000	--	--	--	--	--

DAY	MEAN DISCHARGE (ft^3/s)	CONCEN-TRATION (mg/L)	LOAD (tons)	MEAN DISCHARGE (ft^3/s)	CONCEN-TRATION (mg/L)	LOAD (tons
		October			November	
1	---	---	---	95	13	3.3
2	15	---	---	91	14	3.3
3	64	23	4.1	84	21	4.8
4	64	21	3.6	79	19	4.0
5	59	18	2.9	73	18	3.4
6	55	16	2.4	72	14	2.8
7	53	14	2.0	71	11	2.0
8	52	12	1.7	68	12	2.1
9	50	11	1.5	68	15	2.7
10	52	10	1.5	70	17	3.2
11	51	10	1.4	68	15	2.7
12	47	10	1.2	67	11	2.1
13	49	12	1.6	66	10	1.7
14	56	15	2.3	71	9	1.8
15	60	15	2.4	82	9	2.0
16	53	12	1.7	85	9	2.0
17	57	9	1.4	85	8	2.0
18	65	11	1.9	86	8	1.9
19	65	9	1.6	87	9	2.1
20	65	7	1.3	92	8	2.1
21	64	6	1.1	98	7	1.9
22	59	7	1.2	151	12	5.5
23	58	9	1.4	244	17	11
24	58	10	1.6	272	14	10
25	60	11	1.8	218	16	9.3
26	71	12	2.4	178	15	7.5
27	116	13	4.1	156	12	5.0
28	132	14	4.9	241	39	28
29	142	12	4.7	466	84	107
30	119	10	3.3	618	63	105
31	100	12	3.3	---	---	---
MONTH	2010	12	66	4200	18	343

USGS

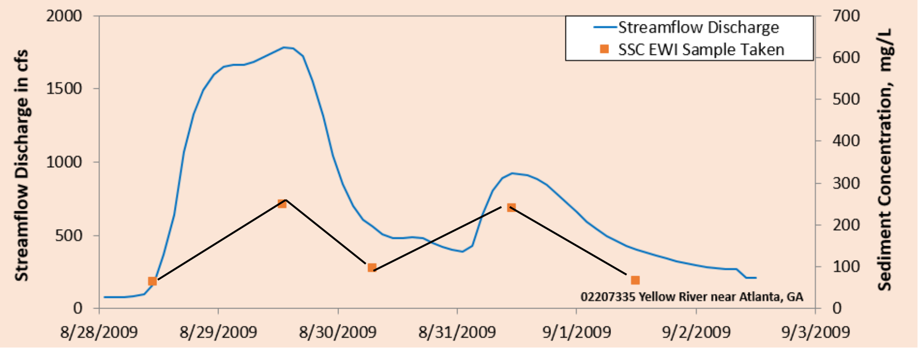
GCLAS Pros and Cons

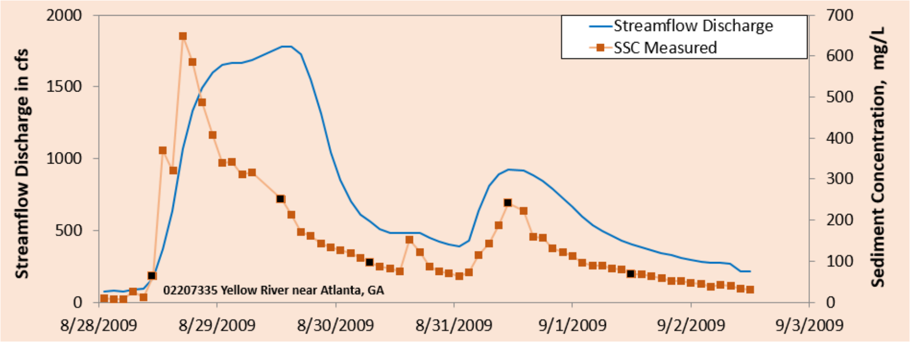
- Pros
  - Loads can be computed for nearly any time interval ≤ water year
  - Cross-section coefficients can be evaluated & applied
  - More flexible than regression methods
  - No need to transform variables – no transformation bias
  - Not dependent on statistical assumptions or having a good surrogate for the constituent of interest
  - Can be used with reference or surrogate data sets to improve estimates
  - GCLAS runs within several operating systems
- Cons
  - Requires high-frequency concentration data
  - Cannot provide confidence limits on estimates
  - Not scriptable (not suitable for real-time applications)
  - Censored concentrations are assumed equal to censoring level
  - Depending on nature of inputs, results can have low to high uncertainty

Censored concentrations are assumed equal to censoring level

- GCLAS treats censored data as being equal to the censoring level (i.e. it ignores the < and > symbols)
- For “less than” values, that results in computing an upper limit of daily mean concentration and loading
- GCLAS typically is not a good choice if there are appreciable censored data

Depending on nature of inputs, results can have low to high uncertainty





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For more information ...

- GCLAS available at:

  http://water.usgs.gov/software/GCLAS/

- Contact Greg Koltun (gfkoltun@usgs.gov) for more information