SAN JUAN RIVER BASIN
RECOVERY IMPLEMENTATION PROGRAM

HYDROLOGY, GEOMOPHOLOGY, HABITAT LONG-TERM MONITORING 2000 PLAN

prepared by

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CHAPTER 1: INTRODUCTION

Hydrology, geomorphology and habitat studies of the San Juan River began in 1992 as a part of the San Juan River Basin Recovery Implementation Program (SJRIP). The activities changed from research to monitoring beginning in 1999. The work reported here summarizes data collected in 2000 as a part of the long-term monitoring program and compares this data to that collected since 1992.

Data collected in the following areas are summarized here:

- Hydrology
- River Cross-Section Measurement
- Cobble Bar Characterization
- Turbidity
- Water Temperature
- Water Quality
- Aquatic Habitat Mapping from the confluence of the San Juan and Animas Rivers (RM180) to the confluence with Lake Powell (RM 0)
- Backwater Characterization (total depth, sediment depth, water depth)

All data sets are from the 2000 field season except habitat mapping. Due to the long data analysis time after the late fall data collection, there is a one-year lag in the habitat data.

Methods for each data set are covered in the Long-Term Monitoring Plan and are not described in detail in this annual progress report. The report concentrates on data reporting with a minimum of data analysis, particularly between data sets.

SAN JUAN RIVER STUDY AREA

The seven-year research program defined 8 geomorphically distinct reaches in the San Juan River (Bliesner and Lamara, 1999). Figure 1 shows these reach locations. The bulk of the studies reported here occur within Reaches 1-6, as this encompasses the critical habitat for the endangered Colorado Pikeminnow and razorback sucker. Some studies extend outside this range where necessary to define processes that effect the critical habitat. The study area for each data set is described with the summary of that data set.

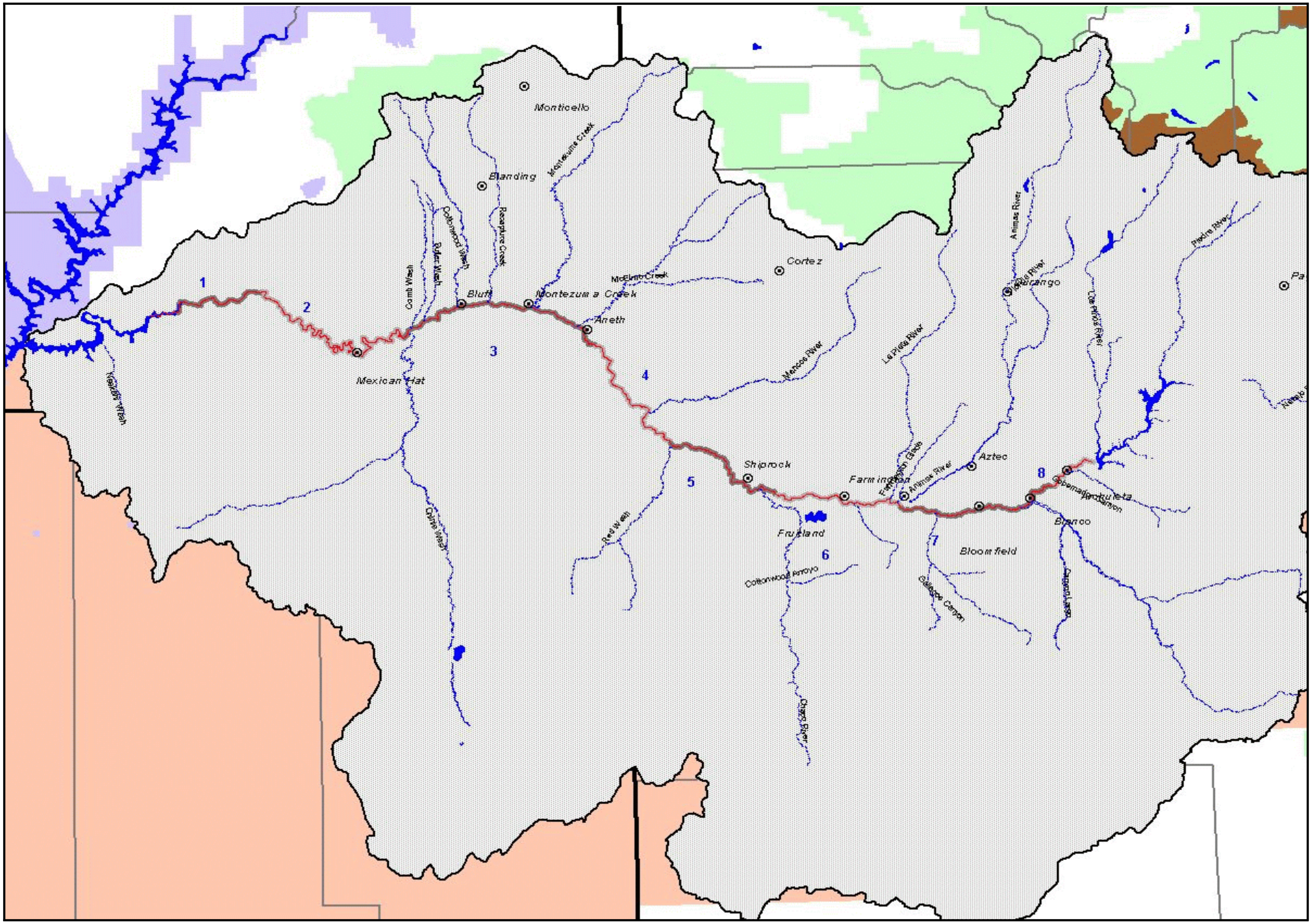


Figure 1.1. **San Juan Basin Location Map Showing Geomorphic Reaches**

CHAPTER 2: HYDROLOGY

BACKGROUND

United States Geological Survey (USGS) flow records for the San Juan River begin in 1911, but are not consistent or complete until about 1929. By this time substantial irrigation development had occurred. While the pre-Navajo Dam hydrology is natural in shape, it is depleted in volume by about 16 percent from natural conditions due to this irrigation development, with most of the depletion coming during the summer months. Since the depletion prior to Navajo Dam was relatively small and the flow was not regulated by major storage reservoirs, the conditions during the pre-dam period (1929-1961) are used to judge effects of later development and the value of future modification of the hydrology for the benefit of the endangered fishes.

Daily flow data recorded by the USGS from 1929 through the present are available for the key points on the San Juan River. These data have been used to analyze the 2000 hydrology and compare the statistics to other years. The foundation of comparison are the flow statistics in the SJRIP Flow Recommendation Report (Holden, 1999).

METHODS

Beginning in 1999, the operating rules recommended in the Flow Recommendation Report have been employed by Reclamation as far as restrictions would allow. Presently, the only restriction is to the minimum release from Navajo Dam, which cannot fall below 500 cfs until an Environmental Impact Statement (EIS) is completed. USGS gage records were used to assess the resulting hydrograph at Archuleta, Farmington, Shiprock, Four Corners and Bluff.

For each release year, the operating rules are evaluated utilizing the anticipated water supply and the release criteria set. The design release pattern and the actual releases are compared. The statistics of each year are computed and the flow recommendation conditions that were met indicated.

RESULTS

Research releases from Navajo Dam were made every year from 1992 through 1998 (1991 was a control year with no modification to the release) to augment the unregulated flows from the Animas River and provide peak spring runoff flows mimicking a natural hydrograph in the San Juan River below Farmington, NM. Beginning in 1999, the operating rules presented in the Flow Recommendation Report were implemented. August and September of 1999 were very wet with flows peaking at over 8000 cfs at the Four Corners Gage. Using the storm event day algorithm presented in Chapter 7 of the SJRIP Flow Recommendation Report shows 1999 to be a perturbating year. Based on the Navajo operation rule tree, this would result in a release of 114,000 ac-ft. However, the high, late season flows cleaned out key backwater habitat areas and so it was determined that there was no perturbation and hence no flushing release was required in 2000.

Table 2.1 describes the nature of the release each year since 1991. The volume of water released in excess of an assumed base release of 600 cfs normally required to meet downstream demands is also shown. In 2000 over 61,000 ac-ft was released although no release was called for. As can be seen in Table 2.1 there was an 8-day ramp up, one day at peak and a 7 day ramp down. This was done to meet a Navajo Reservoir end of June target elevation of 6072 feet. Reclamation was concerned about a repeat of the 1999 flows and the end of June target of 6072 feet was the result of conservative flood control measures in conjunction with monitoring requirements at the dam.

Table 2.2 compares the flow statistics from 2000 to those of the 1992-1999 period for each category identified in the Flow Recommendation Report. Also indicated are the desired conditions that were met. With the exception of average base flow and in July, all flow conditions were met.

Table 2.1. Summary of Navajo Dam release hydrograph characteristics since the beginning of the research period, 1992 to 2000.

YEAR	ASCENDING LIMB	PEAK	DESCENDING LIMB	MATCHED ANIMAS RIVER PEAK	VOLUME ABOVE 600 CFS BASE - AF
1992	6 weeks starting April 13	2 weeks at 4,500 cfs	4 weeks ending July 15	Yes	409,740
1993	Starting March 1, rapid increase to 4,500 (compare with 1987)	split peak, 45 days at 4,500 cfs, 7 days at 4,500 cfs	4 weeks ending July 13	No	773,820
1994	4 weeks starting April 23	3 weeks at 4,500 cfs	6 weeks ending July 28	Yes	486,620
1995	3 weeks at 2,000 cfs in March, ramp to 4,500 over 6 weeks starting April 1	3 weeks at 5,000 cfs	4 weeks ending July 14 (summer flow increased by 200 cfs)	Yes	675,810
1996	1 week starting May 27	3 weeks at 2,500 cfs	1 week ending June 29	No	100,320
1997	3 weeks at 2,000 cfs in March, return to 600-cfs base for 31 days, 10 days starting May 12	2 weeks at 5,000 cfs	6 weeks ending July 16	Yes	433,580
1998	30 days starting April 23	3 weeks at 5,000 cfs	1 week ending June 18	Yes	340,850
1999	9 days starting May 24	8 days at 5000 cfs	9 days ending June 18	No	166,189
2000	8 days starting May 30	1 day at 4580	7 days ending June 13	No	61,484

The 2000 hydrographs for the San Juan River at Archuleta (release hydrograph) and at Four Corners are presented in Figure 2.1. The hydrographs at Four Corners for these years appear in Figures 2.2 and 2.3. The flow statistics that apply to these hydrographs appear in Table 2.3. The Four Corners gage is considered the most representative gage for the habitat range and is used in all correlations reported here.

Table 2.2. Flow Statistics met in each year

Flow Condition	Std	1993	1994	1995	1996	1997	1998	1999	2000
Days at 10,000 cfs or more	5	1	0	**11**	0	**10**	0	0	0
Days at 8,000 cfs or more	10	**16**	**13**	**27**	0	**33**	2	0	0
Days at 5,000 cfs or more	21	**109**	**49**	**72**	0	**50**	**34**	**29**	3
Days at 2,500 cfs or more	10	**128**	**67**	**135**	**36**	**100**	**65**	**70**	**37**
Yrs w/o meeting 10,000cfs	10	**7**	**8**	**0**	**1**	**0**	**1**	**2**	**3**
Yrs w/o meeting 8,000 cfs	6	**0**	**0**	**0**	**1**	**0**	**1**	**2**	**3**
Yrs w/o meeting 5,000 cfs	4	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**
Yrs w/o meeting 2,500 cfs	2	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Note: Values in Bold are those that meet or exceed the minimum standard

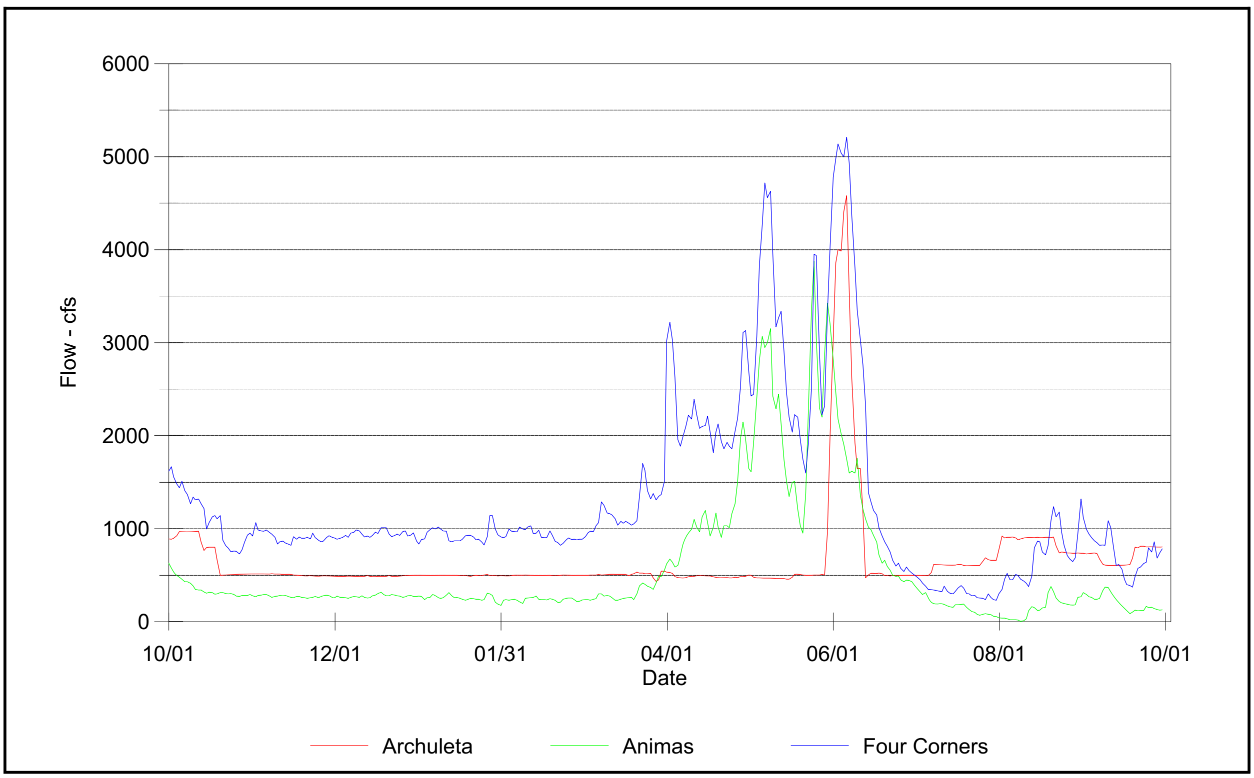


Figure 2.1. 2000 hydrographs for Animas River at Farmington, San Juan River at Archuleta and Four Corners.

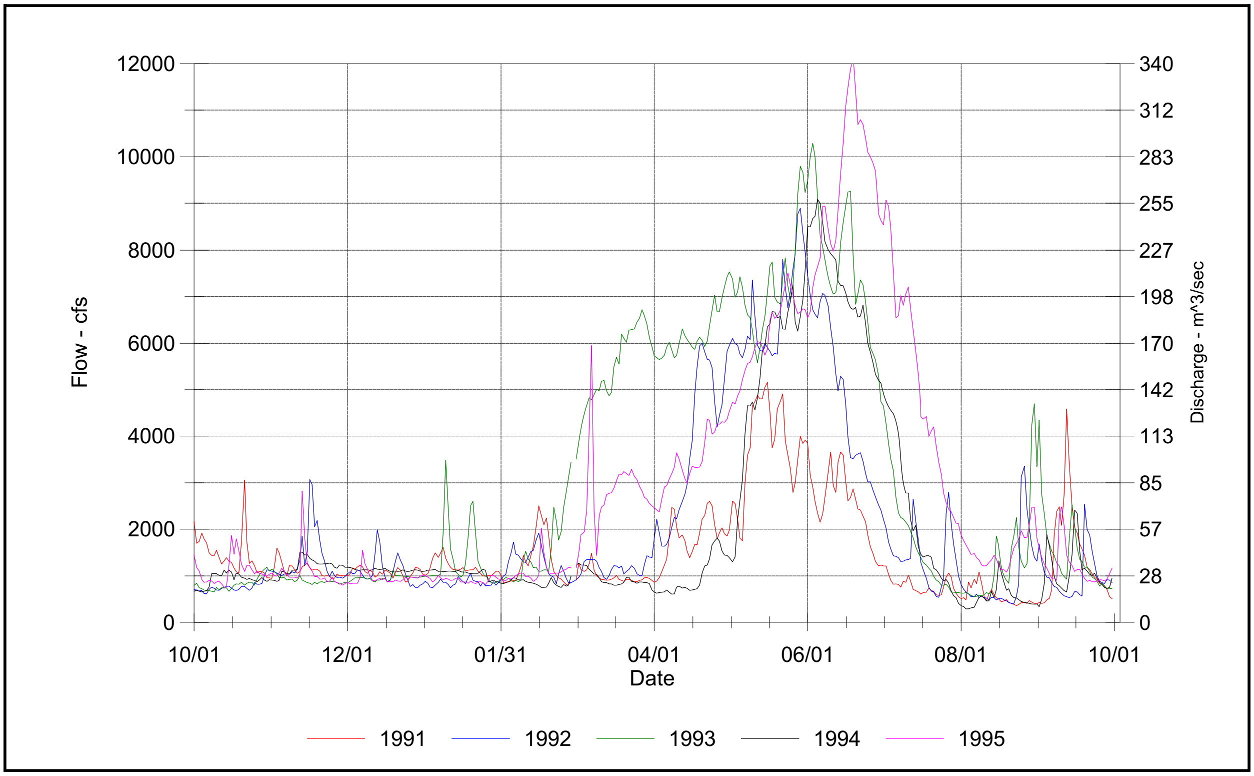


Figure 2.2. Hydrographs for the San Juan River at Four Corners 1991 - 1995

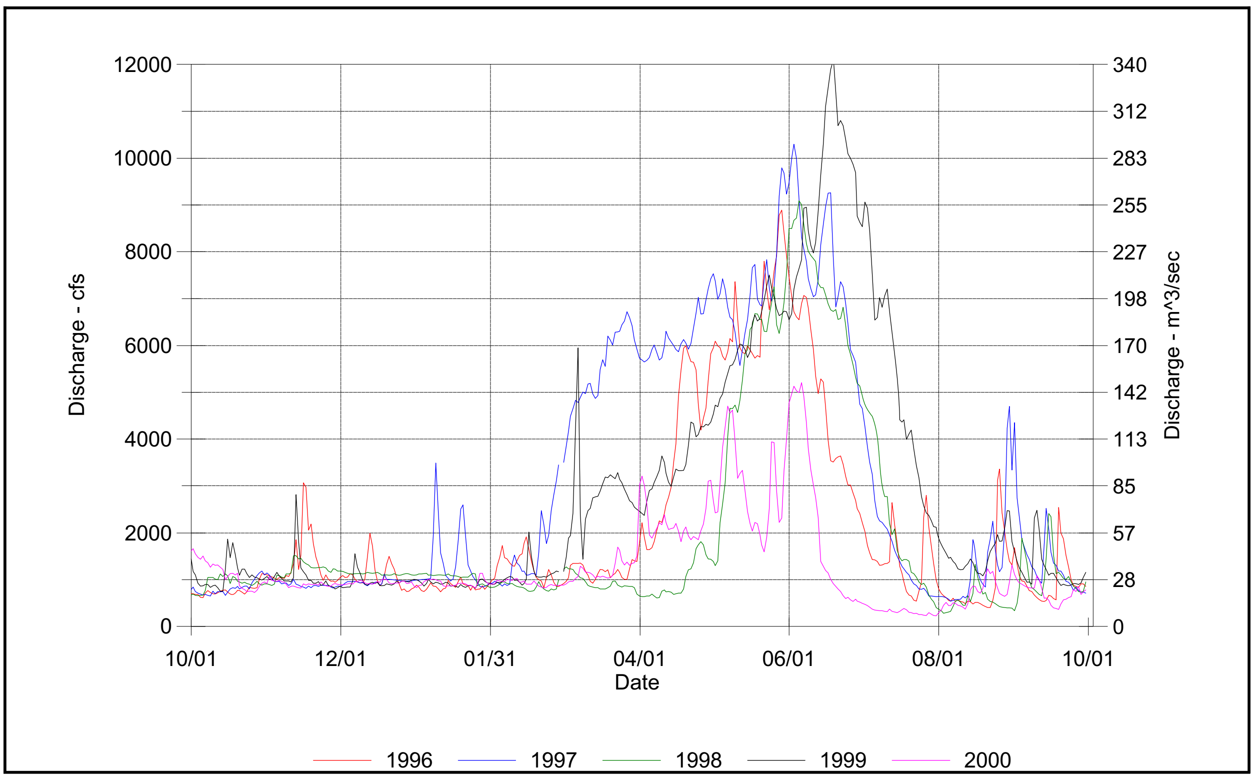


Figure 2.3. Hydrographs for the San Juan River at Four Corners 1996 - 2000

Table 2.3. Summary of flows for the research (1991-1998) and monitoring (1999-2000) periods, San Juan River at Four Corners, New Mexico.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	San Juan River at Four Corners, New Mexico									
Peak Runoff-cfs	5,160	8,900	10,300	10,000	12,100	3,540	11,900	8,580	8,030	5210
Runoff(Mar-Jul)-af	599,459	1,074,795	1,714,328	1,039,601	1,624,927	431,913	1,338,539	931,106	876,846	548,424
Runoff(total annual)-af	1,086,676	1,512,795	2,216,819	1,448,893	2,102,228	815,795	1,844,019	1,401,536	1,901,803	928,807
Peak Date	16-May	29-May	03-Jun	05-Jun	19-Jun	18-May	04-Jun	04-Jun	03-Jun	06-Jun
Days>10,000	0	0	1	0	11	0	10	0	0	0
Days>8,000	0	3	16	13	27	0	33	2	0	0
Days>5,000	2	54	109	49	72	0	50	34	29	3
Days>2,500	46	81	128	67	135	36	100	65	70	37
Ave. Daily Flow for month										
October	1,449	769	827	941	1,109	1,091	1,276	1,404	1,533	1,141
November	1,127	1,356	911	1,210	1,077	1,139	883	1,175	1,494	910
December	1,080	1,088	957	1,105	960	1,088	702	1,154	1,031	940
January	1,173	859	1,358	1,050	918	785	789	1,208	947	935
February	1,289	1,298	1,511	781	1,076	899	690	1,239	976	931
March	995	1,173	5,463	967	2,782	766	2,255	1,267	969	1,186
April	1,810	3,723	6,188	1,028	3,478	607	2,529	1,910	1,174	2,263
May	3,739	6,634	7,298	5,251	6,119	2,150	6,000	5,831	3,439	2,995
June	2,580	4,844	7,701	7,836	9,367	2,925	8,514	4,542	5,986	2,293
July	801	1,444	1,776	2,170	5,187	715	2,904	1,802	2,925	330
August	556	927	1,348	552	1,564	492	2,310	1,073	6,135	708
September	1,441	997		1,142	1,193	891	2,365	574	4,852	733
Uniqueness		Control	early ave.	early ascent	late ave.	late peak	dry	narrow runoff	early ave.	dry
			storm @ spawn					storm @ spawn	storm @ spawn	

CHAPTER 3. GEOMORPHOLOGY

METHODS

Channel Morphology - River Transects

Cross sections have been identified in five of the six geomorphic reaches for monitoring of bed elevation change with time. Reach 2 (RM 67 to RM 17) is canyon-bound and is not subject to channel change so it is not monitored. Two to three cross-sections in each geomorphic reach were identified for monitoring. Each cross-section is surveyed across the active river channel pre- and post-runoff each year. At lease one cross-section in the reach will span the floodplain and the full width will be surveyed every fifth year to monitor the effect of high flows on the floodplain. These were surveyed in 1999.

Table 3.1 lists the cross-sections in each geomorphic reach as identified in the Long-Term Monitoring Plan. The cross sections were selected from those established in 1962 (lettered cross-sections), those established in 1992, and new cross-sections (where existing cross-sections were not representative of a geomorphic reach). Monitoring program cross-sections are coded by geomorphic reach (e.g., CS6-02 = second cross-section in geomorphic Reach 6).

Table 3.1. San Juan River channel morphology monitoring cross-section locations by geomorphic reach.

Geomorphic Reach	X-Section No.	Former Identification	River mile
6	CS6-01	NEW	175.0
	CS6-02	RT-01	168.3
	CS6-03	RT-02	154.4
5	CS5-01	RT-03	142.7
	CS5-02	RT-04	136.6
	CS5-03*	RT-05	132.7
4	CS4-01	RT-06	124.0
	CS4-02	RT-07	122.1
	CS4-03*	Section E	118.2
3	CS3-01	RT-09	90.8
	CS3-02*	RT-10	82.3**
	CS3-03	RT-11	70.0
1	CS1-01	C-01	12.7
	CS1-02	C-02	4.1

*Valley-wide cross-sections surveyed every fifth year to monitor floodplain changes
**Valley-wide cross-section located at RM 82.2

Water depth and channel depth is obtained by stretching a marked cable across river between anchor points for each transect and measuring the channel depth relative to a local bench mark. River depths are measured with a survey level and rod at 5 ft increments unless cross-section length exceeds approximately 300 ft. In such situations, areas of the cross-section that have a change in depth of less than 0.5 ft in 10 ft may be surveyed in 10 ft increments. Substrate type at each survey point is characterized as sand or gravel/cobble and recorded. The full-width floodplain surveys were completed with a total station outside the active channel. The points surveyed correspond to grade breaks such as a change in slope, top of a hill or edge of a channel or bank.

Cobble Bar Characterization

Four cobble bars on the San Juan River (RM 173.7, RM 168.4, RM 132.0, and RM 131.0) that were identified as having attributes suitable for spawning by the Colorado pikeminnow were selected for monitoring. Topographic surveys were completed for each of these cobble bars, utilizing total station survey equipment. Control was provided by established bench marks at each location. Surveys are typically completed as soon as practical (flow at 1,000 cfs or less) after spring runoff, usually during late July or early August.

In addition to the standard required survey data, at each cobble bar the following data were recorded.

- Point descriptions for each point. Edge-of-water points noted and recorded.

- At each non-benchmark point the depth to embeddedness and corresponding surveyed point number is recorded.

- The physical structure of each cobble bar is assessed by measurement of randomly selected particles of surface bed material. Particles are selected by the Wolman pebble count method (Wolman, 1954) over the full extent of the bar within the survey boundary. A minimum of 200 samples is typically collected in a linear pattern over the bar with a spacing of about 8-10 ft (3 steps) within the line and between lines. Particle size is determined by sieving particles through a square hole in a steel plate, cut to represent an equivalent screen size from 1 through 10 cm at 1-cm increments, then 2-cm increments through 20 cm. Particles larger than 20 cm are recorded as greater than 20 cm. Interstitial material smaller than 1 cm is recorded as < 1 cm but is not included in analysis of size distribution.

- Depth of open interstitial space (depth to embeddedness) is measured at the same time and location as the survey points to characterize topography of the bar over the extent of the spawning bar. Measurement is made by a field technician working his/her hand among rocks until the fingers just touch embedded sand. Depth of penetration, measured from adjacent average cobble top-surface, will be recorded as depth of open interstitial space (Osmundson and Scheer, 1998).

Turbidity Monitoring

The continuous turbidity monitoring equipment installed at Shiprock and Montezuma Creek is used to monitor sediment producing events. The turbidity monitoring equipment at Shiprock consists of a D&A OBS-3 turbidity probe connected to a Campbell Scientific CR-510 data logger. The probe is calibrated to read between 0 and 4000 NTU's. Turbidity is measured every hour. The equipment installed at Montezuma Creek is an OmniData data logger with an OBS-3 probe that is calibrate to measure between 0 and 3000 NTU's. Turbidity is measured every two hours. The Shiprock installations has performed flawlessly while the Montezuma Creek installations has been plagued with problems. The Montezuma Creek installation will be replaced in early 2001.

RESULTS

Channel Morphology - River Transects

Cross-section plots referenced in Table 3.1 are contained in Appendix A. The long-term valley wide cross-sections were not surveyed in 2000. Their next planned survey date is 2004. The figures show the pre- and post-runoff cross-section of each transect. The bars with the various hatch patterns show the substrate conditions at the time of survey.

The relative bed elevation for each of the Reach 3-6 transects since the initial survey in 1992 is shown in Figure 3.1. In this plot, the average bed elevation of the first survey in 1992 was normalized to one meter. The change with subsequent surveys is then reported as a relative difference. A bed elevation greater than one shows net deposition since the first survey. Conversely, a bed elevation less than one shows scour. Figure 3.2 shows the minimum relative bed elevation. It shows how the minimum elevation in each of the transects has changed since the first survey in 1992.

The variability makes Figures 3.1 and 3.2 difficult to interpret. Figures 3.3 and 3.4 are the average relative and minimum relative bed elevation, respectively. The values represented in Figures 3.3 and 3.4 are calculated by averaging the individual bed elevations as shown in Figures 3.1 and 3.2 for each survey date. Figure 3.5 shows the cumulative deposition and scour for the Reach 3-6 transects for 1992 to 2000. The net change line shows that on average the cross-sections show a pattern of scour and fill, returning to near 1992 levels in 1997 and 1999. Since 1999 the cross-sections have again scoured somewhat. The deepest part of the cross-sections remain 0.05 meter lower than in 1992 and the average about 0.08 m lower. Figure 3.5 shows that most of the change during the period has been scour and deposition of sand, with relatively little net change in cobble, although there has been a slight net loss of cobble over the 8-year period. The figures also show the post-runoff filling of the cross-sections with sediment and the subsequent flushing between years for most years except for 2000. This is likely due to the high flows in the Fall of 1999 that flushed the system of a lot of sediment and then the dry winter months prevented tributaries from contributing their typical sediment loads.. Table 3.2 shows the volume and peak discharge in each year. Typically, the largest scour occurs during the highest flow years although heavy sediment inflow can refill a previous year's scour, even in the relatively wet years.

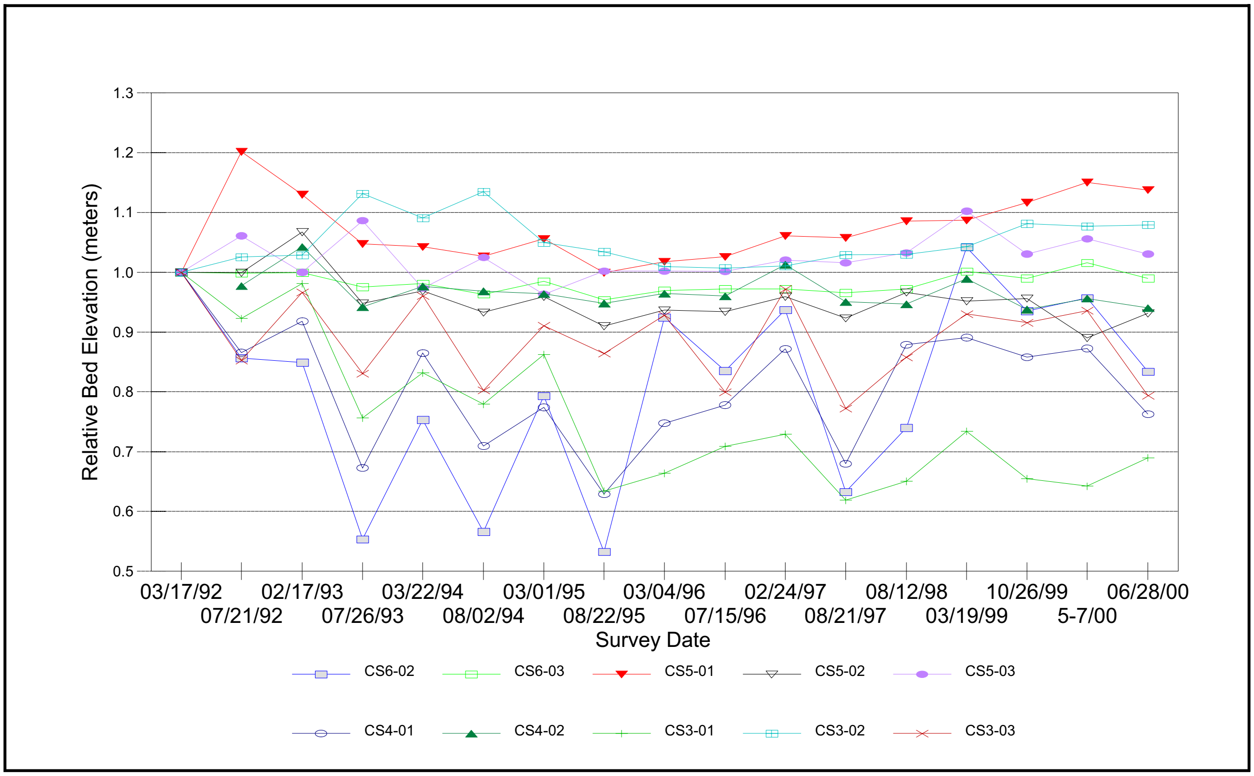


Figure 3.1. Average relative bed elevation for Reach 3-6 transects, 1992-2000

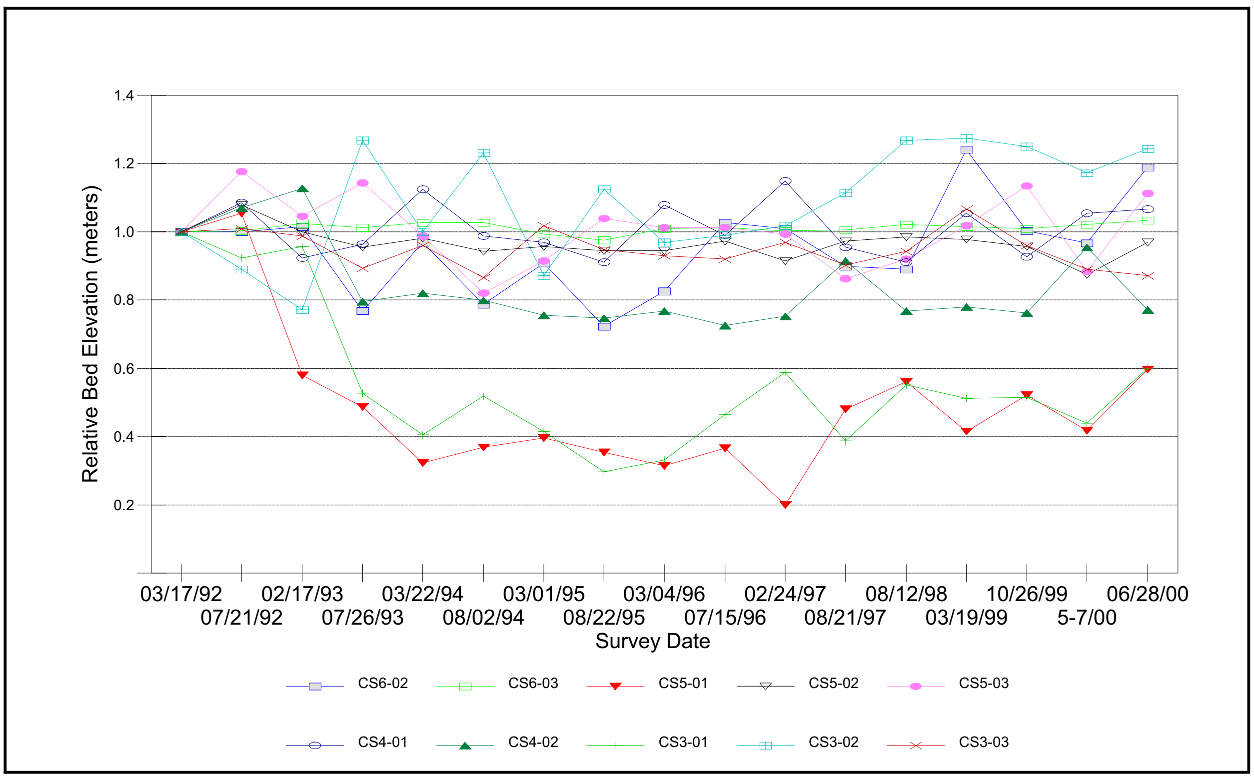


Figure 3.2. Minimum relative bed elevation for Reach 3-6 transects, 1992-2000

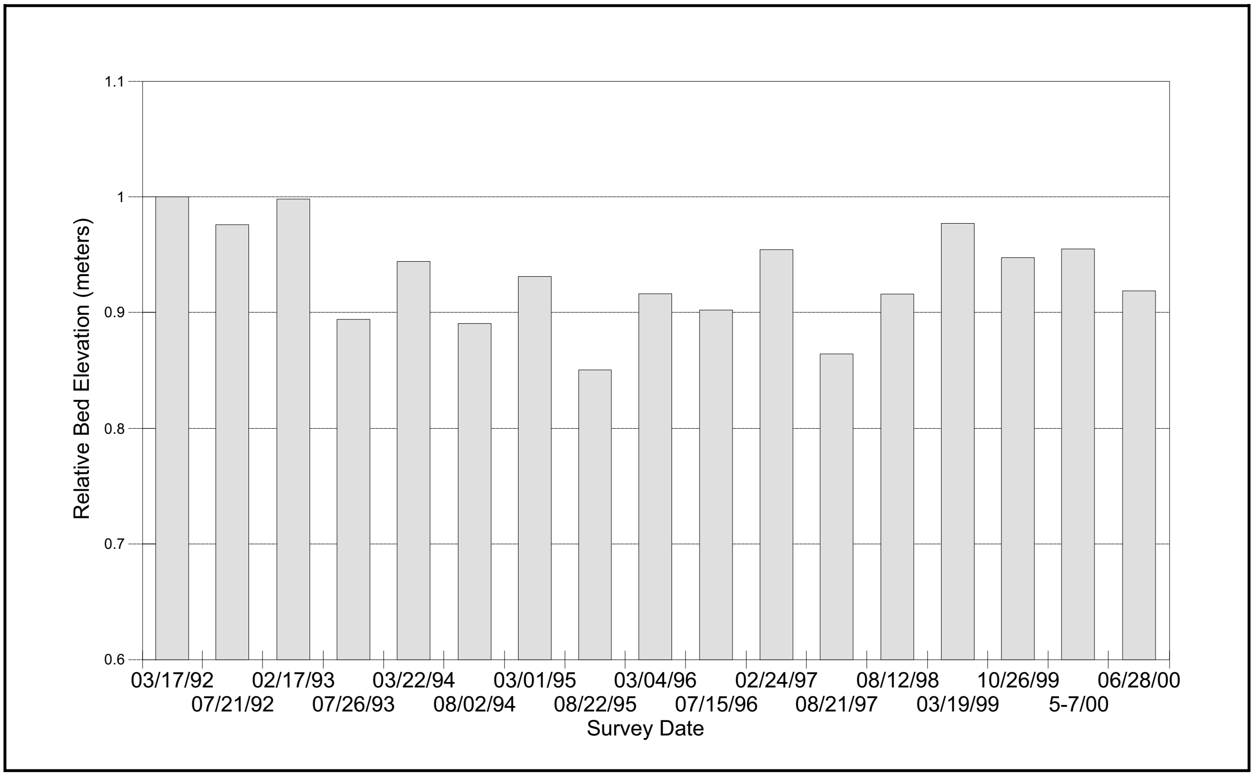


Figure 3.3. Mean relative bed elevation for Reach 3-6 Transects, 1992-2000

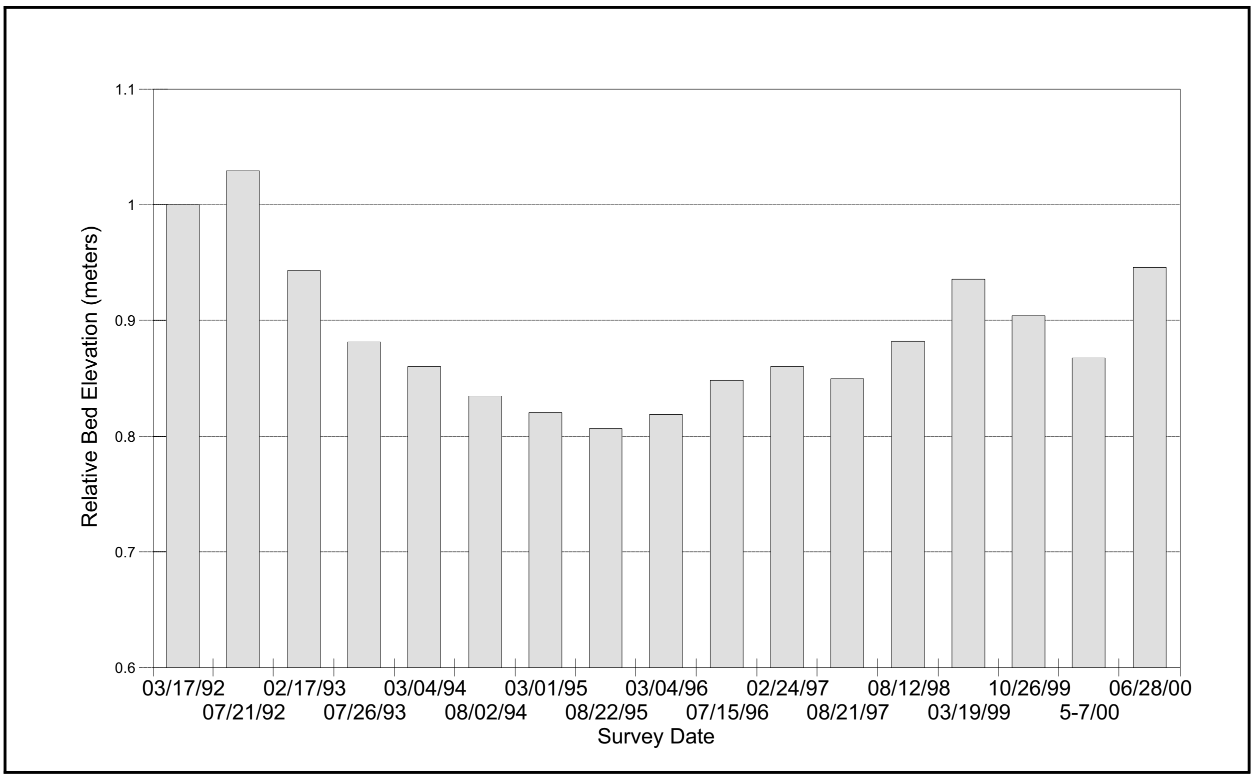


Figure 3.4. Minimum bed elevation averaged for Reach 3-6 Transects, 1992-2000

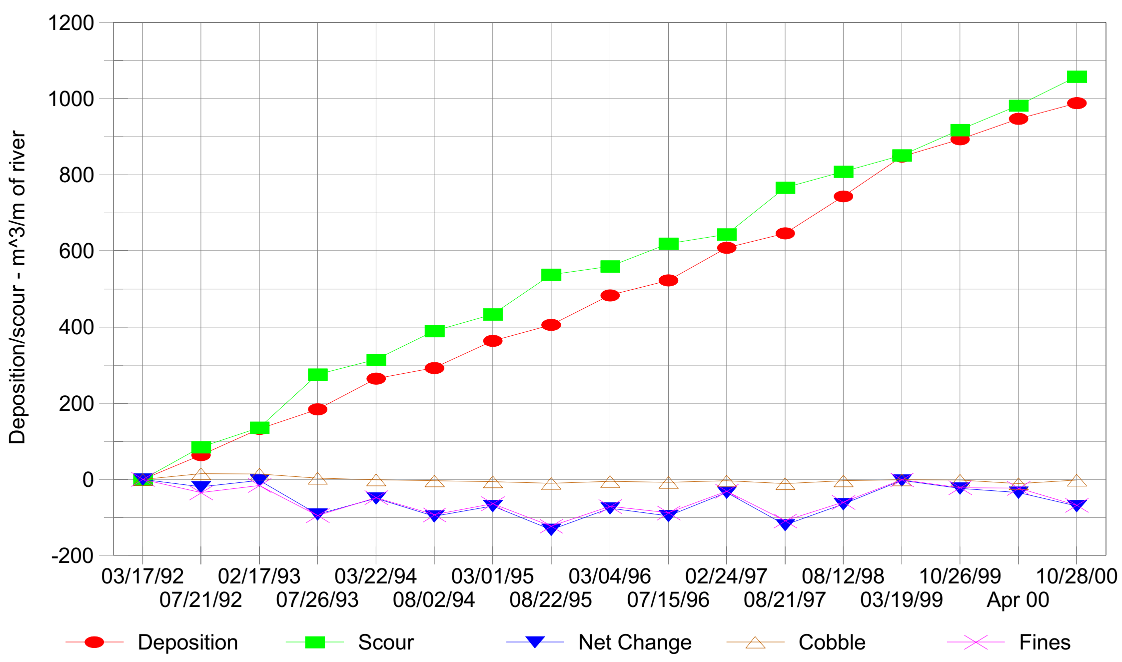


Figure 3.5. Net change in Reach 3-6 Transects, 1992-2000

Table 3.2. Peak discharge and Volume at Bluff (1991 - 1999)

Year	March to July Runoff Volume (ac-ft)	Peak Flow (cfs)
1991	574,000	4,530
1992	1,026,000	8,510
1993	1,681,000	9,650
1994	887,000	8,290
1995	1,504,000	11,600
1996	421,000	3,280
1997	1,279,000	11,300
1998	871,000	8,070
1999	812,000	7,420
2000	461,000	5,120

Measurement of Change in Reach 1 Cross-Sections

The mean bed elevation for each Reach 1 transect is shown in Figure 3.6. The average bed elevation for both transects is shown in Figure 3.7. All data were normalized to use the October 1993 survey as the baseline and the relative elevation of each transect was set to 1.0 meter for that survey. These transects are located in a canyon reach that is influenced by Lake Powell. There is approximately 40-ft of sediment, primarily sand, deposited in the bottom of the canyon in this location. This makes the river bottom very mobile. The thalweg is constantly shifting by eroding and depositing sand shoals. Most of the change in the two cross-sections through July 1996 is a result of this erosion and deposition within the cross-sections.

Beginning in 1996, the elevation of the downstream cross-section (CS1-02) began increasing. CS1-01 began increasing in 1997. Both are at maximum in the fall of 1999. Prior to 1995, Lake Powell levels were sufficiently low to not influence this reach. Even though the lake levels were low, rerouting of the channel at RM 0 placed the channel on a sandstone ledge, preventing erosion upstream. In 1995 lake levels reached a level sufficient to submerge the waterfall that had developed at the ledge, but did not markedly impact channel elevations upstream until 1996. Between 1996 and the 1999, the bed elevation gradually increased in response to this backwater effect

Lake Powell water surface elevation continued to decrease though the end of 1999 and into spring of 2000. There was a small water surface elevation increase during the runoff season and then a continued fall through the end of 2000. By the end of 2000 Lake Powell was at levels not seen since 1997. By the end of 2000, the water fall was no longer submerged. The decrease in bed elevation at CS1-02 can be attributed the reduced backwater effects of Lake Powell and the subsequent scour of fines. A plot of Lake Powell water surface elevation is shown in Figure 3.8. Also shown is the approximate elevation of the waterfall.

Substrate is 100% sand for both of these transects and will remain so regardless of the elevation of the bed. The changes in bed elevation in this reach (below RM 18) are more influenced by Lake Powell than San Juan River discharge.

Cobble Substrate Characterization

Topographic Changes in Cobble Bars

Topographic surveys were completed for the cobble bars at RM 173.7, 168.4, 132 (M-6) and 131 (M-4). The rendered images for the latest survey as well as images for the previous surveys are shown in Figures 3.9, 3.10, 3.11, and 3.12. Each color band represents 15-cm (6-inches) of elevation change. Table 3.3 summarizes the elevation changes of three of the four bars. The cobble bar at RM 131 (M-4) is not included because the survey boundaries have been inconsistent. This will rectified on future surveys.

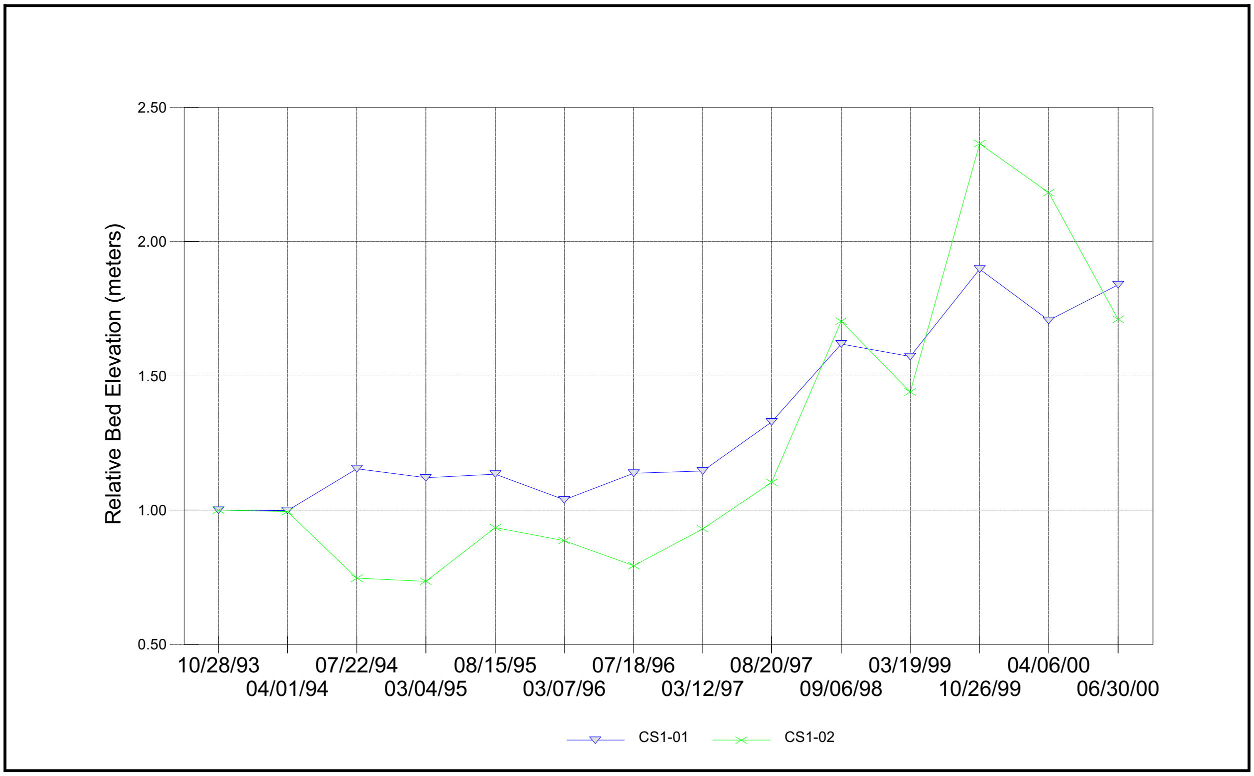


Figure 3.6. Average relative bed elevation for Reach 1 transects, 1993-2000

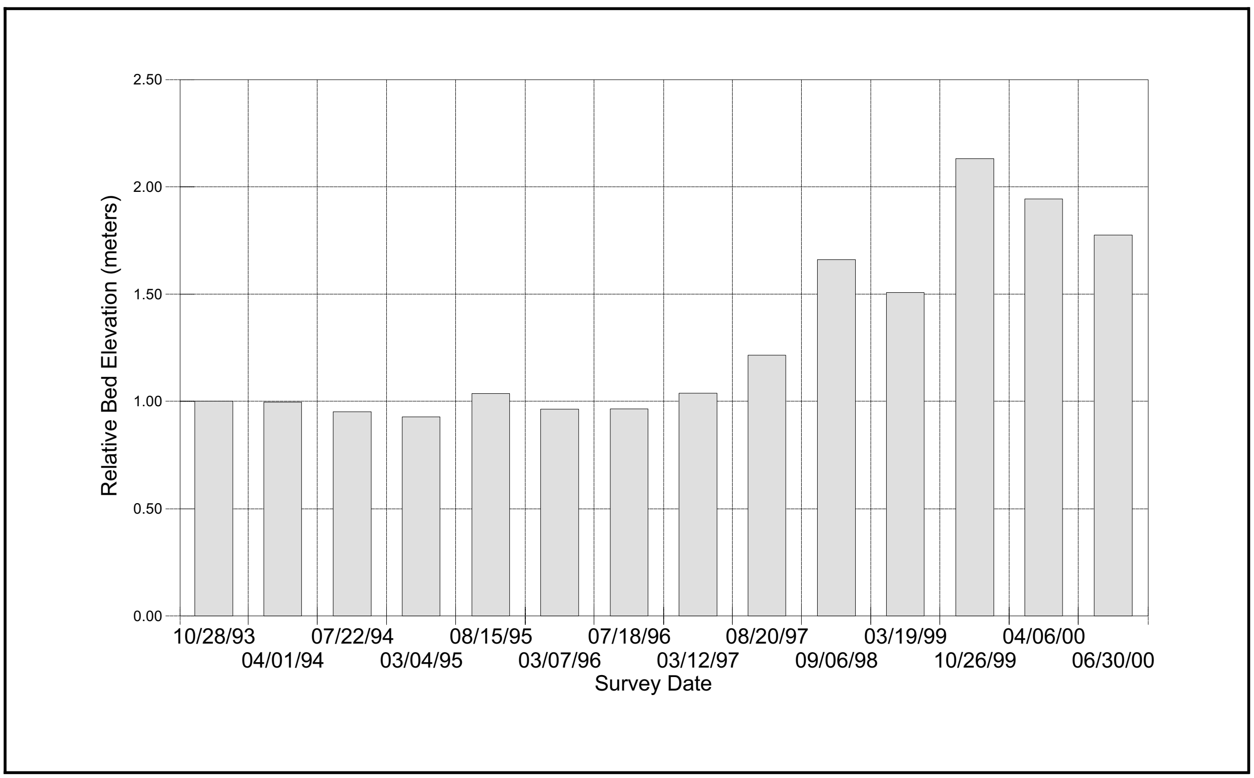


Figure 3.7. Bed elevation averaged for both transects in Reach 1, 1993-2000

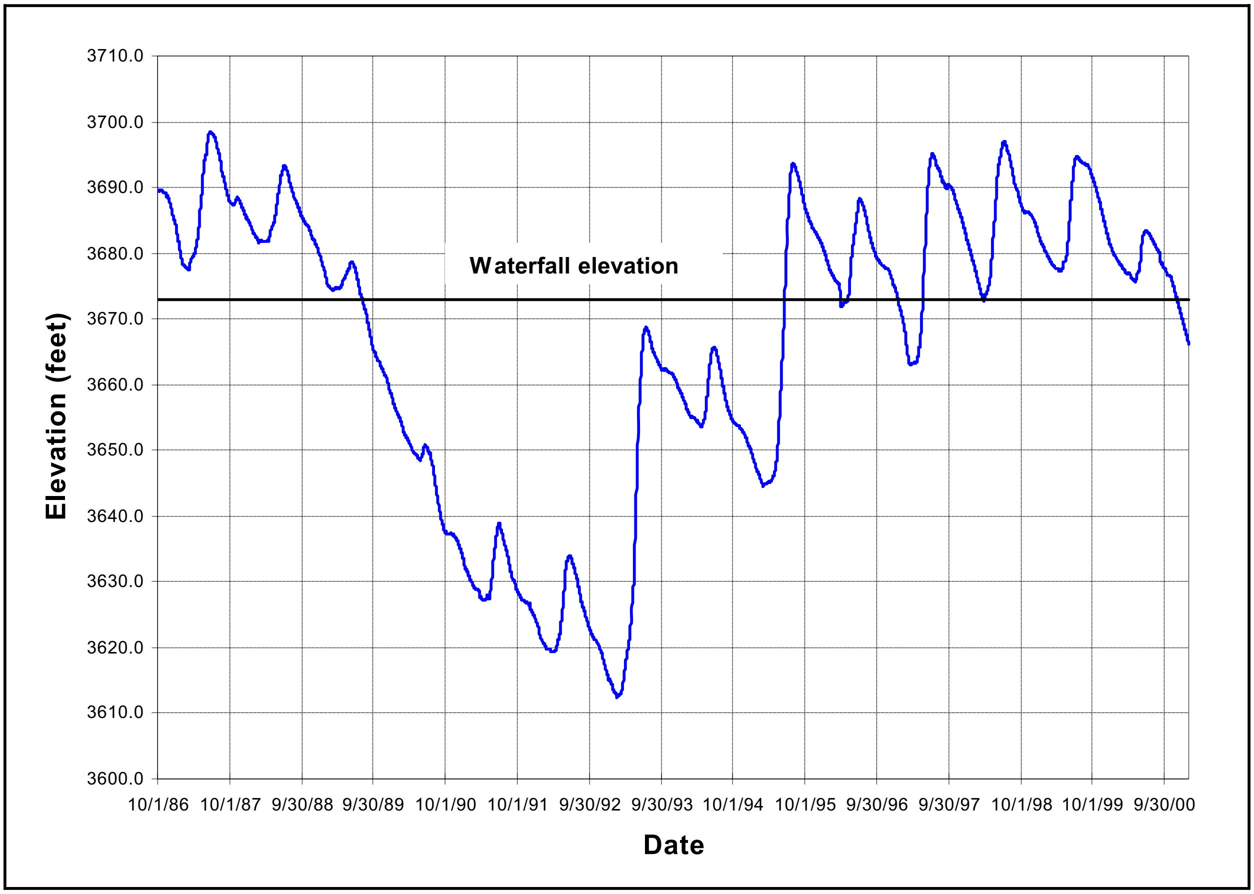


Figure 3.8. Lake Powell water surface elevation, 1986-2000

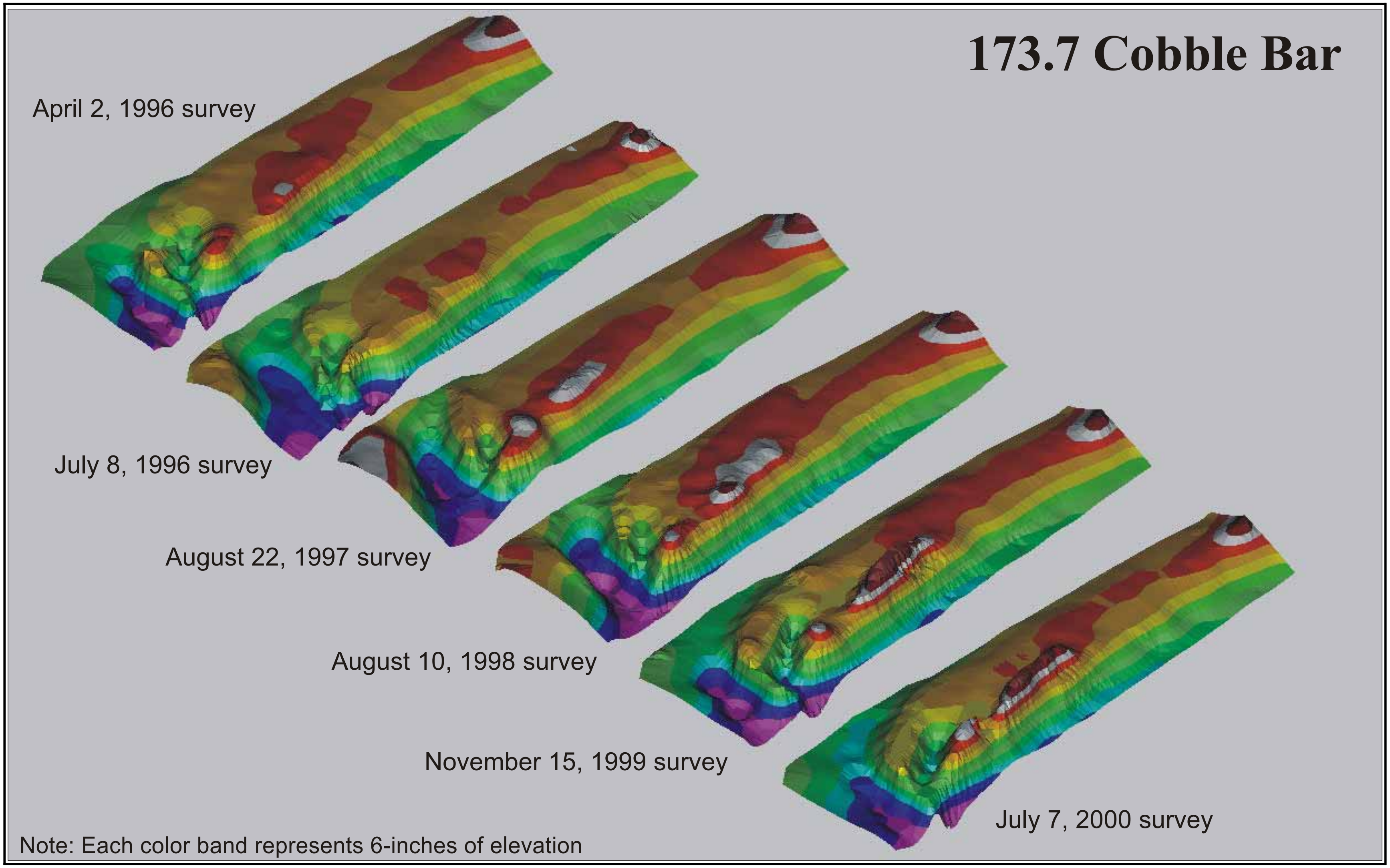


Figure 3.9. Topography of cobble bar at 173.7, 1993-2000.

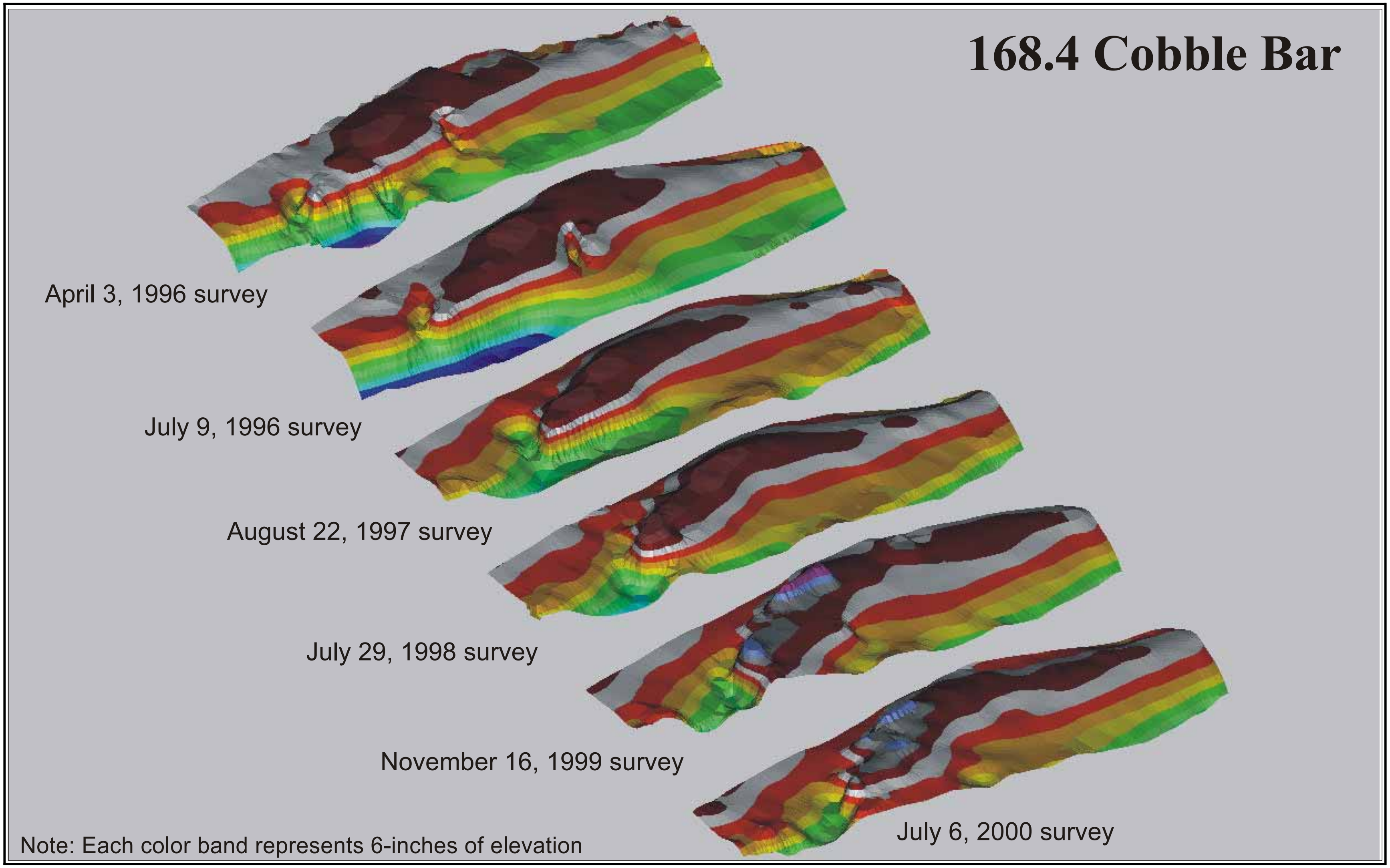


Figure 3.10. Topography of cobble bar at RM 168.4, 1993-2000

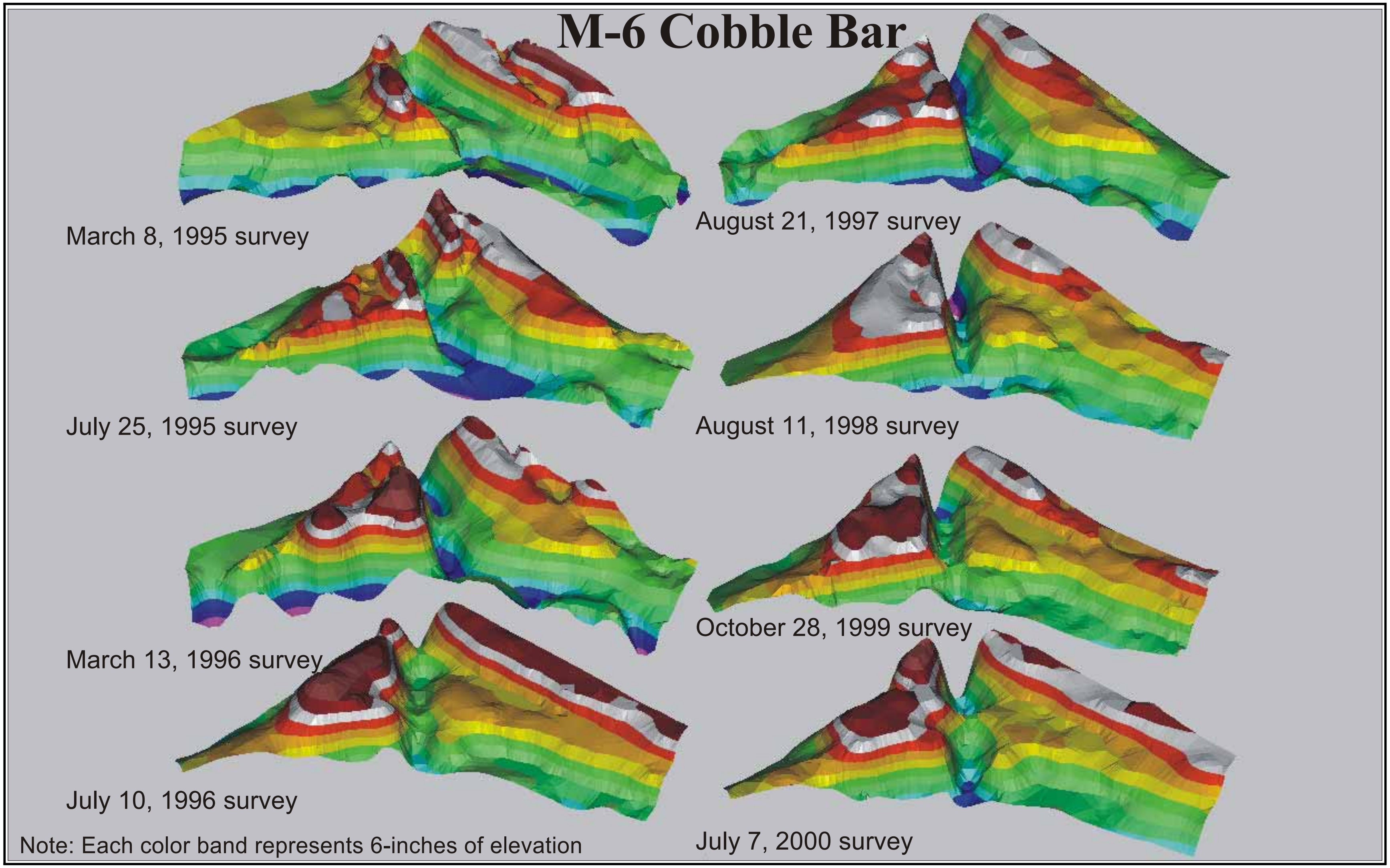


Figure 3.11. Topography of cobble bar at RM 132, 1995-2000.

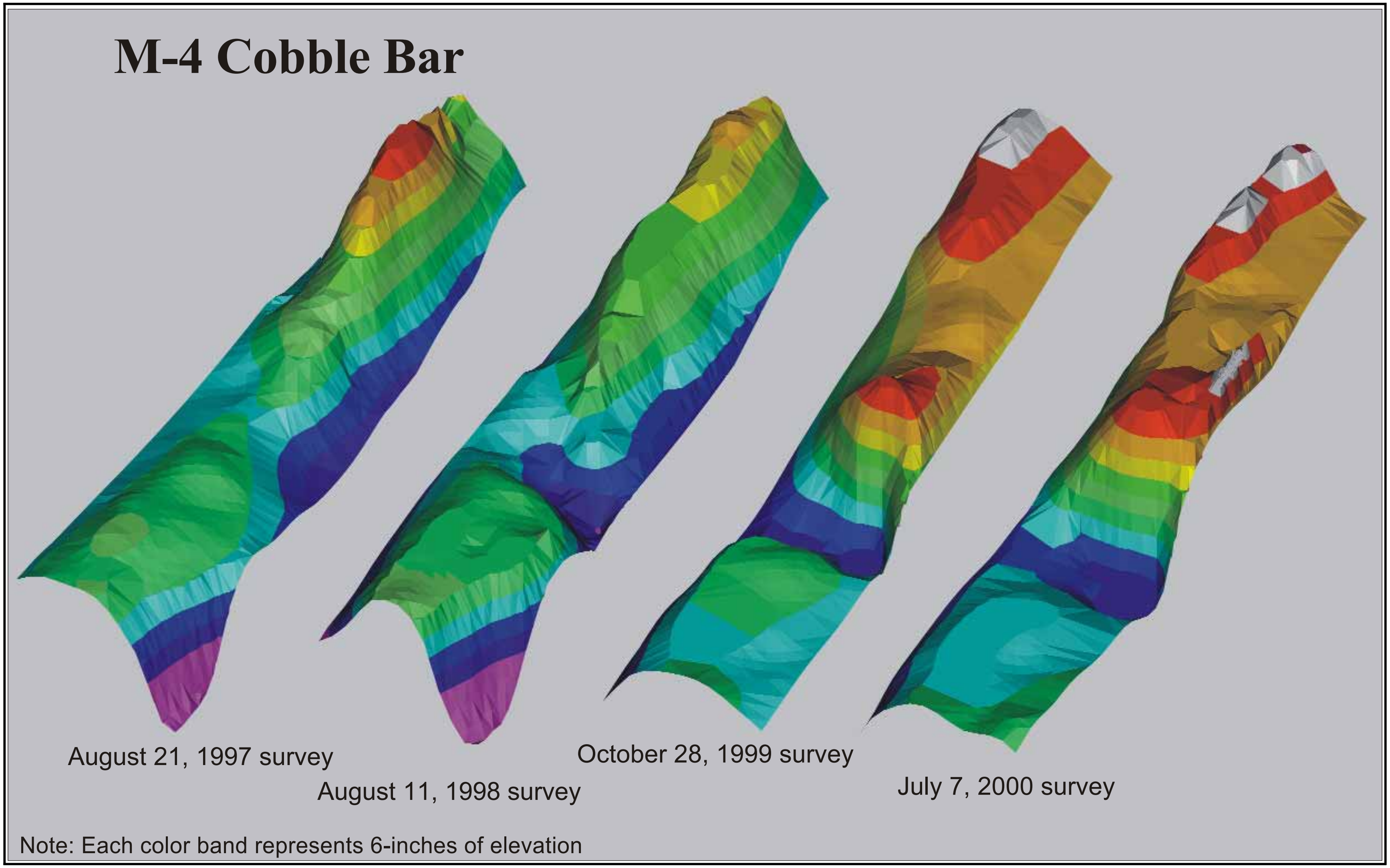


Figure 3.12. Topography of cobble bar at RM 131, 1997-2000

Table 3.3. Summary of cobble bar change for bars at RM 173.7, 168.4 and 132.

Survey Date	Average Elev. (m)	Change in Elev. (m)	Max Elev. (m)	Min Elev. (m)
Bar at RM 173.7				
04/02/96	30.48		28.90	27.13
07/08/96	30.52	3.7	28.80	27.28
08/22/97	30.41	-10.4	28.96	26.76
08/10/98	30.44	3.0	28.90	26.70
11/15/99	30.43	-1.2	28.93	26.82
07/07/00	30.41	-2.13	29.14	26.82
Bar at RM 168.4				
04/03/96	30.48		29.00	27.86
07/09/96	30.47	-0.9	28.99	27.46
08/22/97	30.50	2.4	28.99	27.91
07/29/98	30.54	4.3	29.11	27.84
11/16/99	30.60	6.7	29.43	28.00
07/06/00	30.58	-2.44	29.34	27.94
Bar at RM 132				
03/08/95	30.48		28.73	26.91
07/25/95	30.57	8.5	28.80	27.19
03/13/96	30.56	-0.9	28.68	27.04
07/10/96	30.54	-1.5	28.55	27.00
08/21/97	30.64	10.7	28.52	26.76
08/11/98	30.68	3.7	28.67	27.06
10/28/99	30.76	7.9	28.69	27.28
07/07/00	30.69	-7.32	28.65	27.23

The cobble bar at RM 173.7 showed slight overall scour of 2.1 cm. The maximum elevation increased by 0.21 meters and the minimum elevation remained unchanged. Figure 3.13 shows areas of deposition and scour between the 1999 and 2000 survey. The top image in each figure shows areas of deposition and the bottom image shows areas of scour. The deposition and scour has been separated to more clearly illustrate how the bar changed between the 1999 and 2000 surveys.

The cobble bars at 168.4 showed an overall loss of 2.4 cm while 132 showed a loss of 7.3 cm. This is the first time these two cobble bars have shown a loss since 1996. Both the minimum and maximum elevations decreased from 1999 to 2000 further showing scour. Figures 3.14 and 3.15 show areas of deposition and scour for both 132 (M-6) and 168.4.

Characterization of Bed Material

Table 3.4 shows the surface substrate composition for the 2000 pre- and post-runoff surveys of the Reach 3-6 transects. The pre-runoff survey averaged 58% sand and 42% cobble. The post-runoff survey averaged 44% sand and 56% cobble. The increase in the cobble percentage in the post-runoff survey shows that some fines were flushed from the system during runoff. Figure 3.16 shows the composition of the scour and deposition that occurred at each of the Reach 3-6 transects. Most of the material moved was fines. However, there was some cobble movement at most of the transects,

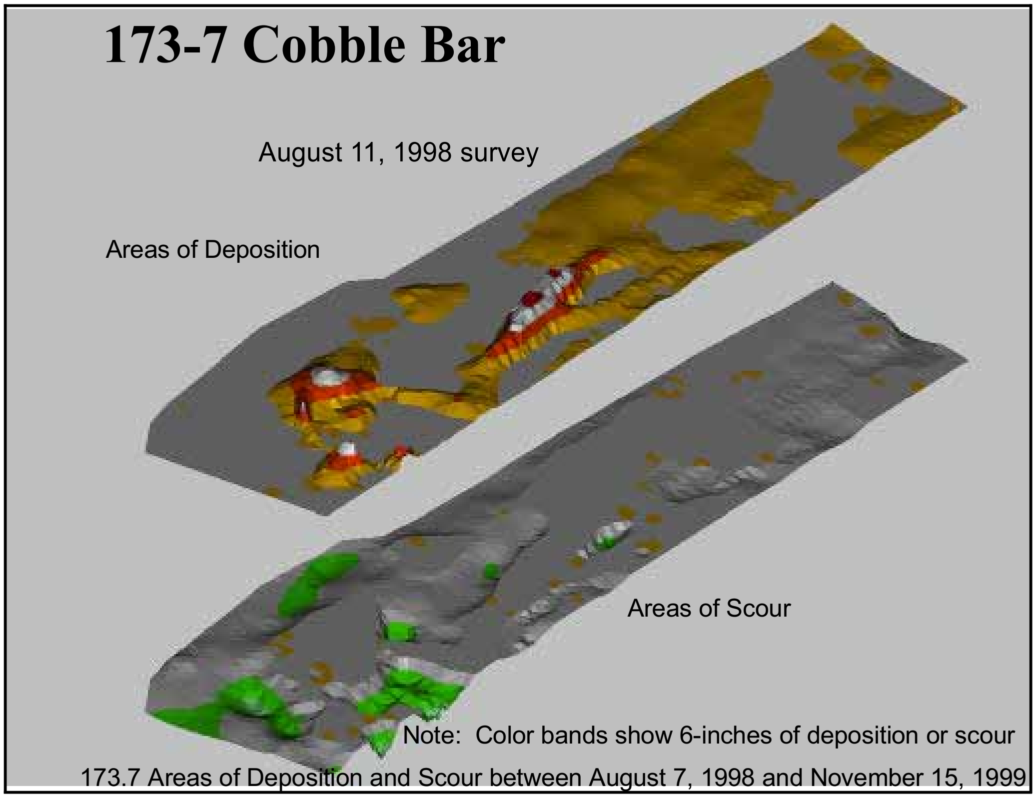


Figure 3.13. Areas of scour and deposition pre- to post-runoff for the RM173.7 cobble bar

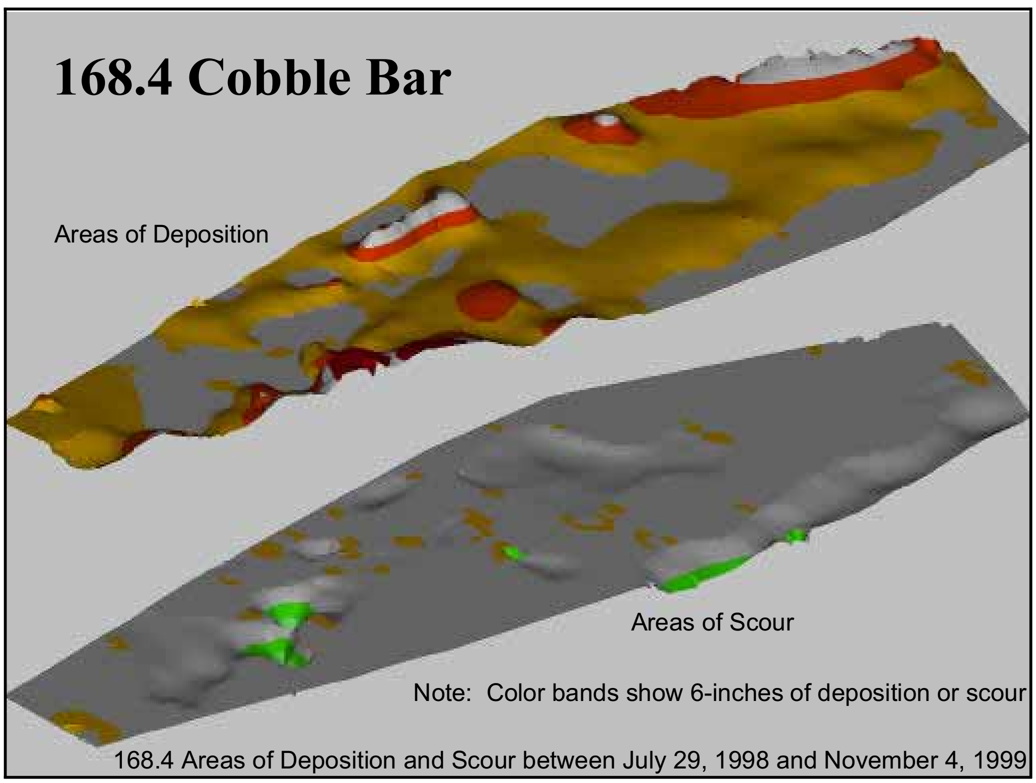


Figure 3.14. Area of scour and deposition pre- to post-runoff for the RM 168.4 cobble bar.

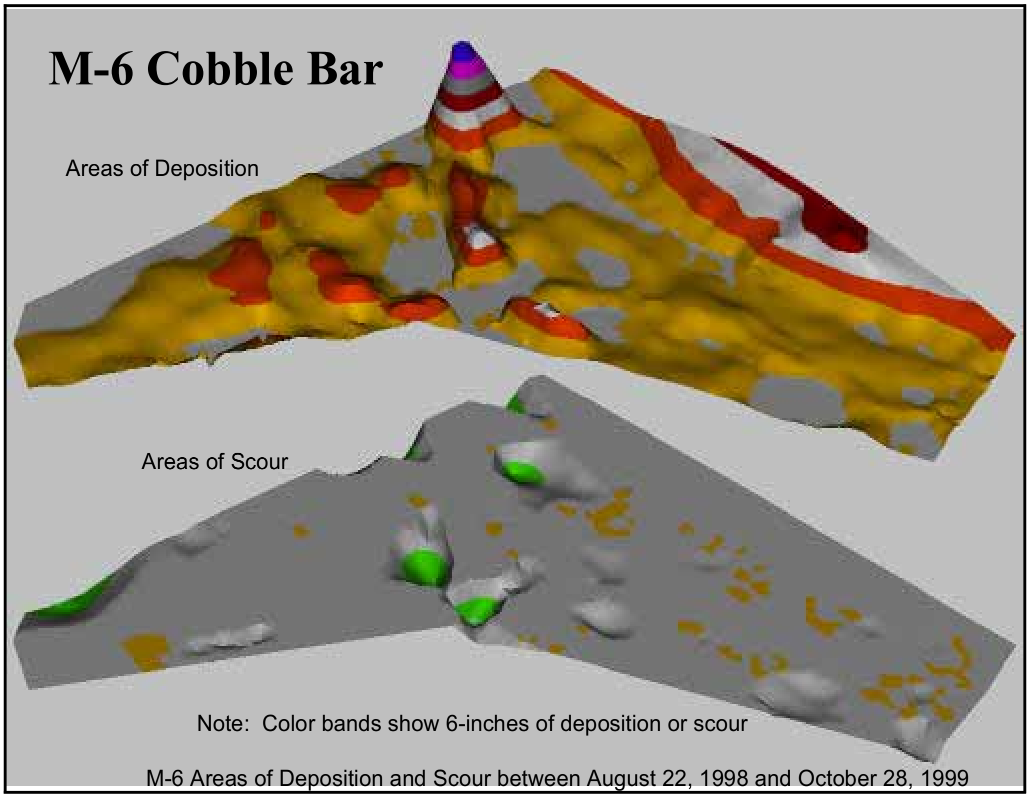


Figure 3.15. Area of scour and deposition pre- to post-runoff for the RM 132 cobble bar.

Table 3.4. Summary of percent cobble substrate, pre- and post-runoff, 2000 for Reach 3-6 transects.

Survey date	03/22/00	06/28/00
Transect	percent cobble	
CS6-02	23%	25%
CS6-03	33%	73%
CS5-01	72%	54%
CS5-02	42%	77%
CS5-03	55%	53%
CS4-01	13%	45%
CS4-02	63%	75%
CS3-01	44%	40%
CS3-02	59%	67%
CS3-03	13%	49%
Average	42%	56%

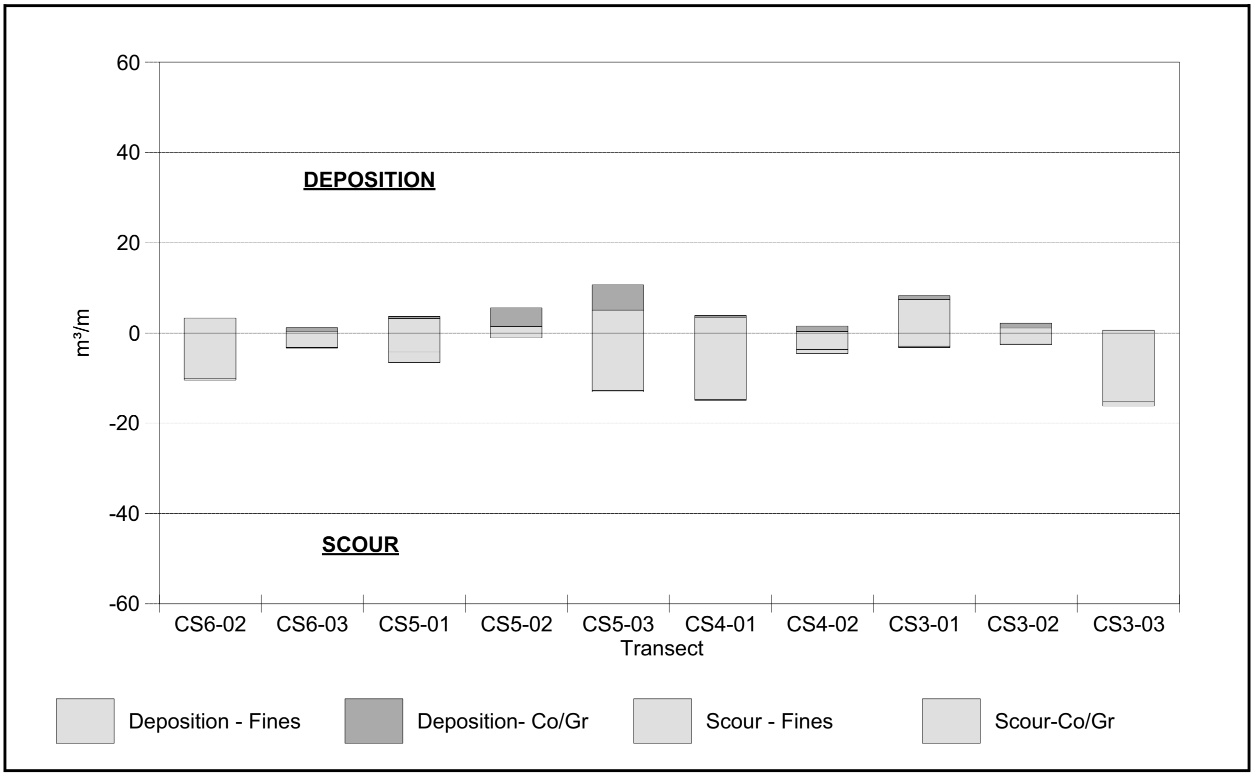


Figure 3.16. Scour and deposition composition at Reach 3-6 transects between pre- and post-runoff, 2000.

particularly at CS5-02 and CS5-03. This occurred with a 5,100 cfs peak at Four Corners. Figure 3.17 simply shows the percent cobble substrate for all surveys of the Reach 3-6 transects.

The cobble size distribution for each of the four surveyed cobble bars is shown in Table 3.5. The cobble bars at 173.3, 168.8 and 131 (M-4) showed a slight decrease in the cobble size from 1999. The cobble bar at 132 (M-6) showed a slight increase. In general, the cobble size is not correlated to river mile within the sample range (RM 131 - 173.7) and there are no increasing or decreasing trends.

Depth of Open Interstitial Space

Depth of open interstitial space was also measured at each cobble bar. Figures 3.18 through 3.21 show three-dimensional plots of the four cobble bars at river mile 173.7, 168.4, 132 (M-6) and 131 (M-4) for the post-runoff 2000 survey. The "posts" seen on the surface of each image represent the depth of open interstitial space as measured at that point. Each color band on the posts indicate 1-cm of embeddedness or open interstitial space. The higher posts represent areas with greater open interstitial space.

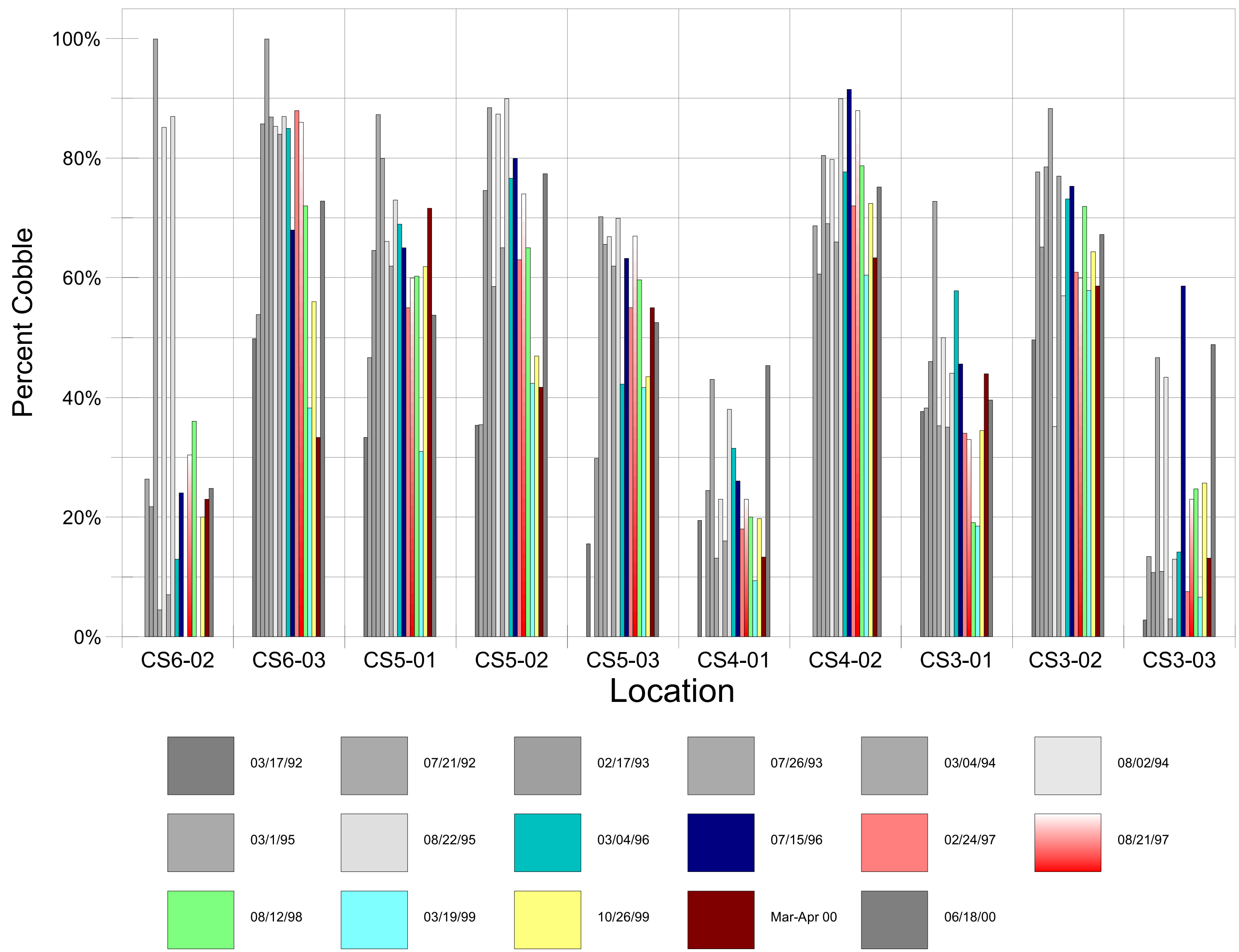


Figure 3.17. Cobble percentage at each transect, 1992 - 2000.

Table 3.5. Cobble size distribution for the four surveyed cobble bars.

Year	1995	1996	1997	1998	1999	2000
Size Fraction	Cobble Size - mm					
			RM 173.7			
D84	n/a	9.93	12.57	12.02	16.68	13.59
D75	n/a	7.95	8.00	10.33	13.17	11.21
D50	n/a	4.83	3.79	6.96	8.03	6.22
D25	n/a	3.03	2.19	4.72	4.41	3.93
D16	n/a	2.59	1.69	3.89	3.33	3.16
			RM 168.8			
D84	10.97	14.65	10.45	11.24	11.91	11.54
D75	10.17	12.62	10.00	9.94	11.00	9.88
D50	7.21	8.38	6.25	6.79	7.45	7.29
D25	4.94	4.99	4.33	4.65	5.41	5.05
D16	4.57	4.58	3.65	3.64	4.64	4.35
			RM 132 (M6)			
D84	8.64	11.64	9.90	9.49	9.98	9.92
D75	7.28	10.64	8.38	8.18	8.52	8.47
D50	5.10	7.79	6.58	5.91	6.04	6.40
D25	3.35	5.54	4.88	3.70	4.08	4.66
D16	2.75	4.60	4.40	3.03	3.44	4.08
				RM 131 (M4)		
D84	6.48	10.82	7.88	8.49	9.98	9.18
D75	5.43	9.81	7.06	6.95	8.50	8.27
D50	4.17	7.96	5.20	4.64	6.64	5.05
D25	2.80	6.58	3.56	2.54	4.68	2.94
D16	2.09	5.60	2.76	1.92	4.15	2.48

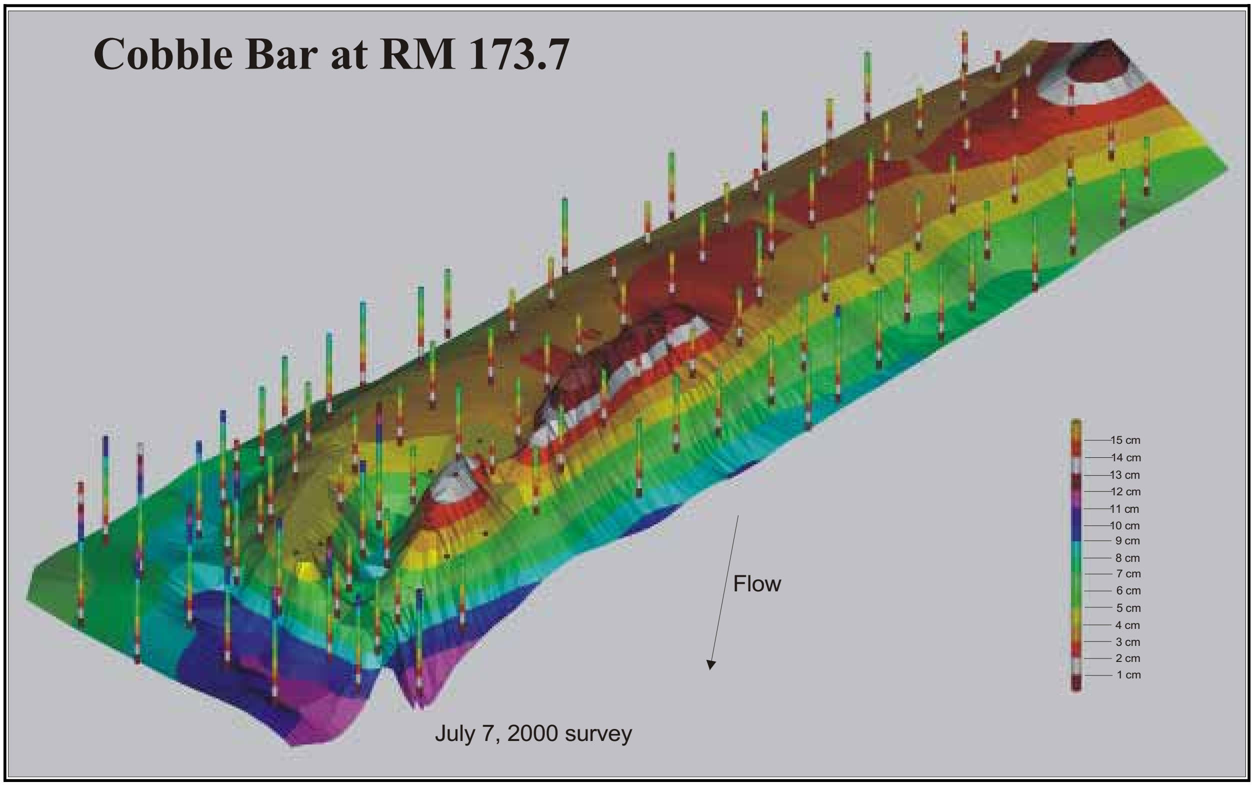


Figure 3.18. July 7, 2000 survey with embeddeness markers.

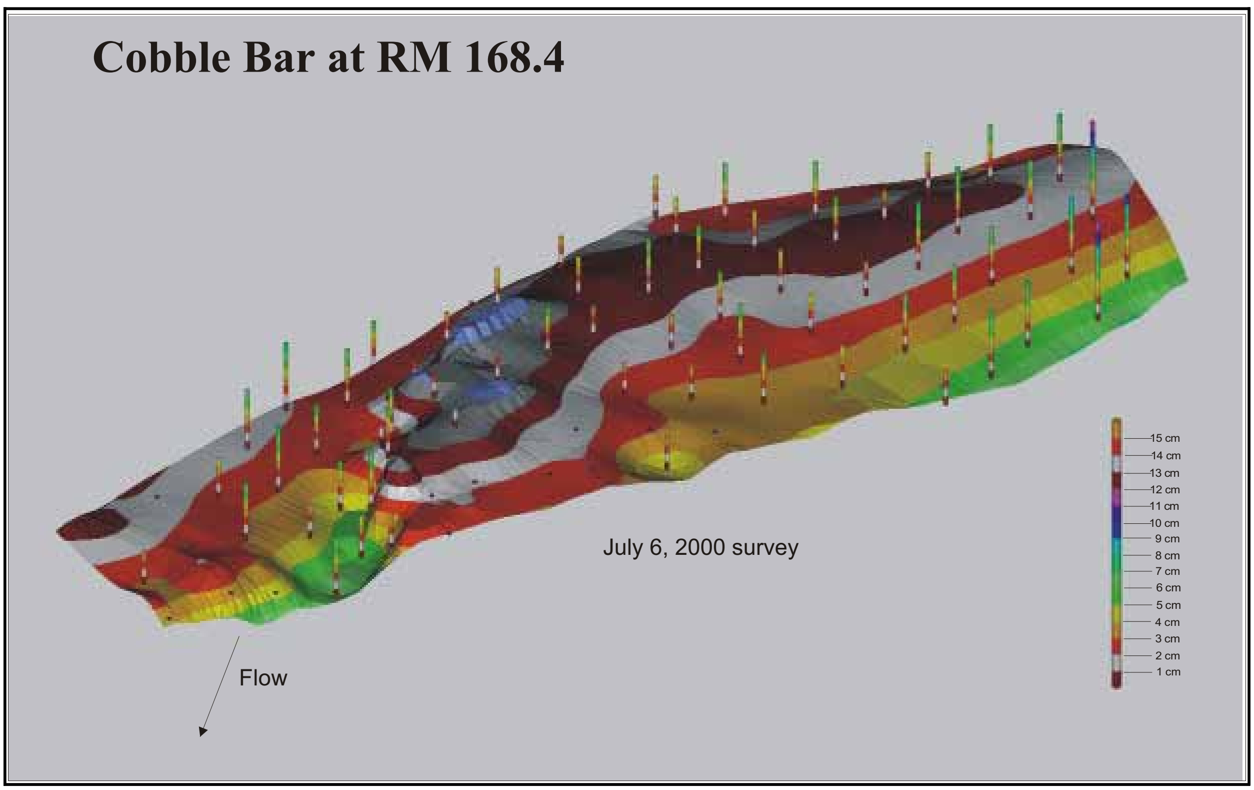


Figure 3.19. July 6, 2000 survey with embeddedness markers.

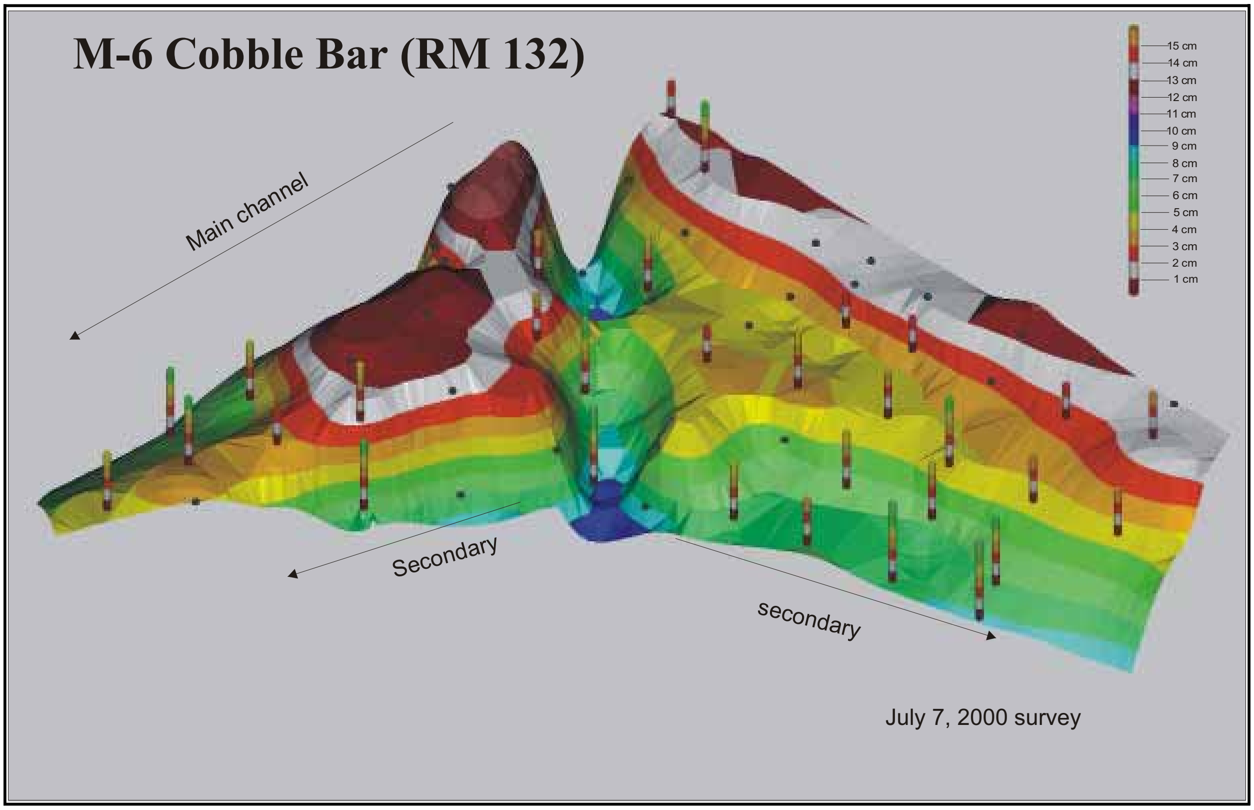


Figure 3.20. July 7, 2000 survey with embeddedness markers.

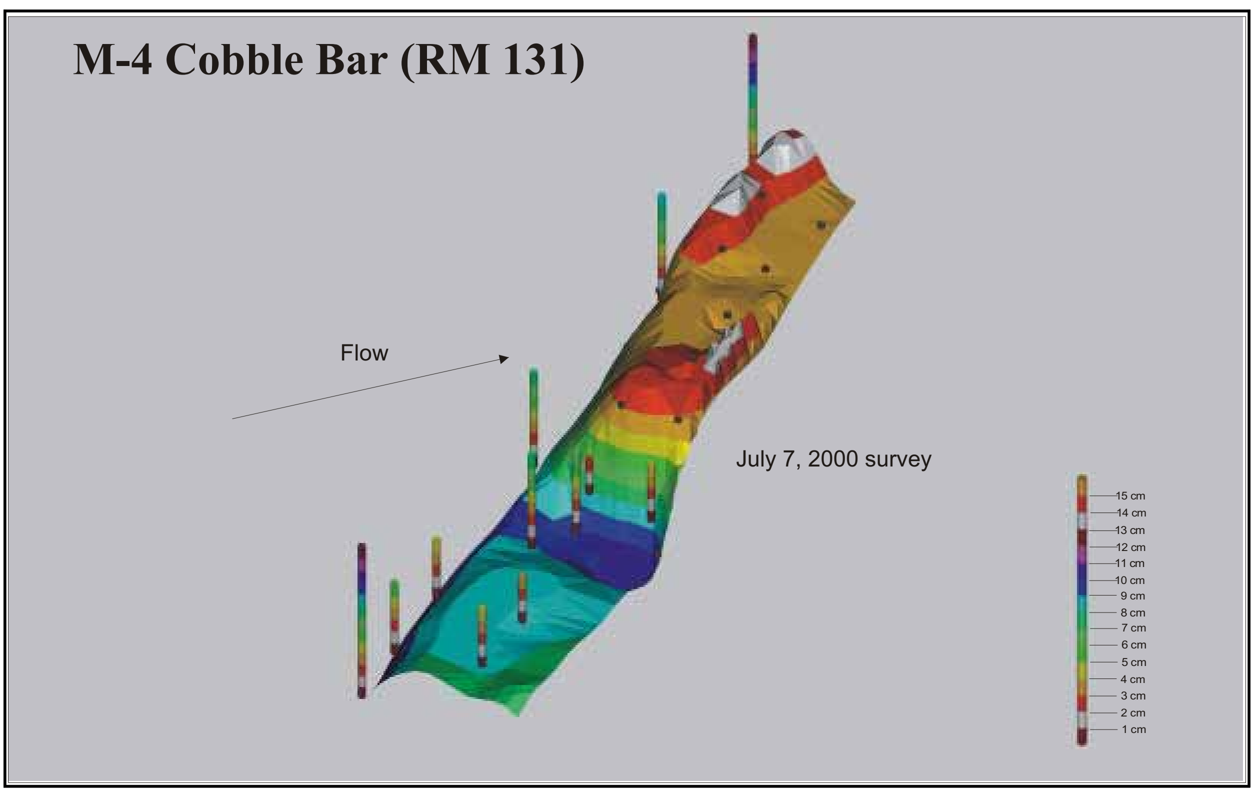


Figure 3.21. July 7, 2000 survey with embeddedness markers.

Figures 3.22 and 3.23 show the frequency distribution of depth of open interstitial space for cobble bar 173.7. The depth is expressed in centimeters in the top plot and as multiples of the d50 cobble size in the bottom plot. Similar data are shown in Figures 3.24 to 3.29 for the cobble bars at 168.4, 132 (M-6) and 131 (M4). The actual area represented by a particular depth of exceedence is shown in Figures 3.30 to 3.33. These figures may be used to put the relative size of the cobble bars in perspective. The cobble bar at 173.7 and 168.4 are over 5,000 m^2 while the bar at 131 (m-4) is only 1,000 m^2. In these plots the area represented by a single reading is the average area which is calculated by dividing the gross area by the number of readings.

Turbidity Monitoring

Turbidity equipment is installed at the USGS gage at Shiprock and at a site near the Montezuma Creek Bridge. The OBS-3 turbidity probe measures the optical properties of the water by emitting an infrared beam of light and measuring the backscatter. The sediment concentration and particle size distributions affect the back scatter. The probes are calibrated to read between 0-3000 NTU's (Nephelometric Turbidity Unit) at Montezuma Creek and 0- 4000 NTU's at Shiprock. The turbidity data collected in1998, 1999 and 2000 are shown plotted with USGS gage flow in Figures 3.34 and 3.35. The missing record at the Montezuma site is due to a data logger malfunction. The logger will be replaced in early 2001.

The turbidity equipment is used to continuously monitor sediment producing events. These events can result in large inflows of sediment that can reduce or eliminate spawning areas of endangered fish. By monitoring these events, reservoir operations the next year may be modified to provide flushing flows in an attempt flush the sediment through the system. These sediment producing events have been defined as storm event days. The definition of a storm event day is flow based. The following algorithm is used to determine Storm Event Days.

The storm event day calculation for Bluff is shown below. The subscripted numbers are day indicators. A 0 represents day 0 (today), -1 represents the previous day (yesterday), +1 represents the following day (tomorrow).

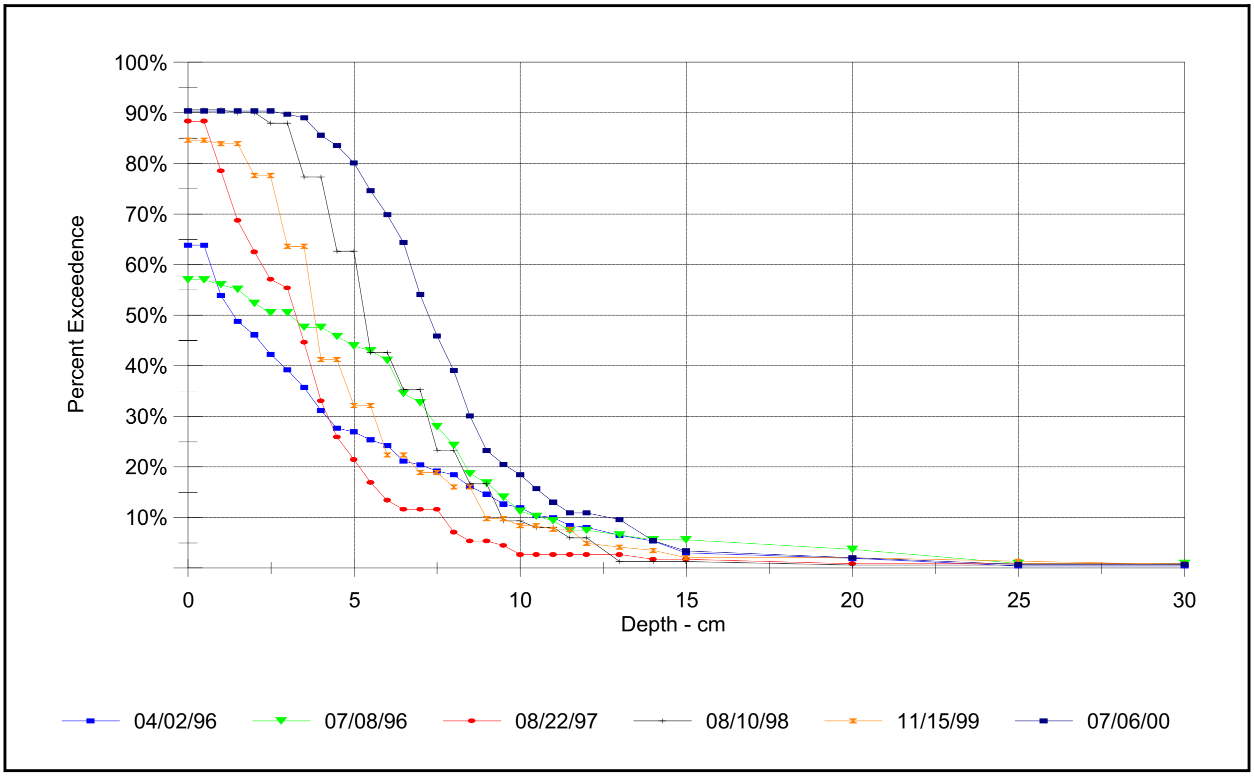


Figure 3.22. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 173.7 expressed in cm.

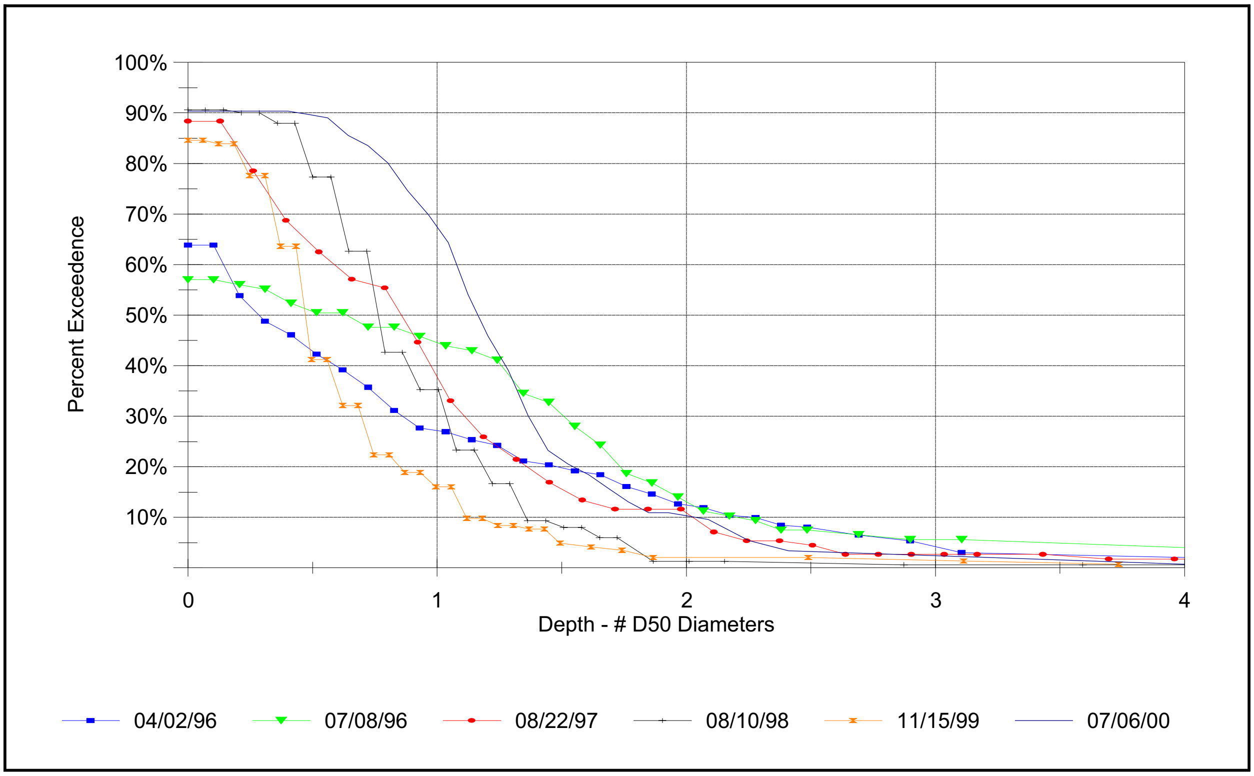


Figure 3.23. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 173.7 expressed in d50 cobble size.

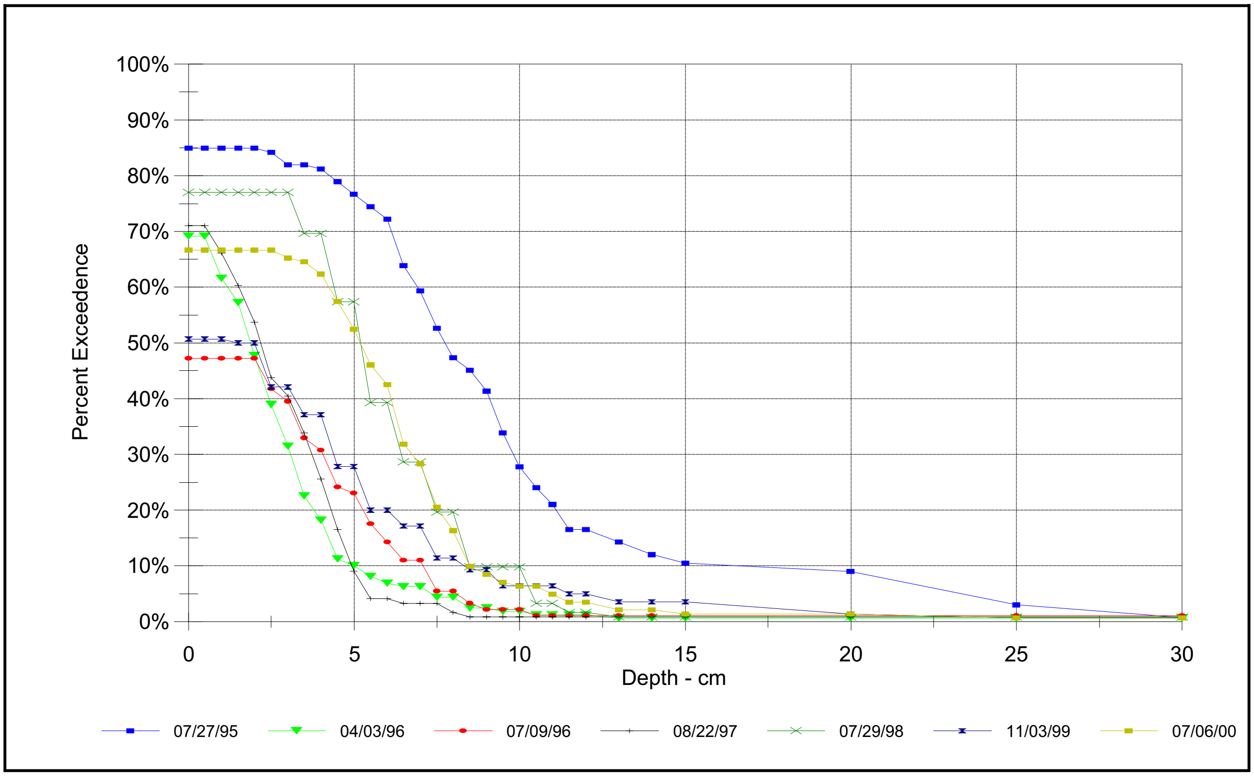


Figure 3.24. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 168.4 expressed in cm.

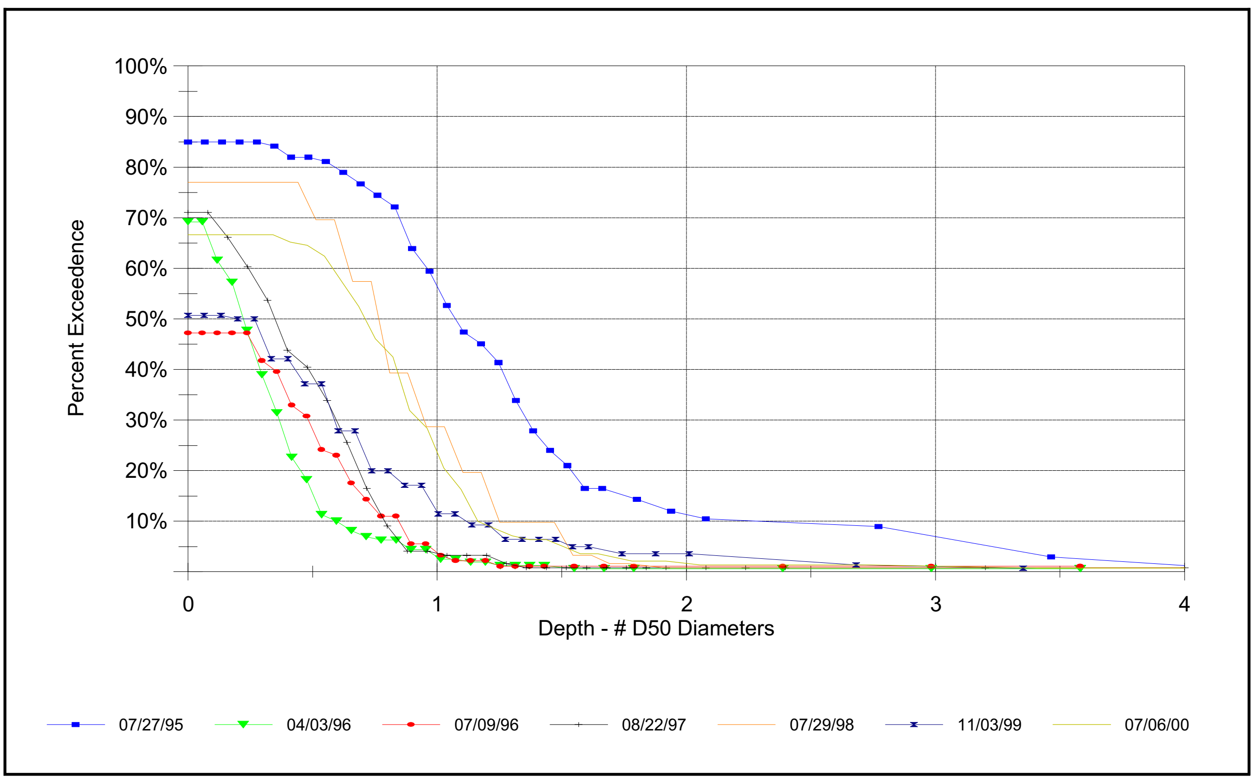


Figure 3.25. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 168.4 expressed in d50 cobble size.

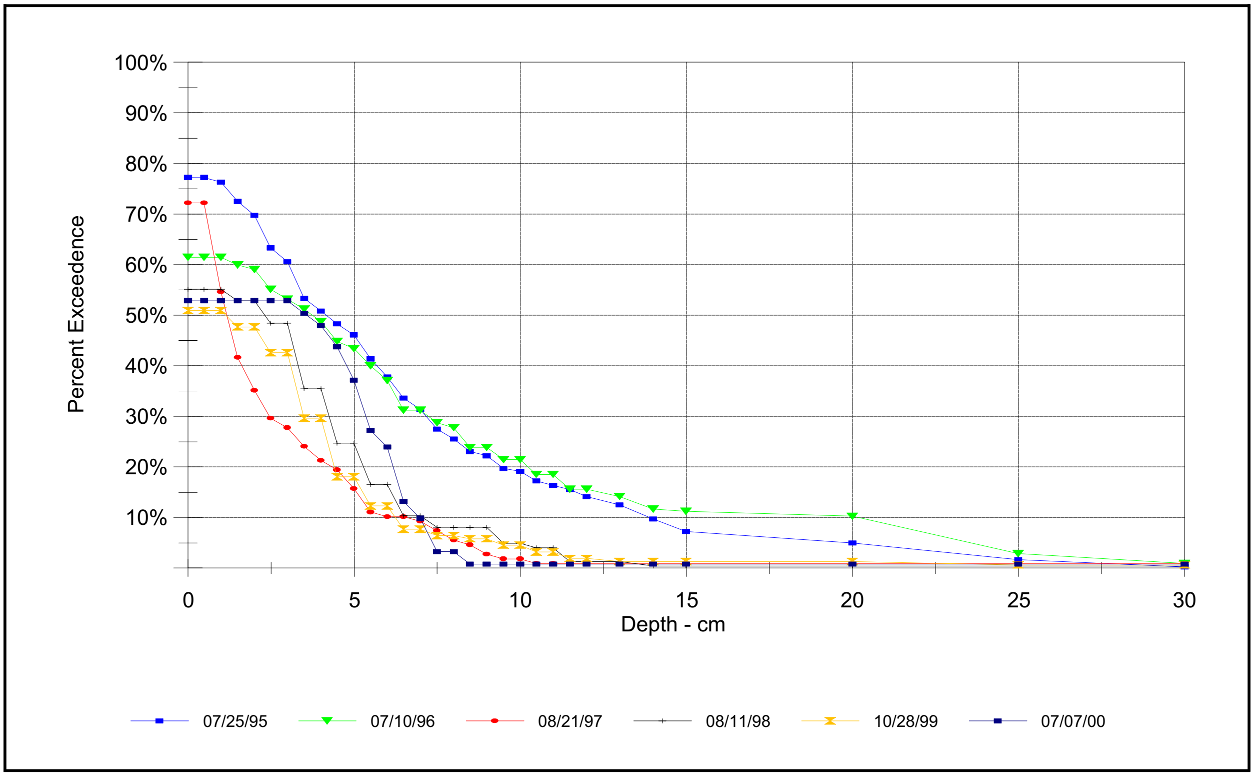


Figure 3.26. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 132 (M-6) expressed in cm.

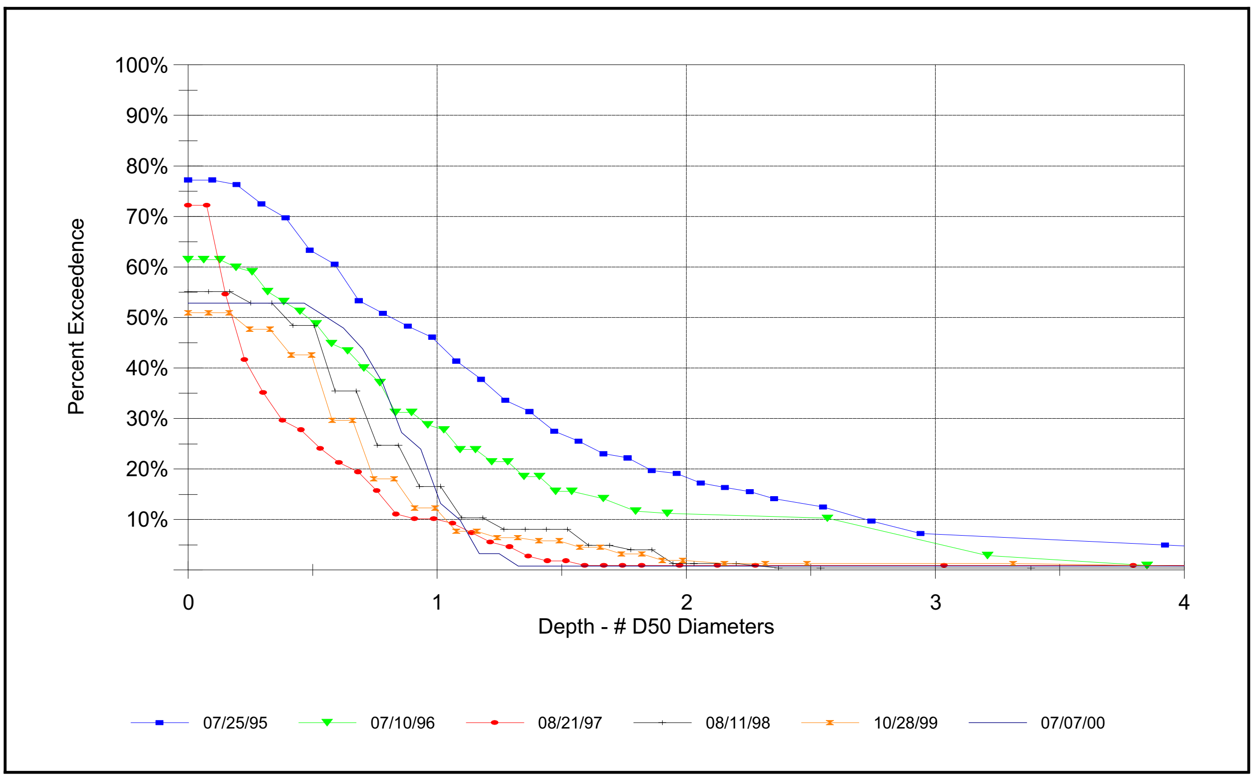


Figure 3.27. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 132 (M-6) expressed in d50 cobble size.

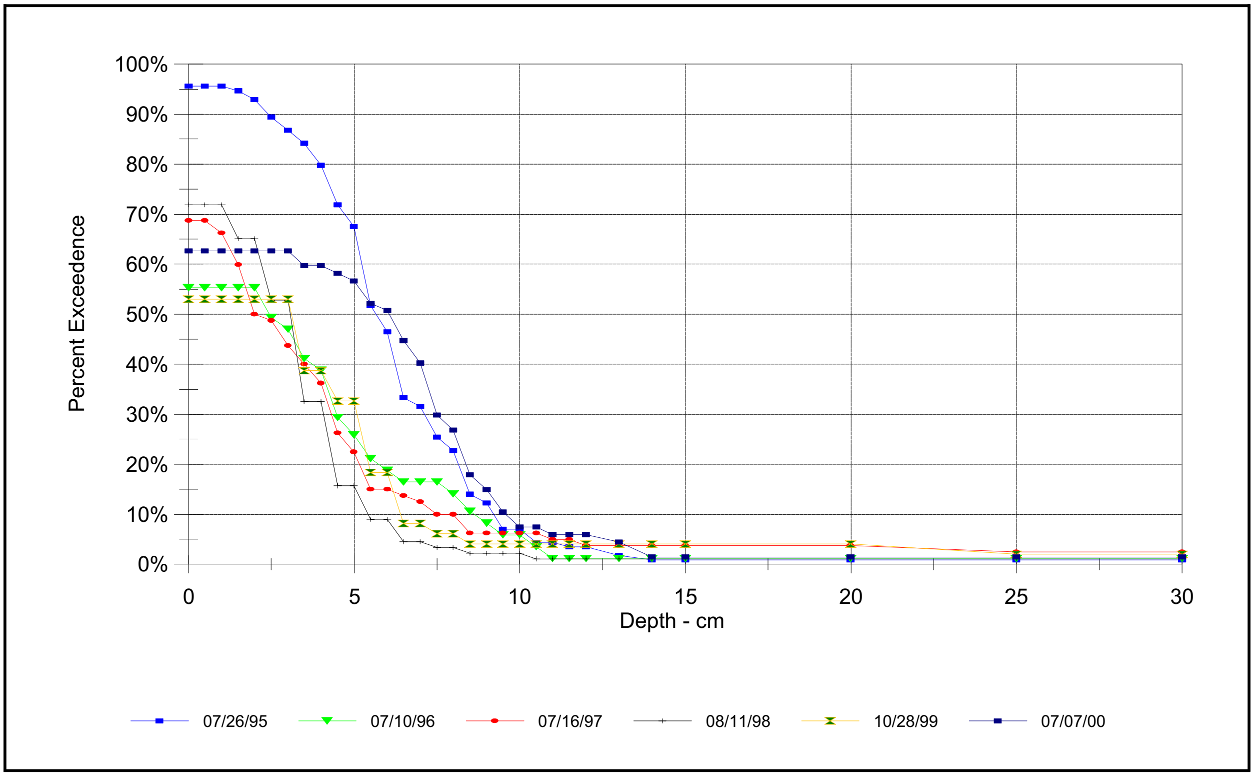


Figure 3.28. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 131 (M-4) expressed in cm.

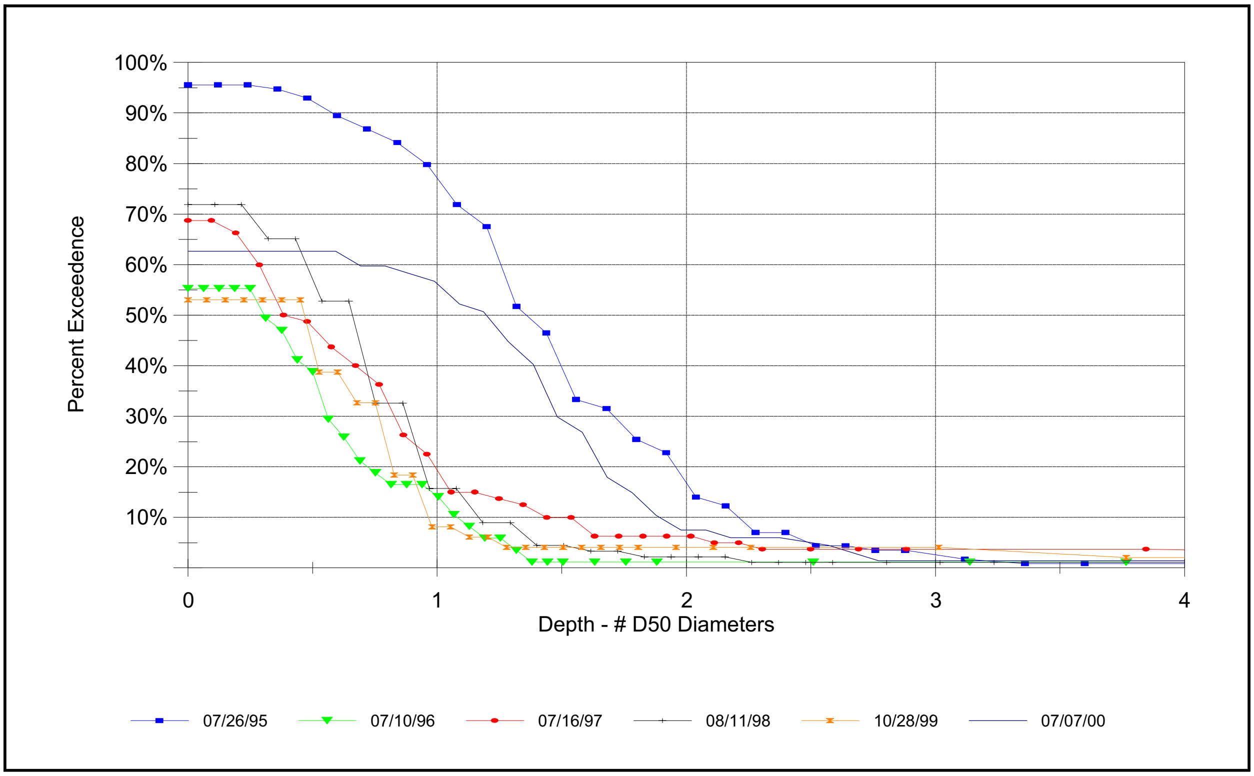


Figure 3.29. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 131 (M-4) expressed in d50 cobble size.

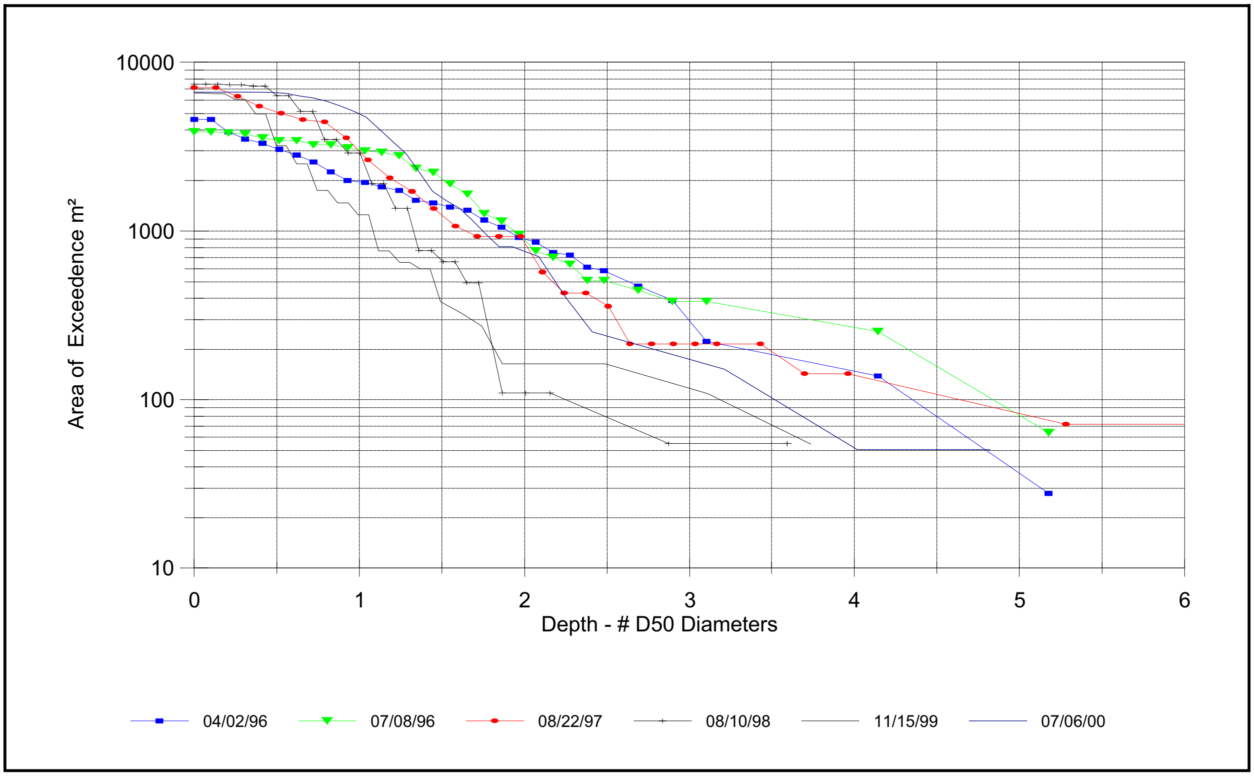


Figure 3.30. Area of Depth of Open Interstitial Space Exceedence for 173.7.

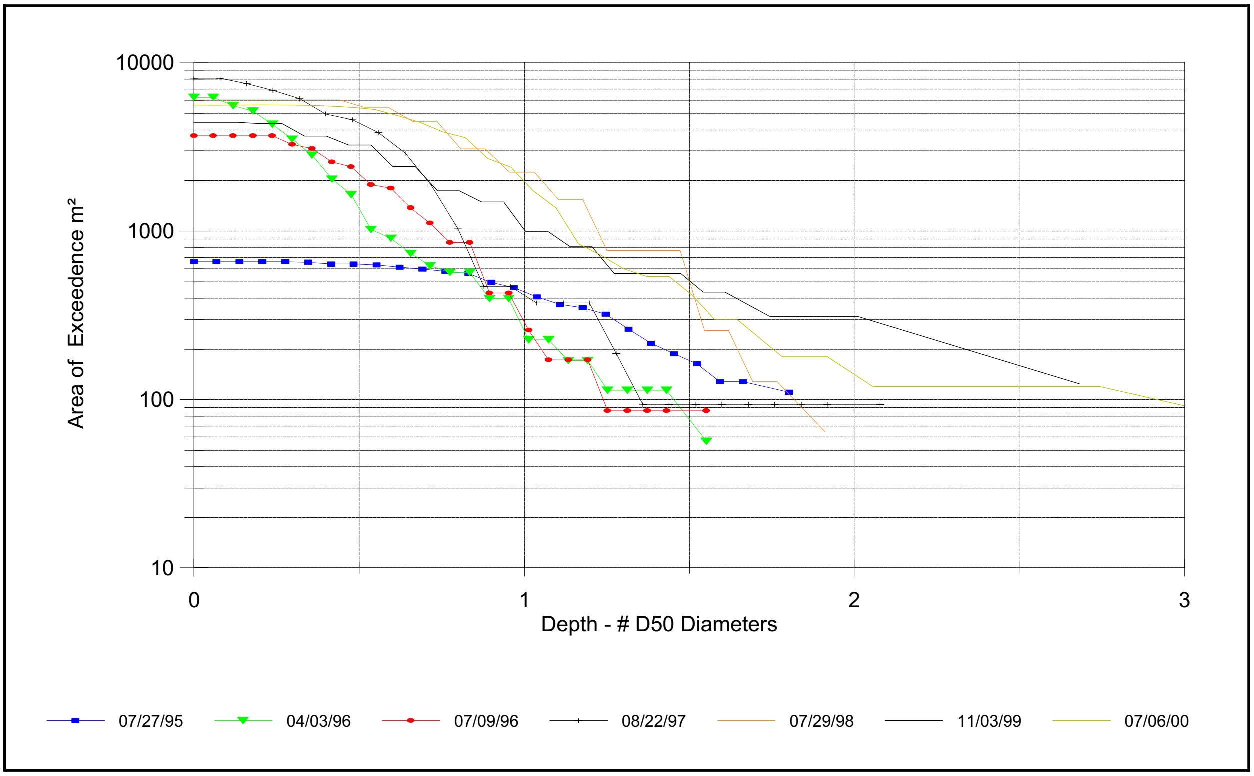


Figure 3.31. Area of Depth of Open Interstitial Space Exceedence for 168.4.

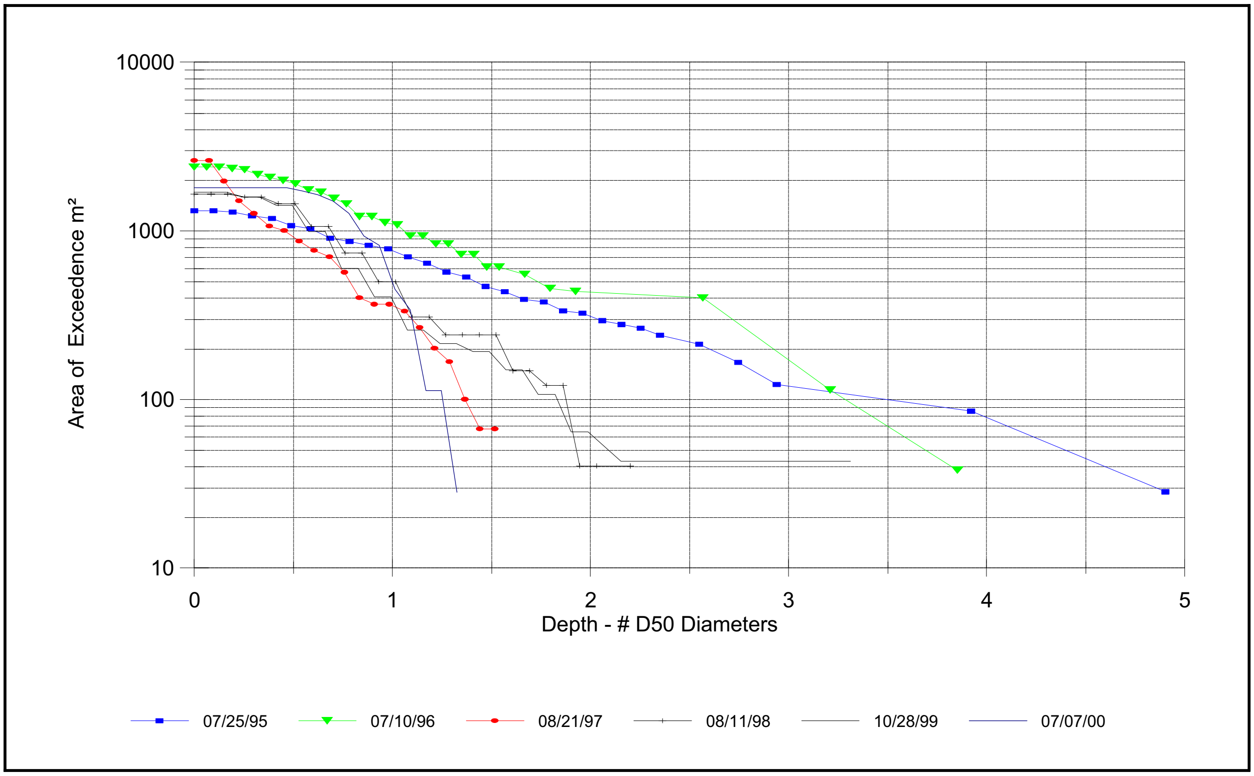


Figure 3.32. Area of Depth of Open Interstitial Space Exceedence for 132 (M-6).

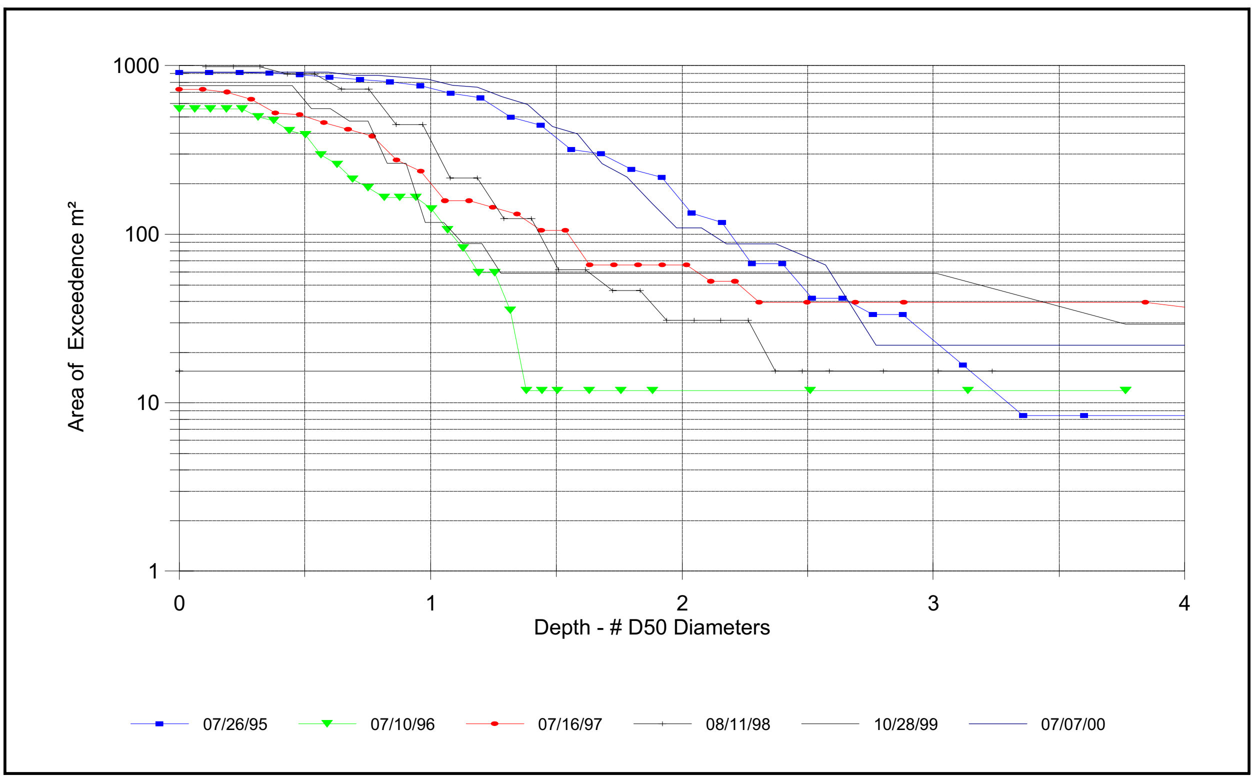


Figure 3.33. Area of Depth of Open Interstitial Space Exceedence for 131 (M-4).

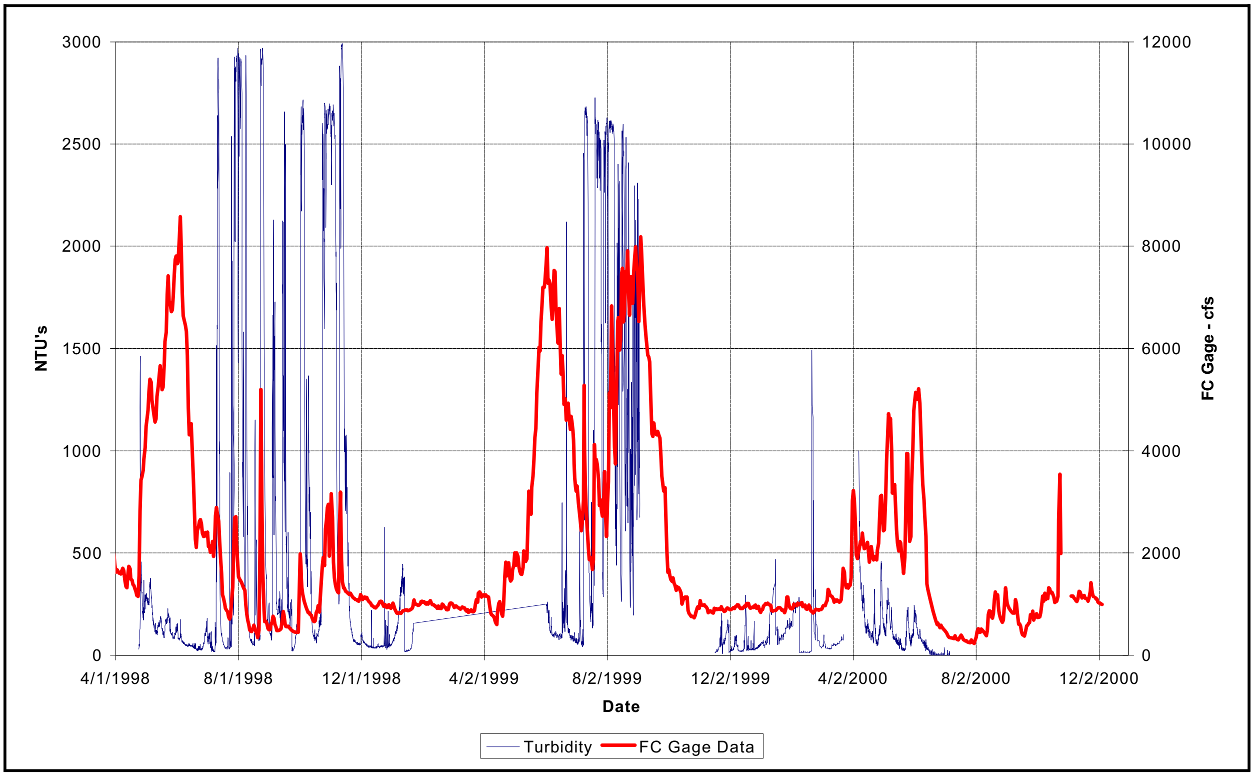


Figure 3.34 Montezuma Creek Turbidity Data and Four Corners Gage Flow

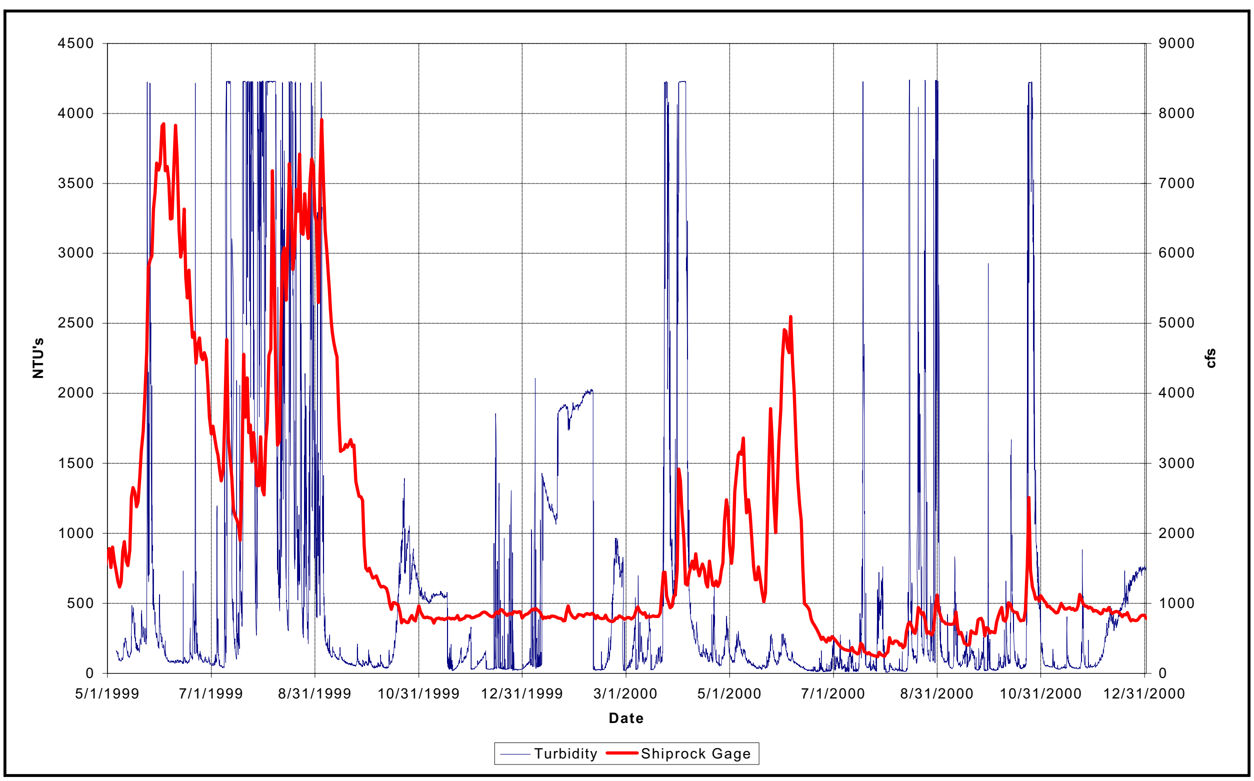


Figure 3.35. Shiprock Turbidity Data and Shiprock Gage Flow

$Gain_0 = Bluff_0 - Animas_{-1} - Archuleta_{-2}$

If [$Gain_0 - AverageGain_{(-2, -1, 0, 1, 2)} > 150$ cfs]

Then If [$Bluff_0 - AverageBluff_{(-2, -1, 0, 1, 2)} > 150$ cfs]

Then If [$Gain_0 - AverageGain_{(-2, -1, 0, 1, 2)} > 3000$ cfs]

Storm Event Day Flag = 2

Storm Event Day Flag =1

Storm Event Day Flag = 0

Storm Event Day Flag = 0

Where,

$Gain_0$ = The flow gain in cfs between Archuleta and Bluff.

$Bluff_0$ = The flow at Bluff today

$Animas_{-1}$ = The Animas contribution to the San Juan in cfs yesterday.

$Archuleta_{-2}$ = The flow at Archuleta two days ago in cfs.

$AverageGain_{(-2, -1, 0, 1, 2)}$ = The average gain over a 5-day period.

$AverageBluff_{(-2, -1, 0, 1, 2)}$ = The average flow at Bluff over a 5-day period.

The above algorithm may be described as follows. The gain in flow between Bluff and Archuleta is determined after subtracting the Animas contribution. All other tributaries are ignored. The flow of the Animas is lagged one day and the flow at Archuleta is lagged two days. If this average gain is more than 150 cfs than the 5-day average and the average flow at Bluff is more than 150 cfs than the 5-day average, the day is flagged a storm event day. If the Gain is greater than 3,000 cfs, the day is given extra weight and counted as two days. A perturbating year is determined by summing the storm event days between July 25 and the end of February. If the number of storm event days is greater than 12 then the year is flagged as a perturbating year and additional flushing releases from Navajo may be necessary the following season.

The 1999 Annual Monitoring Report described an analysis that estimated the average daily turbidity that could be used to estimate storm event days and produce similar results to the flow based algorithm described in the previous paragraph. This analysis determined that 2600 NTU's was a good approximation. The Shiprock turbidity data was used to determine that there were 6-days where the average daily turbidity was greater than or equal to 2600 NTU's between July 25, 2000 and December 31, 2000. The flow based calculation produced 8-days. Four of these days are concurrent or within 1-day. The results are summarized in Table 3.6.

Table 3.6. Flow based Sediment Event Days and Turbidity based Sediment Days.

Year	Days > 2600 NTU's	Flow Based Sediment Event Days	Concurrent Days*
1999	6	8	4

* Concurrent or with 1-day

CHAPTER 4. WATER QUALITY

METHODS

Water Temperature

Nine temperature recorders were originally installed in the San Juan and Animas rivers in July and August of 1992 at the locations shown in Table 4.1. Each station consisted of a temperature sensor, lead wires and an OMNIDATA DP-230 data pod. The temperature was sampled every 10 minutes and stored every 24 hours as a maximum, minimum and mean temperature for the day. Table 2.2 also shows the periods of record at each site. The missing data were caused by equipment problems. Due to equipment problems and other maintenance challenges, the temperature recorders were replaced in July 1999 with the Optic StowAway temperature loggers. These are manufactured by Onset Computer Corporation and are factory sealed, submersible units that communicate via an optic interface. The temperature sensor is embedded in the body of the unit, eliminating any external wires. Water temperature is currently recorded every 15-minutes. The "in place" phrase in Table 4.1 indicates that StowAway's are monitoring temperature at the indicated sites.

Water Chemistry

Twelve water quality monitoring sites (Table 4.2) were identified as necessary to characterize water quality in the San Juan River and key tributaries. Sampling interval are quarterly (trimonthly) in February, May, August, and November. This temporal spacing was adopted to ensure water sampling occurs during spring runoff in the upper portion of the San Juan River basin and during winter base flows.

Chemical analyses performed are listed in Table 4.3. Parameters listed in left column were measured quarterly. In addition, field measurements of water temperature, pH, redox potential, specific conductance, and dissolved oxygen were made. Annually, during low-flow periods in February, water samples were analyzed for all parameters listed in Table 4.3.

RESULTS

Water Temperature

The plot of the 2000 StowAway temperature data is shown in Figure 4.1. Maximum, minimum and average plots are shown for Archuleta and Montezuma Creek in Figures 4.2 and 4.3. The new equipment is operating well and is providing a more consistent and reliable record.

Table 4.1. Water temperature monitoring locations and period of record.

Location	RM	Period of Record
Near Navajo Dam	225	7/9/1999 to 12/31/00 (in place)
Archuleta - San Juan at USGS Gage Location	218.6	7/23/92 to 12/31/00 (in place)
Blanco - San Juan at US-64 Bridge	207.1	8/7/92 to 2/28/95 (missing 11/21 - 12/9/92)
Bloomfield - San Juan at Highway 44 Bridge	195.6	2/27/93 to 7/17/98
Lee Acres - San Juan at Lee Acres Bridge	188.9	8/8/92 to 12/2/92, 2/26/93 to 4/15/93, 5/27/93 to 9/6/94, 3/9/95 to 10/10/95
Farmington - San Juan at USGS Gage Location	180.1	8/5/92 to 1/16/96, 7/8/99 to 12/31/00 (in place)
Shiprock - San Juan at USGS Gage Location	148.0	7/8/99 to 12/31/00 (in place)
Four Corners - San Juan at USGS Gage Location	119.4	10/7/94 to 3/11/96*, 7/9/99 to 12/31/00 (in place)
Montezuma Creek - San Juan at Montezuma Creek Bridge	93.6	8/9/92 to 1/11/93, 2/25 to 3/14/93, 4/14 to 5/10/93, 5/28/93 to 12/31/00 (in place)
Mexican Hat - San Juan near Bluff Gage Location	52.1	7/9/99 to 12/31/00 (in place but not submerged in late 2000)
Cedar Hill - Animas at USGS Gage nr Cedar Hill	n/a	8/7/92 to 9/22/98
Farmington - Animas at USGS Gage Location	n/a	8/5/92 to 4/14/97, 5/7/97 to 8/26/97, 10/15/97 to 6/4/98, 7/8/99 to 12/31/00 (in place)
USGS Data - San Juan at Archuleta	218.6	10/1/50 - 9/30/68 with some missing data
USGS Data - San Juan at Shiprock	148.0	10/1/51 - 9/30/86,9/7/91 - 3/3/93 with some missing data
USGS Data - Animas	n/a	10/1/52 - 9/30/90 with some missing data

Note all locations missing October 1992 data
* installed 8/10/92 but bad data was logged until thermistor was changed in October 1994. Prior to this time it was thought sediment accumulation was causing the warmer readings instead of bad thermistor.

Table 4.2. San Juan River water quality monitoring sites.

Station Name	USGS ID	USGS Record	BIA Record
San Juan River near Archuleta Bridge	9355500	1958 -1984	1991-2000
Animas River @ Farmington	9364500	1958 -1992	1991-2000
San Juan River @ Farmington	9365000	1974 -1991	1991-2000
LaPlata River near Farmington	9367500	1977-1991	1994-2000
San Juan River @ Shiprock	9368000	1958 -1992	1991-2000
Mancos River near Four Corners	9371005		1991-2000
San Juan River @ Four Corners	9371010	1977-1990	1991-2000
San Juan River @ Montezuma Creek	9378610		1991-2000
San Juan River @ Bluff	9379495		1991-2000
San Juan River near Bluff (@ Mex. Hat)	9379500	1974 -1993	1991-2000

Table 4.3. San Juan River Monitoring Program water quality parameters.

Quarterly	Detection	Annually	Detection
Arsenic (total & dissolved)	*0.5 µg/L*	Aluminum (total & dissolved)	*0.2 mg/L*
Calcium (dissolved)	*0.2 mg/L*	Barium (total & dissolved)	*20 µ g/L*
Copper (total & dissolved)	*0.5 µg/L*	Manganese (total & dissolved)	*30 µ g/L*
Lead (total & dissolved)	*40 µg/L*	Nickel (total & dissolved)	*50 µ g/L*
Magnesium (dissolved)	*0.2 mg/L*	Potassium (total & dissolved)	*2 mg/L*
Mercury (total & dissolved)	*0.2µ g/L*	Strontium (total & dissolved)	*50 µ g/L*
Sodium (dissolved)	*2 mg/L*	Orthophosphate (total & dissolved)	*5 mg/L*
Selenium (total, dissolved, & total recoverable)	*1 µ g/L*	Chloride (dissolved)	*10 mg/L*
Zinc (total & dissolved)	*10 µ g/L*	Ammonia (dissolved)	*50 µ g/L*
Alkalinity (HCO_3)	*2 mg/L*	Nitrate (dissolved)	*20 µ g/L*
Hardness	*1 mg/L*	Nitrite (dissolved)	*10 µ g/L*
TDS	*10 mg/L*	Silica (total & dissolved)	*1 mg/L*
TSS	*5 mg/L*	Sulfate (dissolved)	*100 mg/L*
Turbidity	*0.1 NTU*		

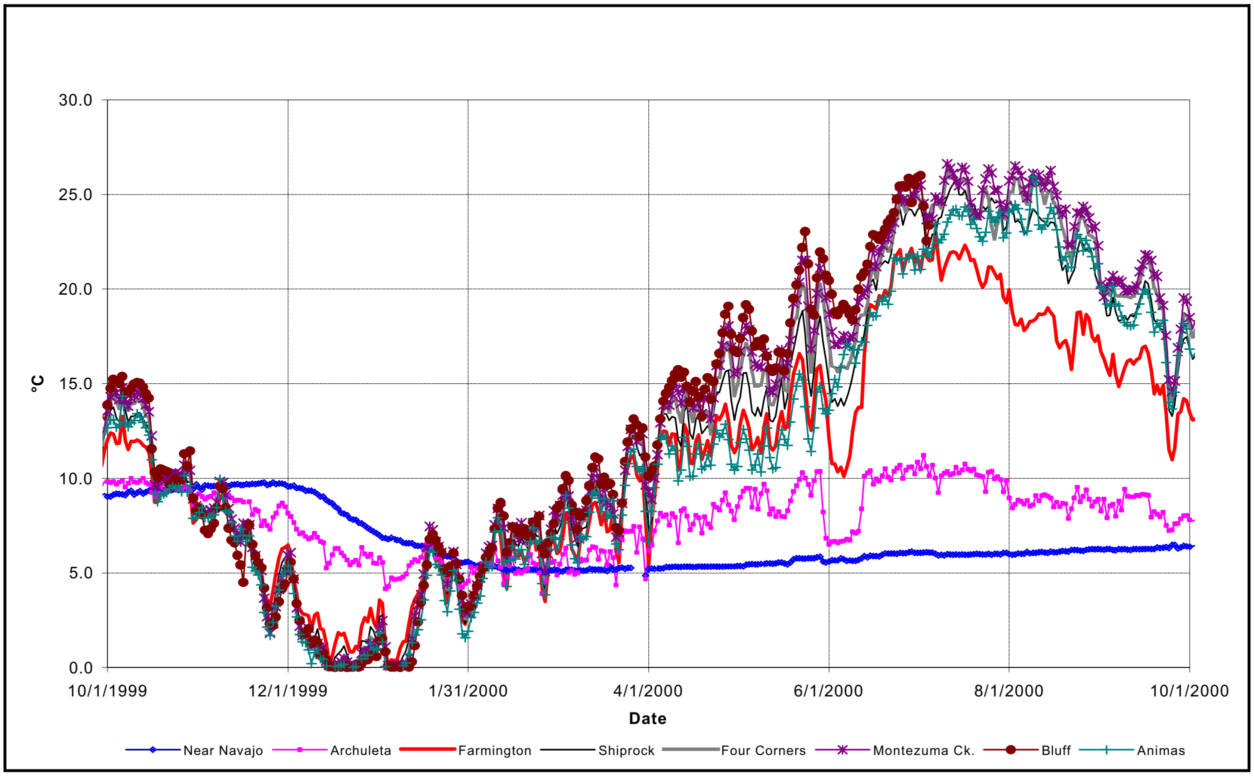


Figure 4.1. San Juan Basin Average Water Temperature Data

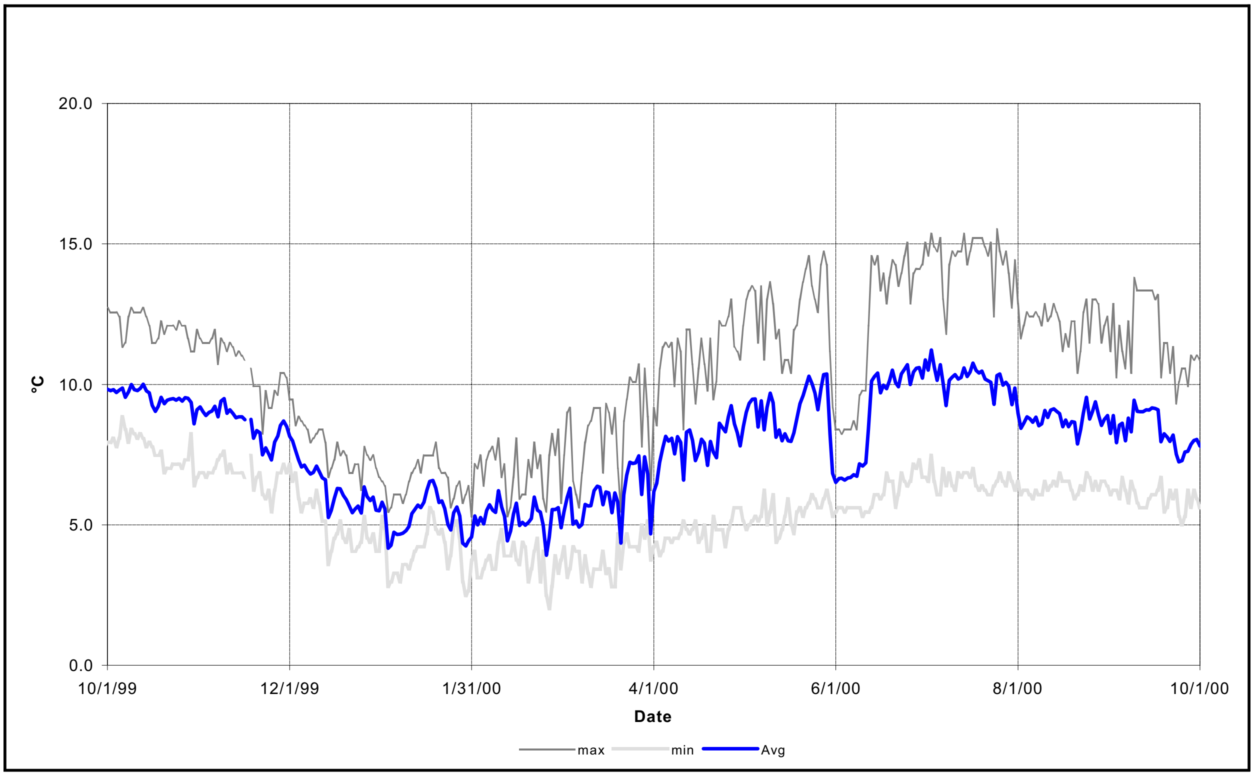


Figure 4.2 Archuleta Maximum, Minimum and Average Water Temperatures

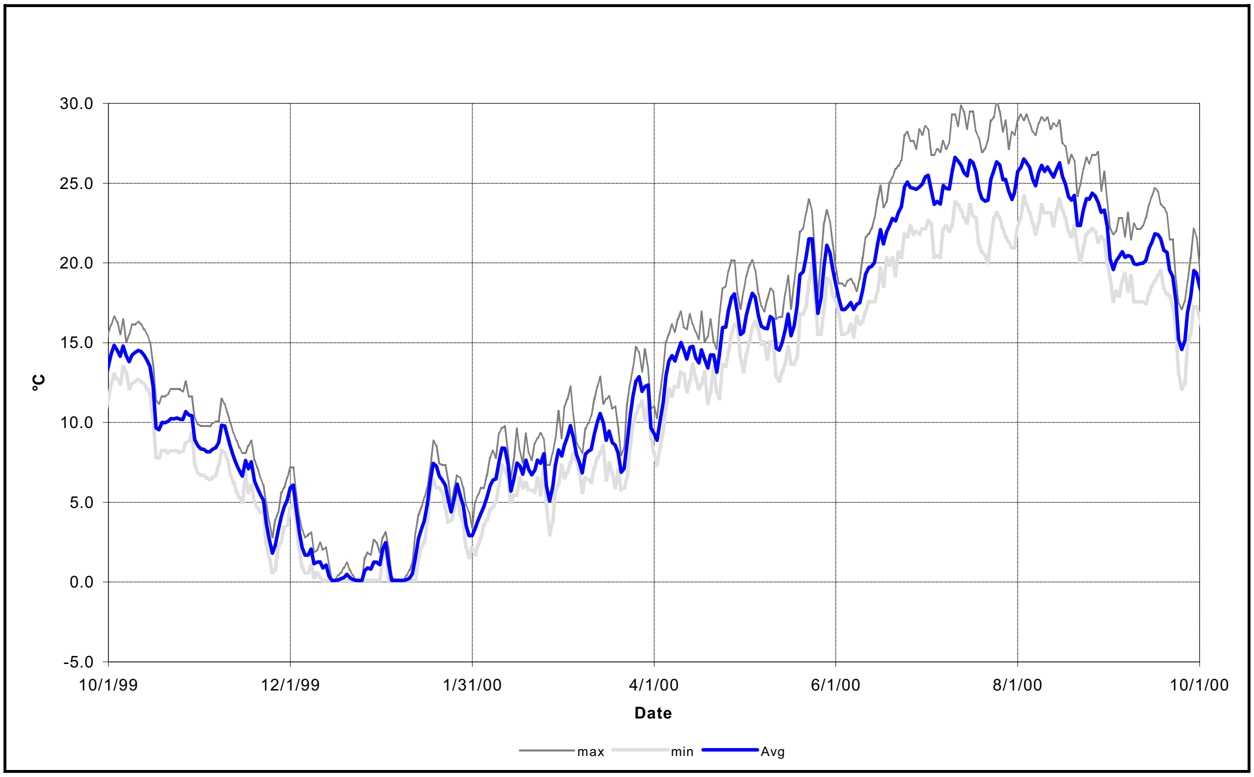


Figure 4.3 Montezuma Creek Maximum, Minimum and Average Water Temperatures.

Water Chemistry

Tables 4.4 through 4.13 summarize the water quality data for the 10 permanent stations, comparing the 1994 -1999 statistics to those for 2000. In each case the minimum, maximum, mean and standard deviation is given for each parameter in Table 4.3. When values fall below detection, they are shown at ½ detection limit.

Table 4.4. Water chemistry data for San Juan River at Archuleta Bridge

San Juan River at Archuleta Bridge	1994-1999					2000				
Parameter	N of cases	Minimum	Maximum	Mean	Standard Dev	N of cases	Minimum	Maximum	Mean	Standard Dev
Bicarbonate (mg/l)	35	43	99	74.2	9.6	4	68	74	70.5	3
Alkalinity (mg/l)	35	43	99	74.6	9.7	4	68	76	72.5	3.4
Arsenic dissolved (µg/l)	63	0.3	2.5	1.9	0.8	4	0.3	1.5	0.8	0.5
Arsenic total (µg/l)	63	0.5	642	12.5	80.6	4	0.5	0.5	0.5	0
Calcium dissolved (mg/l)	35	25.1	33.6	29.2	2.5	4	26.4	28.5	27.4	1.2
Copper dissolved (µg/l)	35	1	21	3.7	3.5	4	0.9	1.5	1.3	0.3
Copper total (µg/l)	35	1	41	7.4	9.9	4	2	4	2.5	1
Hardness ((mg/l)	35	83	112	96.1	8.2	4	86	93	89.3	3.3
Mercury dissolved (µg/l)	63	0.1	0.5	0.1	0.1	4	0.1	0.1	0.1	0
Mercury total (µg/l)	63	0.1	0.1	0.1	0	4	0.1	0.1	0.1	0
Magnesium dissolved (mg/l)	35	4.9	6.9	5.6	0.5	4	4.9	5.3	5.1	0.2
Sodium dissolved (mg/l)	12	10.7	15.3	12.8	1.3	4	11.4	12.5	12.1	0.5
Lead dissolved (µg/l)	63	0.1	5.7	0.6	0.9	4	0.1	0.3	0.1	0.1
Lead total (µg/l)	63	0.1	19.2	1.3	2.6	4	0.1	0.5	0.2	0.2
Selenium dissolved (µg/l)	63	0.5	0.5	0.5	0	4	0.5	0.5	0.5	0
Selenium total (µg/l)	63	0.5	3	0.6	0.3	4	0.5	0.5	0.5	0
Selenium total recoverable (µg/l)	13	0.5	0.5	0.5	0	4	0.5	0.5	0.5	0
Total dissolved solids (mg/l)	33	90	280	160	39.7	4	120	150	130	14.1
Total suspended solids (mg/l)	62	1	57	9	10.1	4	2.5	2.5	2.5	0
Turbidity (NTU)	60	0	33	5.9	5.3	4	1.3	6	3	2.1
Zinc dissolved (µg/l)	63	5	70	7.2	8.9	4	5	20	13.8	7.5
Zinc total (µg/l)	63	5	360	26.3	53.3	4	5	10	8.8	2.5
Temperature (°C)	63	3.4	19.9	8.1	2.9	4	6.3	10.1	8	1.8
pH	63	7.2	9	8.2	0.4	4	7.5	9.1	8.4	0.6
Conductance (µmhos/cm)	63	200	1210	250	124.8	4	200	220	210	7.9
Redox Potential (mv)	63	223	527	379	71	4	257	455	392	90.9
Oxygen dissolved (mg/l)	62	5.4	14.3	10.5	1.5	4	10.1	12.4	10.8	1.1

Table 4.5. Water Chemistry data for Animas River at Farmington

Animas River at Farmington	1994-1999					2000				
Parameter	N of cases	Minimum	Maximum	Mean	Standard Dev	N of cases	Minimum	Maximum	Mean	Standard Dev
Bicarbonate (mg/l)	34	43	171	118	34.2	4	70	177	139	48.7
Alkalinity (mg/l)	34	43	171	118.7	34.4	4	70	177	139	48.7
Arsenic dissolved (µg/l)	63	0.3	2.5	1.9	0.8	4	0.3	1	0.7	0.4
Arsenic total (µg/l)	63	0.5	13	2.6	1.8	4	0.5	2	1.1	0.8
Calcium dissolved (mg/l)	34	27.6	101	68.9	22.1	4	36.8	103	84	31.7
Copper dissolved (µg/l)	34	1	9	3.9	2.1	4	1.4	4.2	2.3	1.3
Copper total (µg/l)	34	1.5	68	14	14.4	4	3	33	12.5	13.9
Hardness ((mg/l)	34	85	319	218.5	72.3	4	114	317	260.8	98.2
Mercury dissolved (µg/l)	63	0.1	0.1	0.1	0	4	0.1	0.1	0.1	0
Mercury total (µg/l)	63	0.1	0.9	0.1	0.1	4	0.1	0.1	0.1	0
Magnesium dissolved (mg/l)	34	3.8	19.2	11.3	4.2	4	5.3	15.6	12.3	4.7
Sodium dissolved (mg/l)	11	6	37.7	24.5	11.1	4	8	40.9	29.7	14.9
Lead dissolved (µg/l)	63	0.1	4.5	0.5	0.6	4	0.2	0.7	0.3	0.3
Lead total (µg/l)	63	0.5	80	14.1	18.7	4	0.6	55.7	16.9	26.2
Selenium dissolved (µg/l)	63	0.5	3	0.6	0.3	4	0.5	1	0.6	0.3
Selenium total (µg/l)	63	0.5	4	0.6	0.5	4	0.5	0.5	0.5	0
Selenium total recoverable (µg/l)	13	0.5	1	0.5	0.1	4	0.5	0.5	0.5	0
Total dissolved solids (mg/l)	33	110	520	321.8	121.8	4	150	480	380	154.3
Total suspended solids (mg/l)	62	1	2170	140.3	321.1	4	8	276	125.5	131.8
Turbidity (NTU)	60	0.9	1240	72.5	189.4	4	2.1	1030	270.8	506.4
Zinc dissolved (µg/l)	63	5	40	9.6	7.3	4	10	30	20	8.2
Zinc total (µg/l)	63	5	430	86.7	84.8	4	30	290	105	124.8
Temperature (°C)	63	-0.2	27.3	11.5	6.9	4	3.3	22.2	12.4	8.5
pH	63	7.5	8.9	8.2	0.3	4	7.9	8.3	8.1	0.2
Conductance (µmhos/cm)	63	200	970	550	181	4	250	750	590	225.8
Redox Potential (mv)	63	253	545	396	65.2	4	341	480	423	63.1
Oxygen dissolved (mg/l)	62	3.7	13.2	9.5	2.1	4	6.9	12.3	9.5	2.3

Table 4.6. Water Chemistry data for San Juan River at Farmington Bridge

San Juan River at Farmington Bridge	1994-1999					2000				
Parameter	N of cases	Minimum	Maximum	Mean	Standard Dev	N of cases	Minimum	Maximum	Mean	Standard Dev
Bicarbonate (mg/l)	33	49	143	102.6	22.2	4	77	110	99	15.3
Alkalinity (mg/l)	33	49	143	102.9	21.8	4	77	110	99	15.3
Arsenic dissolved (µg/l)	63	0.3	5	2	0.9	4	0.3	1.5	0.8	0.6
Arsenic total (µg/l)	63	0.5	7	2.5	1.2	4	0.5	4	1.9	1.5
Calcium dissolved (mg/l)	33	28.8	83.5	53.7	14.9	4	38.4	58.2	51.2	8.9
Copper dissolved (µg/l)	33	1	10	3.9	2.4	4	0.8	3.6	1.9	1.2
Copper total (µg/l)	33	2.5	50	15.7	12.2	4	3	32	15.3	14.6
Hardness ((mg/l)	33	91	265	170.1	47	4	119	183	159	27.8
Mercury dissolved (µg/l)	63	0.1	0.2	0.1	0	4	0.1	0.1	0.1	0
Mercury total (µg/l)	63	0.1	0.2	0.1	0	4	0.1	0.1	0.1	0
Magnesium dissolved (mg/l)	33	4.6	13.9	8.7	2.4	4	5.6	9.1	7.6	1.6
Sodium dissolved (mg/l)	10	12.2	46.7	32.3	10.2	4	13.4	37.1	29.3	10.9
Lead dissolved (µg/l)	63	0.1	4	0.5	0.6	4	0.1	0.6	0.3	0.3
Lead total (µg/l)	63	0.5	105	11.6	16	4	1.1	49.8	18.1	22.8
Selenium dissolved (µg/l)	63	0.5	2	0.6	0.2	4	0.5	0.5	0.5	0
Selenium total (µg/l)	63	0.5	2.5	0.6	0.3	4	0.5	0.5	0.5	0
Selenium total recoverable (µg/l)	13	0.5	0.5	0.5	0	4	0.5	0.5	0.5	0
Total dissolved solids (mg/l)	33	140	450	290	84.3	4	180	300	265	56.9
Total suspended solids (mg/l)	62	2.5	2660	239.7	387.1	4	22	1070	332.5	499.8
Turbidity (NTU)	60	2.5	1880	106	256.8	4	11.2	7400	1866.5	3689
Zinc dissolved (µg/l)	63	5	30	7.5	5.7	4	5	20	13.8	7.5
Zinc total (µg/l)	63	5	320	61.8	52.9	4	10	260	95	115.6
Temperature (°C)	63	-0.3	24.3	10.5	6.2	4	1.3	20.7	11.7	8.9
pH	63	7.2	8.8	8.1	0.3	4	7.8	8.3	8	0.3
Conductance (µmhos/cm)	63	200	700	430	118.9	4	290	620	520	152.4
Redox Potential (mv)	63	252	535	402	60.3	4	352	457	423	49.6
Oxygen dissolved (mg/l)	62	0	12.5	8.9	2.2	4	6.9	12.1	9.1	2.3

Table 4.7. Water chemistry data for La Plata River near Farmington

La Plata River near Farmington	1994-1999					2000				
Parameter	N of cases	Minimum	Maximum	Mean	Standard Dev	N of cases	Minimum	Maximum	Mean	Standard Dev
Bicarbonate (mg/l)	25	111	370	231.6	55.2	2	246	250	248	2.8
Alkalinity (mg/l)	25	111	370	231.6	55.1	2	246	250	248	2.8
Arsenic dissolved (µg/l)	54	0.2	5	2.3	0.9	2	1.5	2.9	2.2	1
Arsenic total (µg/l)	54	0.5	29	4.2	5.2	2	1.5	3	2.3	1.1
Calcium dissolved (mg/l)	25	65.4	507	181.3	96.2	2	178	339	258.5	113.8
Copper dissolved (µg/l)	25	1	20	8.6	5.5	2	1.5	16	8.8	10.3
Copper total (µg/l)	25	1.5	136	23.1	28.2	2	4	6	5	1.4
Hardness ((mg/l)	25	279	2120	798.1	409.6	2	850	1520	1185	473.8
Mercury dissolved (µg/l)	54	0.1	0.1	0.1	0	2	0.1	0.1	0.1	0
Mercury total (µg/l)	54	0.1	1.7	0.2	0.3	2	0.1	0.1	0.1	0
Magnesium dissolved (mg/l)	25	18.1	208	83.8	42.9	2	98.6	163	130.8	45.5
Sodium dissolved (mg/l)	5	56.7	453	214.7	162.5	2	129	546	337.5	294.9
Lead dissolved (µg/l)	54	0.1	1	0.4	0.2	2	0.1	0.3	0.2	0.1
Lead total (µg/l)	54	0.3	408	16.8	58.3	2	0.3	1.7	1	1
Selenium dissolved (µg/l)	54	0.5	4	1.2	0.9	2	0.5	2	1.3	1.1
Selenium total (µg/l)	54	0.5	10	1.5	1.7	2	0.5	2	1.3	1.1
Selenium total recoverable (µg/l)	9	0.5	2	1.1	0.6	2	0.5	2	1.3	1.1
Total dissolved solids (mg/l)	25	80	3240	1366	750.8	2	1510	3780	2645	1605.1
Total suspended solids (mg/l)	54	2	65600	1981.3	9329	2	32	120	76	62.2
Turbidity (NTU)	54	0.1	18900	552.9	2592.6	2	1.5	62	31.8	42.8
Zinc dissolved (µg/l)	54	5	20	6.5	3.7	2	10	20	15	7.1
Zinc total (µg/l)	54	5	1850	81.5	263.9	2	20	30	25	7.1
Temperature (°C)	54	-0.3	32.2	12.9	8.7	2	0.8	29.5	15.1	20.4
pH	54	7	8.5	8.1	0.3	2	8	8	8	0
Conductance (µmhos/cm)	54	270	3740	1700	729.3	2	1790	4190	2990	1697.1
Redox Potential (mv)	54	239	498	390	61.3	2	378	481	430	72.8
Oxygen dissolved (mg/l)	53	3.1	12.8	8.8	2.2	2	6.4	11.9	9.2	3.9

Table 4.8. Water chemistry data for San Juan River at Shiprock Bridge

San Juan River at Shiprock Bridge	1994-1999					2000				
Parameter	N of cases	Minimum	Maximum	Mean	Standard Dev	N of cases	Minimum	Maximum	Mean	Standard Dev
Bicarbonate (mg/l)	63	17	165	108.1	29.2	8	72	126	110.9	24
Alkalinity (mg/l)	63	17	166	109.3	29.7	8	72	126	110.9	24
Arsenic dissolved (µg/l)	122	0.5	2.5	2	0.8	8	0.5	5	1.7	1.4
Arsenic total (µg/l)	121	0.5	44	4.1	5.8	8	0.5	4	1.9	1.4
Calcium dissolved (mg/l)	63	30.8	96.3	59.6	16.4	8	37.2	72.4	61.9	15.2
Copper dissolved (µg/l)	63	1	18	4.6	3.2	8	1.3	5	2.7	1.3
Copper total (µg/l)	63	2.5	155	28.6	31.5	8	3	26	13.5	11.3
Hardness ((mg/l)	63	98	317	194.7	55.7	8	117	236	198	50.9
Mercury dissolved (µg/l)	122	0.1	0.3	0.1	0	8	0.1	0.1	0.1	0
Mercury total (µg/l)	122	0.1	1.6	0.1	0.2	8	0.1	0.1	0.1	0
Magnesium dissolved (mg/l)	63	5.2	18.6	11.1	3.7	8	5.8	15	10.5	3.7
Sodium dissolved (mg/l)	16	13	58.5	37.3	12.9	8	13.7	51.2	39.2	16
Lead dissolved (µg/l)	122	0.1	18	0.9	2.4	8	0.1	1	0.5	0.3
Lead total (µg/l)	121	0.5	323	26.4	44.4	8	1.5	38.1	16.9	14.2
Selenium dissolved (µg/l)	122	0.5	1	0.5	0.1	8	0.5	0.5	0.5	0
Selenium total (µg/l)	122	0.5	3	0.7	0.4	8	0.5	1	0.6	0.2
Selenium total recoverable (µg/l)	26	0.5	2	0.7	0.3	8	0.5	0.5	0.5	0
Total dissolved solids (mg/l)	62	130	550	339.4	104.3	8	170	410	338.8	101.8
Total suspended solids (mg/l)	120	2.5	17700	1047	3006.6	8	34	878	284.3	358.8
Turbidity (NTU)	118	3.8	11100	538.2	1680.2	8	5.2	7440	1425	2769.9
Zinc dissolved (µg/l)	122	5	50	7.3	6	8	5	30	15.6	8.2
Zinc total (µg/l)	122	5	1380	122.3	225.1	8	20	150	67.5	57.3
Temperature (°C)	122	0.1	26.1	12.2	6.8	8	3.6	22.5	13.3	8
pH	122	7.7	9	8.3	0.3	8	7.8	8.7	8.2	0.4
Conductance (µmhos/cm)	122	240	830	520	148.4	8	280	600	520	145.8
Redox Potential (mv)	122	250	544	408	63.3	8	339	474	429	57.1
Oxygen dissolved (mg/l)	120	3.6	13.9	9.5	2.3	8	6.8	12.6	9.7	2.6

Table 4.9. Water chemistry data for Mancos River near Four Corners

Mancos River near Four Corners	1994-1999					2000				
Parameter	N of cases	Minimum	Maximum	Mean	Standard Dev	N of cases	Minimum	Maximum	Mean	Standard Dev
Bicarbonate (mg/l)	29	92	360	168.9	55.1	3	171	258	216.7	43.7
Alkalinity (mg/l)	29	92	360	171.7	54.8	3	175	258	218	41.6
Arsenic dissolved (µg/l)	52	0.3	5	2.1	0.9	3	1	3	1.7	1.1
Arsenic total (µg/l)	52	1	37	5.5	7.6	3	1.5	2	1.7	0.3
Calcium dissolved (mg/l)	29	43.6	211	134.4	52.9	3	132	225	181.7	46.8
Copper dissolved (µg/l)	29	2.5	20	9	5.6	3	1.5	5.2	3.9	2.1
Copper total (µg/l)	29	1.5	198	34.3	43.8	3	3	10	6	3.6
Hardness ((mg/l)	29	165	1110	639.9	288.1	3	624	1110	908.7	253.5
Mercury dissolved (µg/l)	52	0.1	0.1	0.1	0	3	0.1	0.1	0.1	0
Mercury total (µg/l)	52	0.1	2	0.2	0.3	3	0.1	0.1	0.1	0
Magnesium dissolved (mg/l)	29	13.7	145	73.9	39.6	3	71.5	132	110.2	33.6
Sodium dissolved (mg/l)	6	22	206	108.3	73.9	3	104	188	154.3	44.4
Lead dissolved (µg/l)	52	0.1	1	0.4	0.2	3	0.1	0.3	0.2	0.1
Lead total (µg/l)	52	0.2	78.6	11.5	19.7	3	0.4	3.4	1.5	1.7
Selenium dissolved (µg/l)	52	0.5	30	7.6	6.2	3	8	16	12.3	4
Selenium total (µg/l)	52	0.5	30	7.6	5.9	3	6	14	11.3	4.6
Selenium total recoverable (µg/l)	13	2	16	8.5	4.9	3	5	17	11.7	6.1
Total dissolved solids (mg/l)	28	240	2100	1174.6	556.6	3	1050	2100	1640	536.9
Total suspended solids (mg/l)	51	2.5	33500	1250.8	4754.7	3	14	120	50.7	60.1
Turbidity (NTU)	51	3.9	18500	644.3	2596.3	3	4.8	277	101.2	152.5
Zinc dissolved (µg/l)	52	5	40	7.3	6.2	3	5	10	6.7	2.9
Zinc total (µg/l)	52	5	2300	100.1	319.8	3	5	30	15	13.2
Temperature (°C)	52	-0.2	32.3	12.4	8.5	3	0.7	22.3	10.5	11
pH	52	7.8	8.8	8.2	0.2	3	8	8.3	8.2	0.2
Conductance (µmhos/cm)	52	380	2450	1520	594.8	3	1400	2370	1930	494.9
Redox Potential (mv)	52	4	548	402	85.4	3	308	451	396	76.8
Oxygen dissolved (mg/l)	51	4.8	12.7	9.3	2	3	7.9	12.2	10.2	2.1

Table 4.10. Water chemistry data for San Juan River at Four Corners Bridge

San Juan River at Four Corners Bridge	1994-1999					2000				
Parameter	N of cases	Minimum	Maximum	Mean	Standard Dev	N of cases	Minimum	Maximum	Mean	Standard Dev
Bicarbonate (mg/l)	34	67	165	113.5	23.3	4	91	129	117	17.8
Alkalinity (mg/l)	34	67	165	114.1	23.6	4	91	129	117	17.8
Arsenic dissolved (µg/l)	63	0.5	2.5	2	0.8	4	0.6	1.5	1	0.5
Arsenic total (µg/l)	63	1	19	3.6	3.3	4	0.5	7	2.9	2.9
Calcium dissolved (mg/l)	34	31.7	99.9	64.1	18.5	4	47.4	75	66.5	13
Copper dissolved (µg/l)	34	1	11	5	2.5	4	1.4	2.1	1.8	0.4
Copper total (µg/l)	34	2.5	130	25.2	26.3	4	3	49	21	21.6
Hardness ((mg/l)	34	103	340	217.8	68.5	4	153	263	219.8	48
Mercury dissolved (µg/l)	63	0.1	0.3	0.1	0	4	0.1	0.1	0.1	0
Mercury total (µg/l)	63	0.1	0.8	0.1	0.1	4	0.1	0.1	0.1	0
Magnesium dissolved (mg/l)	34	5.5	23.8	14	5.6	4	8.3	18.4	13.1	4.3
Sodium dissolved (mg/l)	11	14	60.1	42.9	15.2	4	21.7	57.3	42.3	14.9
Lead dissolved (µg/l)	63	0.1	7	0.6	0.9	4	0.1	0.3	0.1	0.1
Lead total (µg/l)	63	0.5	271	22	45.1	4	1	53.1	21.3	24.8
Selenium dissolved (µg/l)	63	0.5	2	0.8	0.5	4	0.5	1	0.6	0.3
Selenium total (µg/l)	63	0.5	4	1	0.7	4	0.5	1	0.6	0.3
Selenium total recoverable (µg/l)	13	0.5	2	0.9	0.4	4	0.5	1	0.8	0.3
Total dissolved solids (mg/l)	33	110	640	384.8	133.8	4	240	480	375	100.8
Total suspended solids (mg/l)	63	2.5	11700	700.5	1957.3	4	18	2420	758.5	1129.6
Turbidity (NTU)	61	2	7900	410.8	1294.1	4	9.6	60500	15155.4	30229.7
Zinc dissolved (µg/l)	63	5	30	6.8	4.6	4	5	20	11.3	6.3
Zinc total (µg/l)	63	5	920	85.2	140.7	4	20	150	57.5	62.4
Temperature (°C)	63	0	26.3	12.3	7.3	4	2.1	22.8	13.3	9.7
pH	63	7.5	8.8	8.2	0.3	4	7.8	8.4	8.1	0.3
Conductance (µmhos/cm)	63	250	870	580	177.3	4	390	660	570	124.3
Redox Potential (mv)	63	256	592	410	63.4	4	314	475	419	72.4
Oxygen dissolved (mg/l)	62	4.3	12.7	9.3	2	4	6.6	12.4	9.2	2.7

Table 4.11. Water chemistry data for San Juan River at Montezuma Creek Bridge

San Juan River at Montezuma Creek Bridge	1994-1999					2000				
Parameter	N of cases	Minimum	Maximum	Mean	Standard Dev	N of cases	Minimum	Maximum	Mean	Standard Dev
Bicarbonate (mg/l)	31	59	192	122.1	30.2	4	112	140	129.3	12
Alkalinity (mg/l)	31	59	192	122.8	30.5	4	112	140	129.3	12
Arsenic dissolved (µg/l)	59	0.5	2.5	1.9	0.8	4	0.7	1.2	0.9	0.2
Arsenic total (µg/l)	59	1	21	3.5	3.5	4	0.5	3	1.3	1.2
Calcium dissolved (mg/l)	31	33.9	132	72.8	24.9	4	61.4	85.3	75	10.6
Copper dissolved (µg/l)	31	2	15	5.1	3.3	4	1.5	2.4	1.9	0.4
Copper total (µg/l)	31	1.5	120	25.3	28.5	4	5	12	9.5	3.1
Hardness ((mg/l)	31	111	465	264.2	100	4	208	300	264.3	43.8
Mercury dissolved (µg/l)	59	0.1	0.2	0.1	0	4	0.1	0.1	0.1	0
Mercury total (µg/l)	59	0.1	0.8	0.1	0.1	4	0.1	0.1	0.1	0
Magnesium dissolved (mg/l)	31	6.5	40.5	20	9.4	4	13.3	23.8	18.7	4.5
Sodium dissolved (mg/l)	7	16	196	60.1	62.3	4	32.1	59.8	45.8	12.4
Lead dissolved (µg/l)	59	0.1	4	0.5	0.5	4	0.1	0.2	0.1	0.1
Lead total (µg/l)	59	0.5	129	18.1	26.7	4	0.8	9.1	4.7	3.9
Selenium dissolved (µg/l)	59	0.5	4	0.9	0.6	4	0.5	1	0.6	0.3
Selenium total (µg/l)	59	0.5	6	1.1	0.9	4	0.5	1	0.6	0.3
Selenium total recoverable (µg/l)	13	0.5	2	0.9	0.4	4	0.5	0.5	0.5	0
Total dissolved solids (mg/l)	29	170	800	445.5	173.4	4	330	530	440	92
Total suspended solids (mg/l)	58	2.5	9100	703.4	1534.7	4	22	360	168.5	149.8
Turbidity (NTU)	58	3.9	6900	364.3	987.9	4	7.8	4080	1042.4	2025.1
Zinc dissolved (µg/l)	59	5	60	7.3	7.8	4	5	20	13.8	7.5
Zinc total (µg/l)	59	5	540	83.5	109.7	4	20	50	32.5	15
Temperature (°C)	59	-0.2	27.8	12.7	7.3	4	0.3	22.7	12.5	10.8
pH	59	7.7	8.7	8.2	0.2	4	7.9	8.3	8.1	0.2
Conductance (µmhos/cm)	59	280	1160	670	222.6	4	520	750	660	103.7
Redox Potential (mv)	59	250	516	404	63.4	4	315	469	411	73.6
Oxygen dissolved (mg/l)	58	5.1	12.3	9	1.9	4	6.9	12.6	9.3	2.7

Table 4.12. Water chemistry data for San Juan River at Bluff Bridge

San Juan River at Bluff Bridge	1994-1999					2000				
Parameter	N of cases	Minimum	Maximum	Mean	Standard Dev	N of cases	Minimum	Maximum	Mean	Standard Dev
Bicarbonate (mg/l)	65	47	175	121.9	30.6	8	115	138	131.1	9.7
Alkalinity (mg/l)	65	47	175	122	30.6	8	115	138	131.1	9.7
Arsenic dissolved (µg/l)	122	0.5	2.5	2	0.7	8	0.6	1.4	0.9	0.3
Arsenic total (µg/l)	121	0.5	20	4.2	4.4	8	0.5	3	1.8	0.9
Calcium dissolved (mg/l)	65	32.3	121	73	21.9	8	63.8	86.6	77.2	9.3
Copper dissolved (µg/l)	65	1	13	5.8	3.1	8	1.6	2.9	2.1	0.5
Copper total (µg/l)	65	1.5	200	32.4	36.3	8	4	12	8.4	2.9
Hardness ((mg/l)	65	106	507	266.4	92.6	8	221	309	272.8	38.1
Mercury dissolved (µg/l)	122	0.1	0.5	0.1	0	8	0.1	0.1	0.1	0
Mercury total (µg/l)	122	0.1	0.7	0.1	0.1	8	0.1	0.1	0.1	0
Magnesium dissolved (mg/l)	65	6.2	49.8	20.6	9.5	8	14.9	24.5	19.4	4
Sodium dissolved (mg/l)	18	18	83	48.7	22.8	8	36.8	61.7	48	10.3
Lead dissolved (µg/l)	122	0.1	4	0.6	0.7	8	0.1	0.3	0.1	0.1
Lead total (µg/l)	121	0.5	144	22.2	32.1	8	1.2	9.4	5	3.6
Selenium dissolved (µg/l)	122	0.5	3	0.9	0.6	8	0.5	1	0.6	0.2
Selenium total (µg/l)	122	0.5	8	1.2	1.1	8	0.5	1	0.6	0.2
Selenium total recoverable (µg/l)	26	0.5	1	0.8	0.3	8	0.5	1	0.6	0.2
Total dissolved solids (mg/l)	62	160	990	476.3	179.8	8	360	530	452.5	73.2
Total suspended solids (mg/l)	122	1	9820	895.8	1778.9	8	28	378	205	156.9
Turbidity (NTU)	120	2	7900	556.6	1290.4	8	7.4	2930	641.7	1152.7
Zinc dissolved (µg/l)	122	5	40	7.3	5.7	8	5	20	10.6	6.2
Zinc total (µg/l)	122	5	650	102.1	138.9	8	20	60	36.3	17.7
Temperature (°C)	122	-0.3	29.4	12.4	7.6	8	0.1	23.1	12.6	10.4
pH	122	7.7	8.6	8.2	0.2	8	7.9	8.3	8.1	0.1
Conductance (µmhos/cm)	122	280	1150	690	226.4	8	560	760	680	82.4
Redox Potential (mv)	122	4	535	403	82.4	8	283	463	400	77.1
Oxygen dissolved (mg/l)	120	5.4	12.7	9.1	2	8	6.7	12.6	9.3	2.5

Table 4.13. Water chemistry data for San Juan River at Mexican Hat Bridge

San Juan River at Mexican Hat Bridge	1994-1999					2000				
Parameter	N of cases	Minimum	Maximum	Mean	Standard Dev	N of cases	Minimum	Maximum	Mean	Standard Dev
Bicarbonate (mg/l)	34	71	180	129	27.7	4	118	138	132.3	9.6
Alkalinity (mg/l)	34	71	180	129	27.7	4	118	138	132.3	9.6
Arsenic dissolved (µg/l)	63	0.5	2.5	2	0.7	4	0.7	1.4	1.1	0.4
Arsenic total (µg/l)	63	1	50	4.8	6.9	4	1	4	2.1	1.3
Calcium dissolved (mg/l)	34	32.7	112	74.5	23.2	4	67.5	86.7	78.8	9.5
Copper dissolved (µg/l)	34	2	13	5.4	3.2	4	1.6	3.2	2.3	0.7
Copper total (µg/l)	34	1.5	170	22.7	29.9	4	5	19	9.5	6.5
Hardness ((mg/l)	34	108	460	273.9	97.5	4	236	322	280	40.2
Mercury dissolved (µg/l)	63	0.1	0.1	0.1	0	4	0.1	0.1	0.1	0
Mercury total (µg/l)	63	0.1	1.1	0.1	0.2	4	0.1	0.1	0.1	0
Magnesium dissolved (mg/l)	34	6.3	43.8	21.3	9.8	4	16.4	25.7	20.2	4.3
Sodium dissolved (mg/l)	11	15	77.5	50.2	21	4	41	65.8	50.6	11.6
Lead dissolved (µg/l)	63	0.1	1	0.4	0.2	4	0.1	0.1	0.1	0
Lead total (µg/l)	63	0.5	327	22.2	50.4	4	0.8	17.4	5.9	7.7
Selenium dissolved (µg/l)	63	0.5	2	0.9	0.6	4	0.5	1	0.6	0.3
Selenium total (µg/l)	63	0.5	5	1.2	0.9	4	0.5	1	0.6	0.3
Selenium total recoverable (µg/l)	13	0.5	2.5	1.3	0.7	4	0.5	1	0.6	0.3
Total dissolved solids (mg/l)	33	170	800	481.8	176.4	4	390	540	467.5	69.5
Total suspended solids (mg/l)	63	1	16090	1298.4	2719.8	4	36	670	234	293.1
Turbidity (NTU)	61	1	11000	722.7	1769.8	4	21	6800	1735.1	3376.7
Zinc dissolved (µg/l)	63	5	100	8.3	12.7	4	5	30	16.3	11.1
Zinc total (µg/l)	63	5	1620	108.2	223.3	4	10	70	30	27.1
Temperature (°C)	63	-0.2	29.8	12.6	7.8	4	0.8	23.7	13.1	11.3
pH	63	7.7	8.6	8.2	0.2	4	8	8.3	8.1	0.2
Conductance (µmhos/cm)	63	270	1050	690	218.3	4	610	770	700	72.7
Redox Potential (mv)	63	245	537	405	69.1	4	231	462	384	107.5
Oxygen dissolved (mg/l)	62	5.8	12.9	9.1	2	4	6.4	12	9	2.6

CHAPTER 5. HABITAT STUDIES

HABITAT QUANTITY

Habitat quantity was determined using airborne videography as previously described by Bliesner and Lamarra (1998) and established as part of the Long Range Monitoring Program. Habitat types mapped can be seen in Table 5.1 with habitat categories summarized into seven general categories. Mapping occurred between November 16 and December 4, 1999 between RM 2 and RM 180. Flows during the habitat mapping ranged between 840 and 910 cfs. Run habitats had the most surface area with 81.9 percent of the wetted area of the San Juan River. Riffles were second most dense (7.37%), followed by shoals (7.0 %) and slackwaters (1.70 %). Backwaters made up only 0.33 percent of the surface area of habitats (Figure 5.1). The spatial distribution of these same general categories can be seen in Figures 5.2 and 5.3. Low velocity and backwater habitats were distributed throughout the river but are in highest magnitude between RM 68 and RM 105 (19,760 m^2).The second location of relatively high backwater densities was between RM 131 and RM 154 with a total area of 14,375 $m^{2.}$ Shoals which are the third most dense habitat type are found throughout the river system but are a major habitat feature in the lower 19 miles of the San Juan River where it is influenced by the backwater effects of Lake Powell. Slackwater habitats are mostly found between RM 20 and RM 80 and are associated with riffle complexes within the canyon bound reach of the river.

Table 5.1. Seven general categories of habitat types on the San Juan River.

LOW VELOCITY TYPES	RUN TYPES	RIFFLE TYPES	BACK-WATER TYPES	SHOAL TYPES	SLACK-WATER TYPES	VEGETATION ASSOCIATED HABITAT TYPES
pool	shoal/run	riffle	backwater	sand shoal	slackwater	overhanging vegetation
debris pool	run	shore riffle	backwater pool	cobble shoal	pocket water	inundated vegetation
rootwad pool	scour run	riffle chute	embayment			
eddy	shore run	shoal/riffle				
edge pool	undercut run	chute				
riffle eddy	run/riffle	rapid				

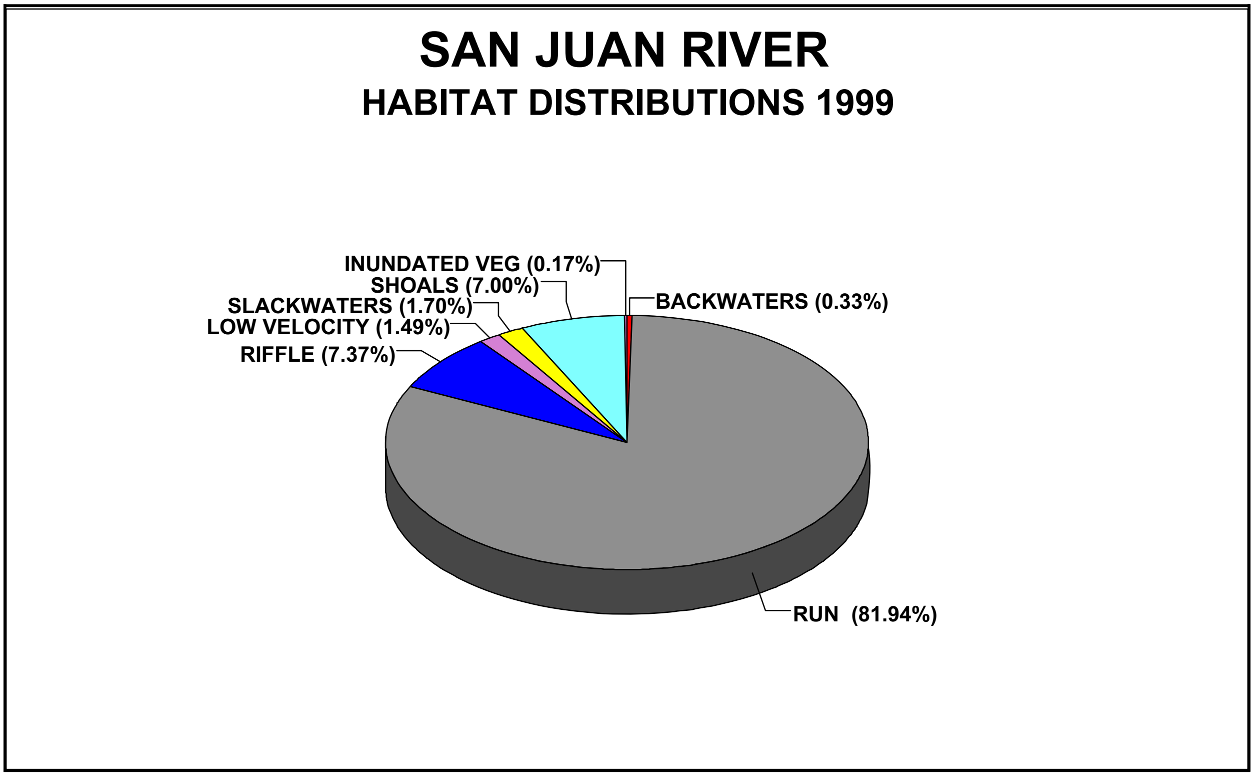


Figure 5.1. **The distributions of habitat types (expressed as a per cent of total wetted area) in the San Juan River in 1999. Data are for RM2 to RM 180.**

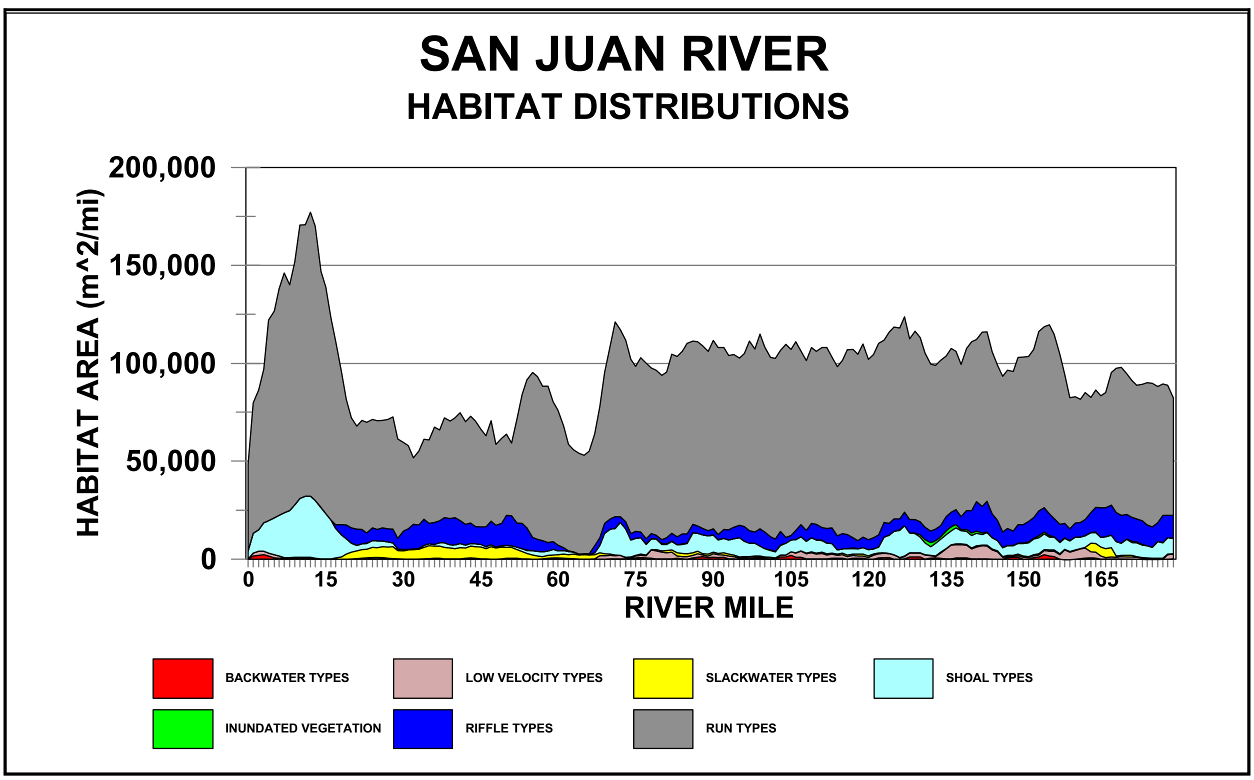


Figure 5.2. **The spatial distribution of the major habitat types in the Sam Juan River from RM 2 to RM 180 in November and December 1999.**

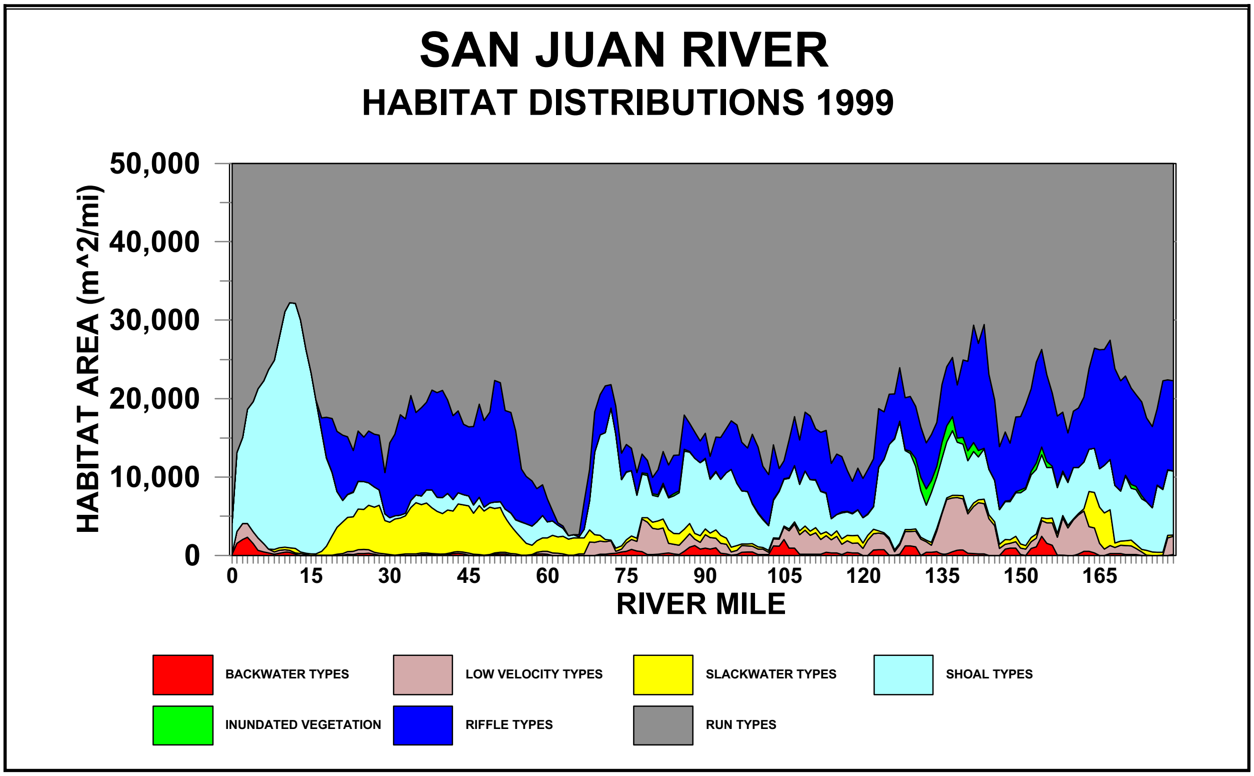


Figure 5.3. The spatial distribution of the major habitat types with the run habitats not shown in order to demonstrate more detail in the less dominant types.

Backwater habitats represent an important component of the life cycle of many of the native species found in the San Juan River. Because of this fact, the temporal trend of this habitat type is used as a monitoring indicator to assess influences of flows on habitat quantity. As noted in previous investigations (Bliesner and Lamarra 1998), the magnitude of backwater habitats are influenced by the location in the river, flow magnitude, and summer storm events. In order to simplify the analysis, only mapping runs between 800 and 1200 cfs are used in a comparison of temporal trends. These data are shown in Figure 5.4 for both surface area and the number of backwaters. The data indicated that after reaching a maximum surface area of 143,000 m^2 (373 backwaters) between RM 2 and RM 180, there was a decrease to 43,000 m^2 (164 backwaters) in November 1998. The loss of the 100,000 m^2, or 200 backwaters, primarily occurred in reaches 3 and 4. In the 1999 inventory, backwaters slightly increased to just over 56,300 m^2 (Figure 5.4) in 178 backwaters.

HABITAT QUALITY

The depths of backwaters is an important attribute relative to use by native endangered species. In the San Juan River system, backwater depths are effected by sediment laden summer storms. Bed sediment depths in backwaters have been periodically measured since August 1995. A good example of the influence of storms can be seen during August, September and November 1995. Seven storms during the summer and fall of 1995 deposited an average of 0.5 meters of sediment in backwaters (Figure 5.6). Since 1995, summer sediment depths have ranged river-wide between 0.2 and 0.4 meters in depth. In the fall of 1997, sediment depths again reached almost 0.6 meters.
The December 1999 monitoring of backwater sediment depths indicated that sediment depths were the second most shallow (average 0.14 meters and SD 0.04 meters) since the August 1995 sampling. The deepest sediment depths were in reach 2 (average 0.22 meters and SD of 0.03 meters) and the most shallow in reach 4 (average 0.09 meters and SD of 0.03 meters).

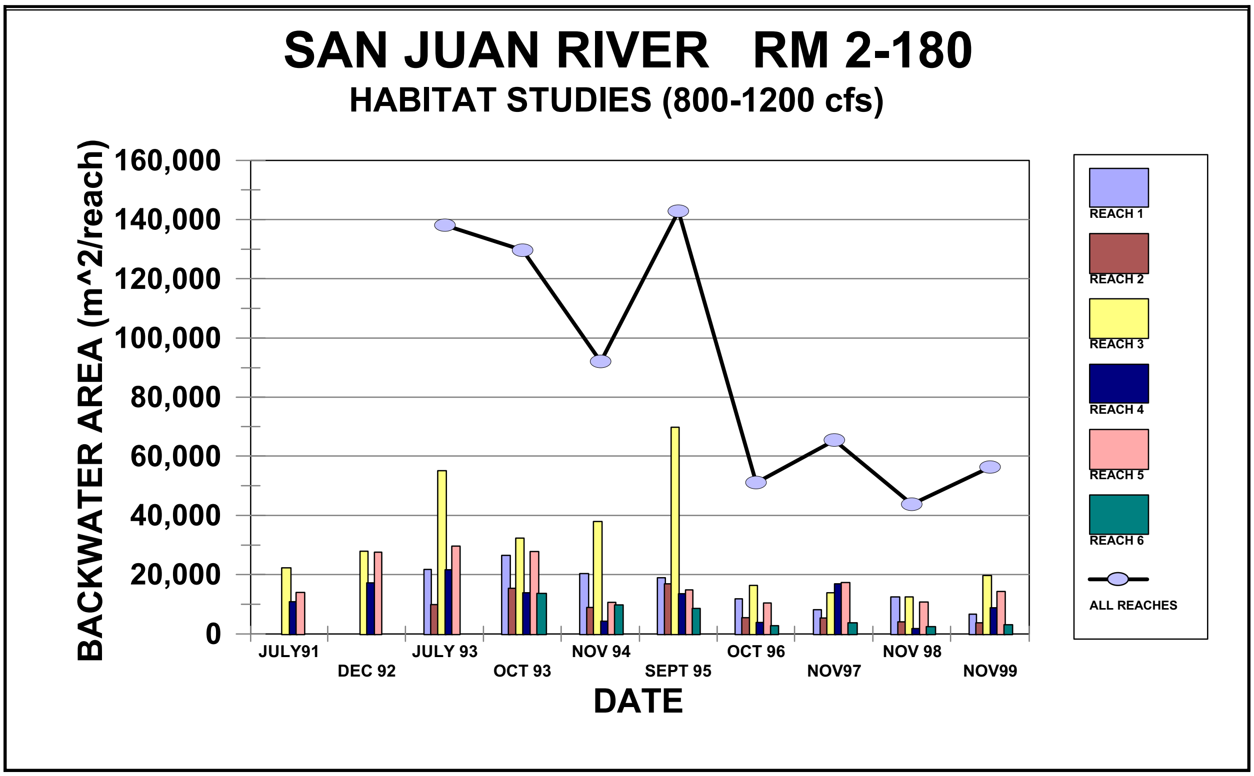


Figure 5.4. The distribution of backwater habitat area by reach and total for each mapping date where flows were between 800 and 1200 cfs.

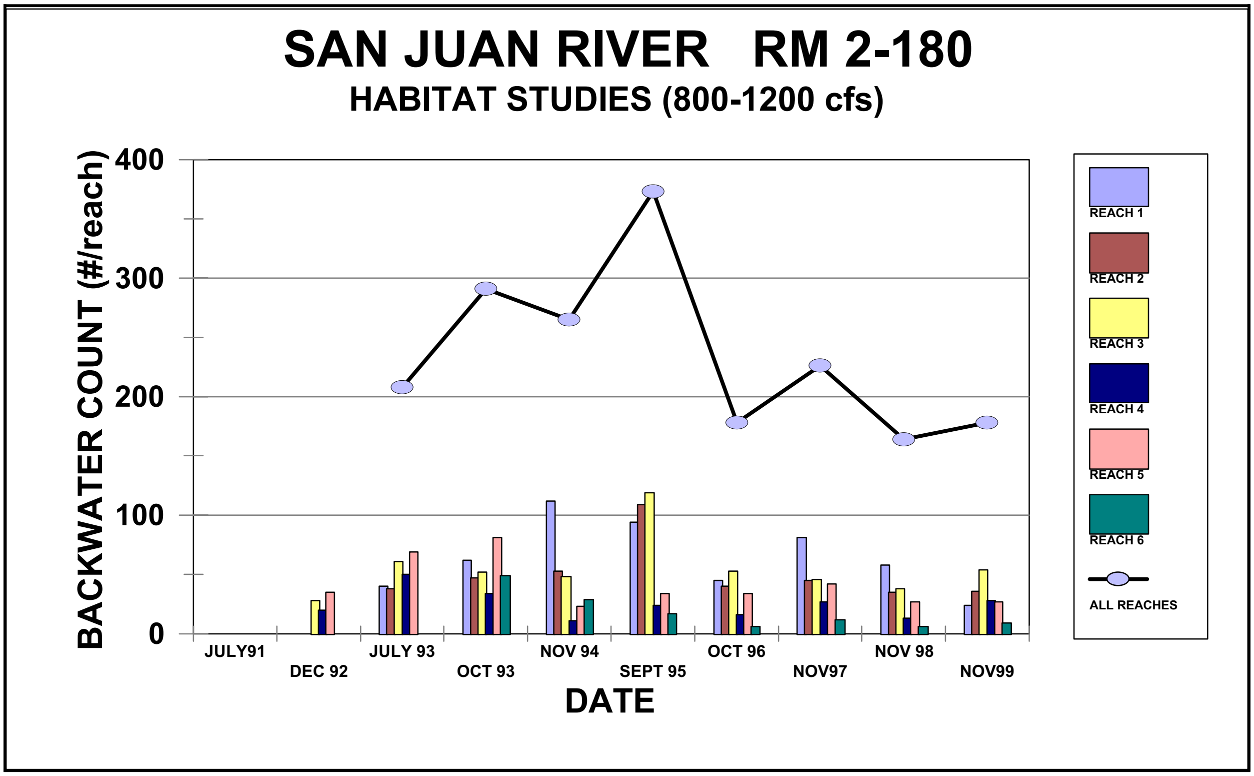


Figure 5.5. **The distribution of backwater habitat counts by reach and total for each mapping date where flows were between 800 and 1200 cfs.**

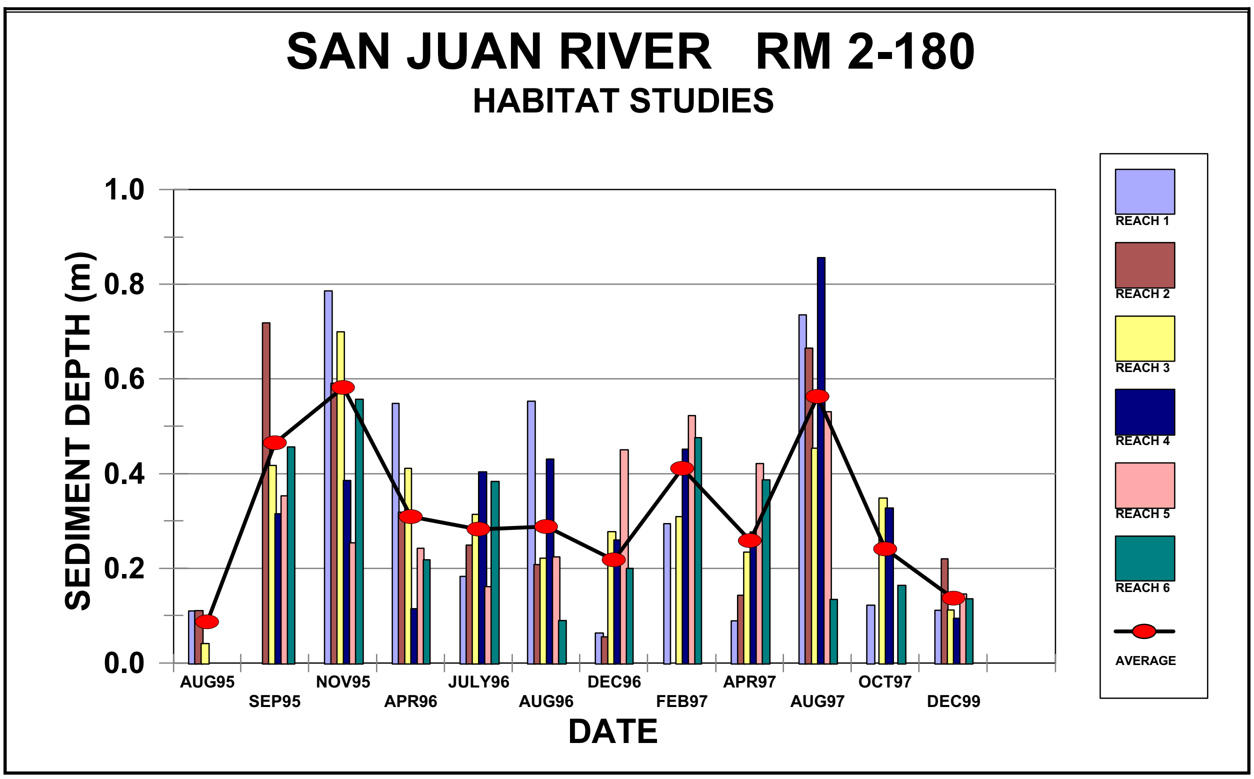
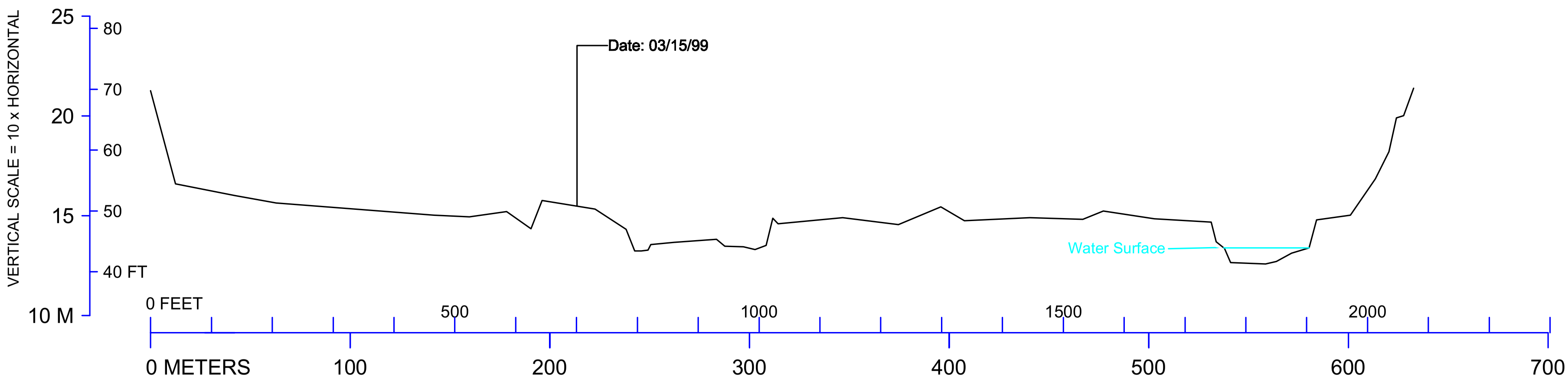
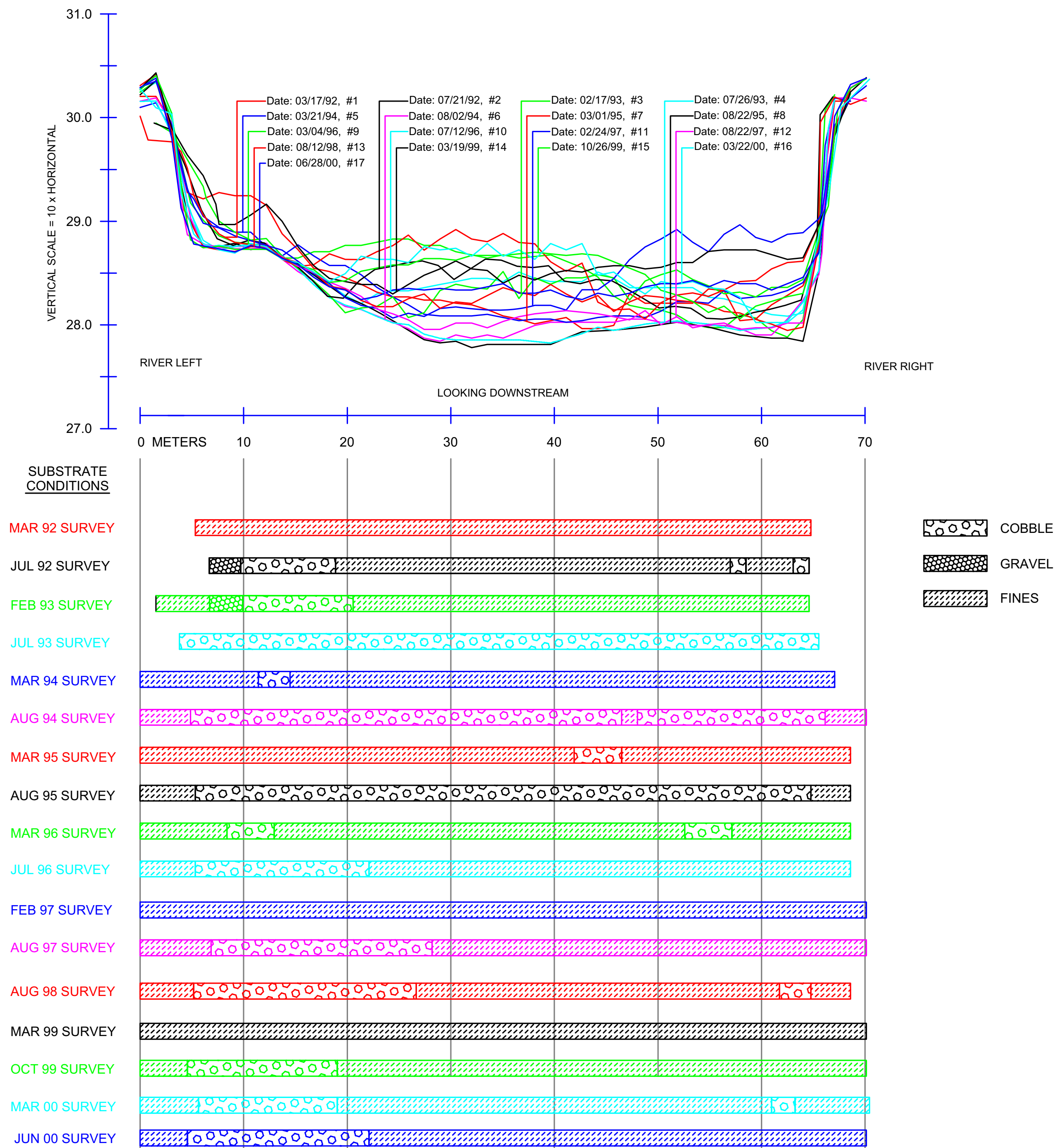


Figure 5.6. **The depth of sediment (meters) in backwaters displayed by reaches from the San Juan River.**

Valley Wide Cross-Section CS6-01 (RM 175.0)
USGS 7.5 Min Quadrangle: Kirtland, NM

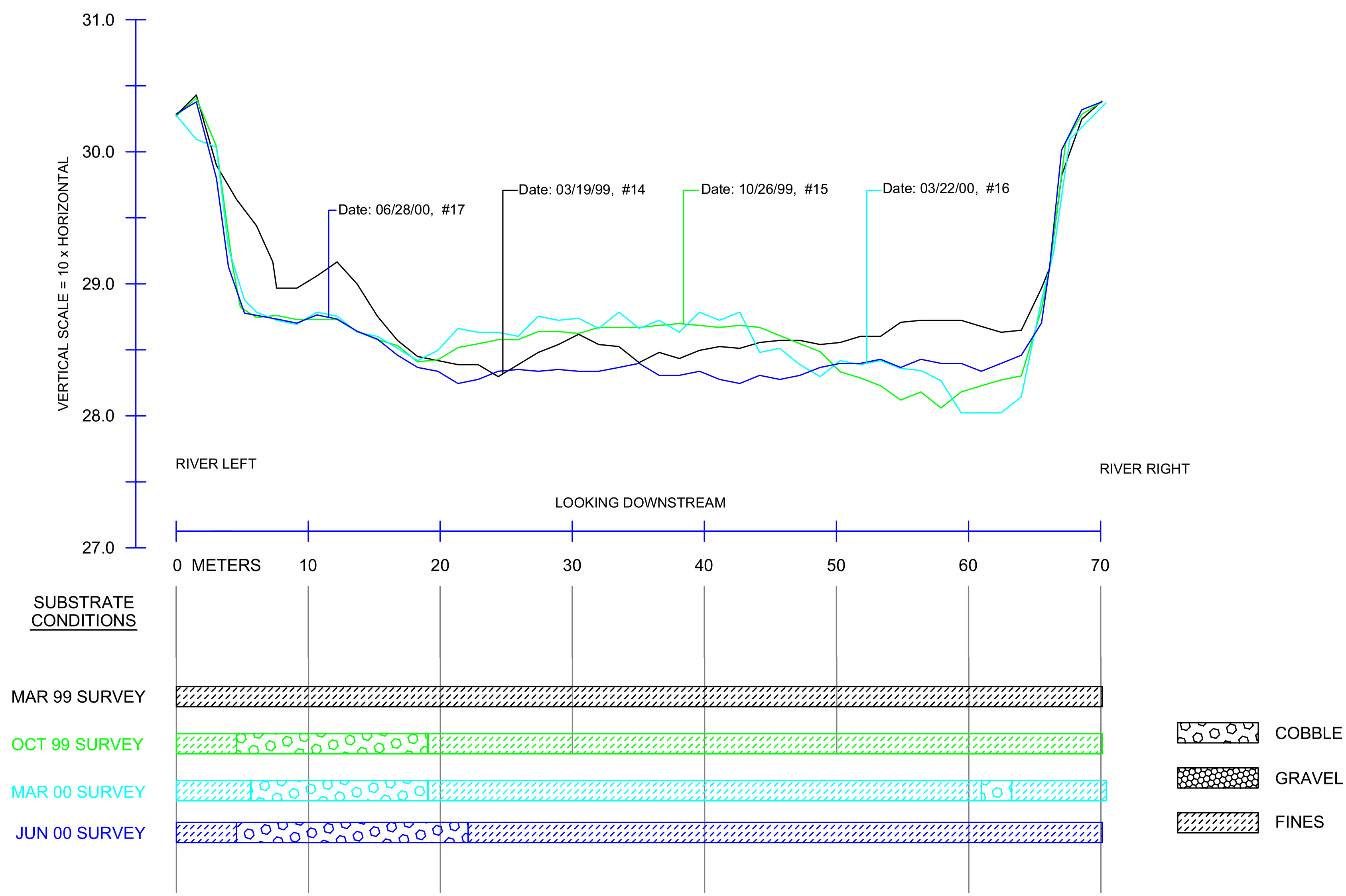


TRANSECT CS6-02 (RT01)
PHOTO 357-67
FRUITLAND QUAD.

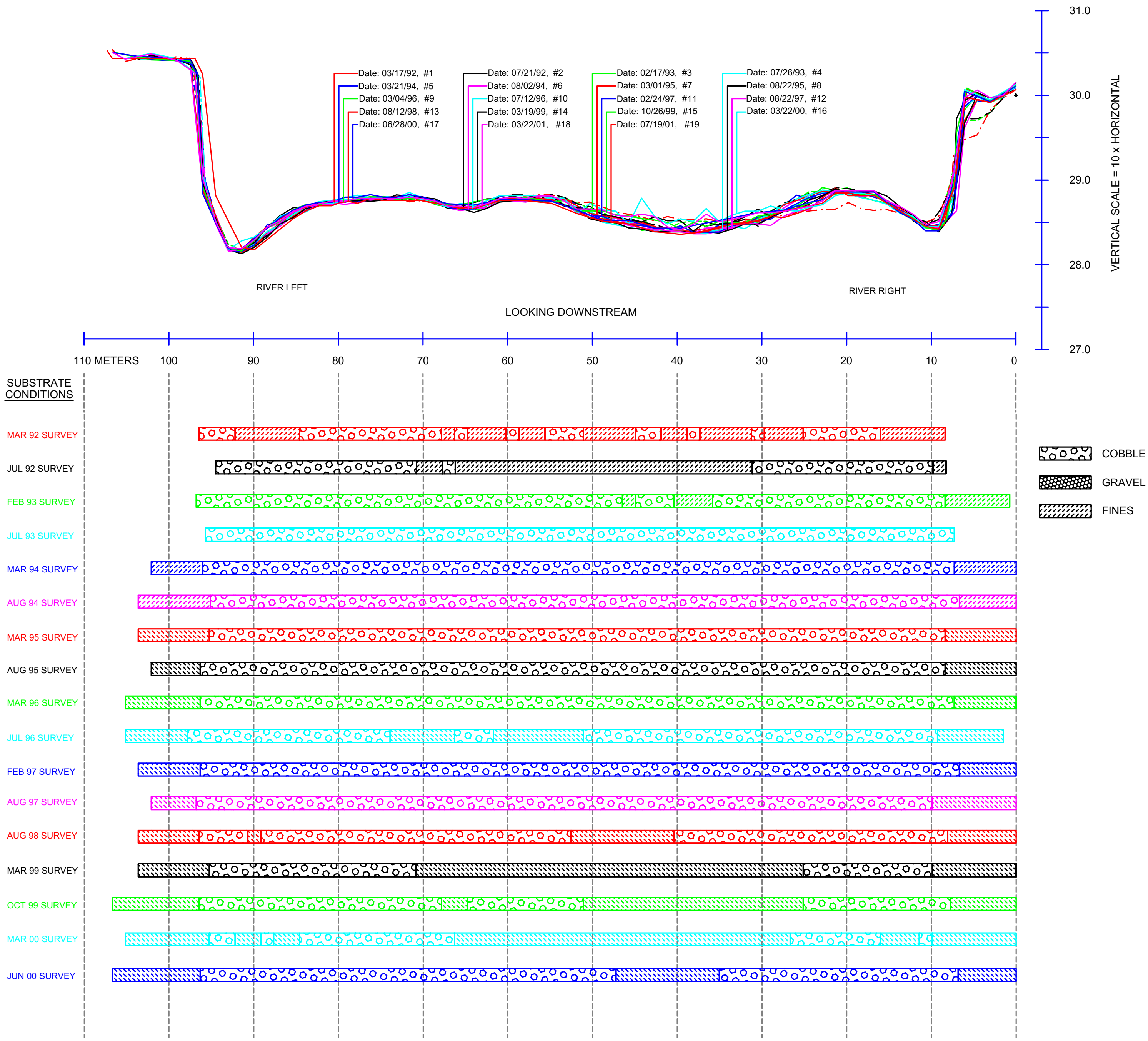


FILE: RT01-GIS.DWG DATE: 09/03/01

TRANSECT CS6-02 (RT01)
PHOTO 357-67
FRUITLAND QUAD.

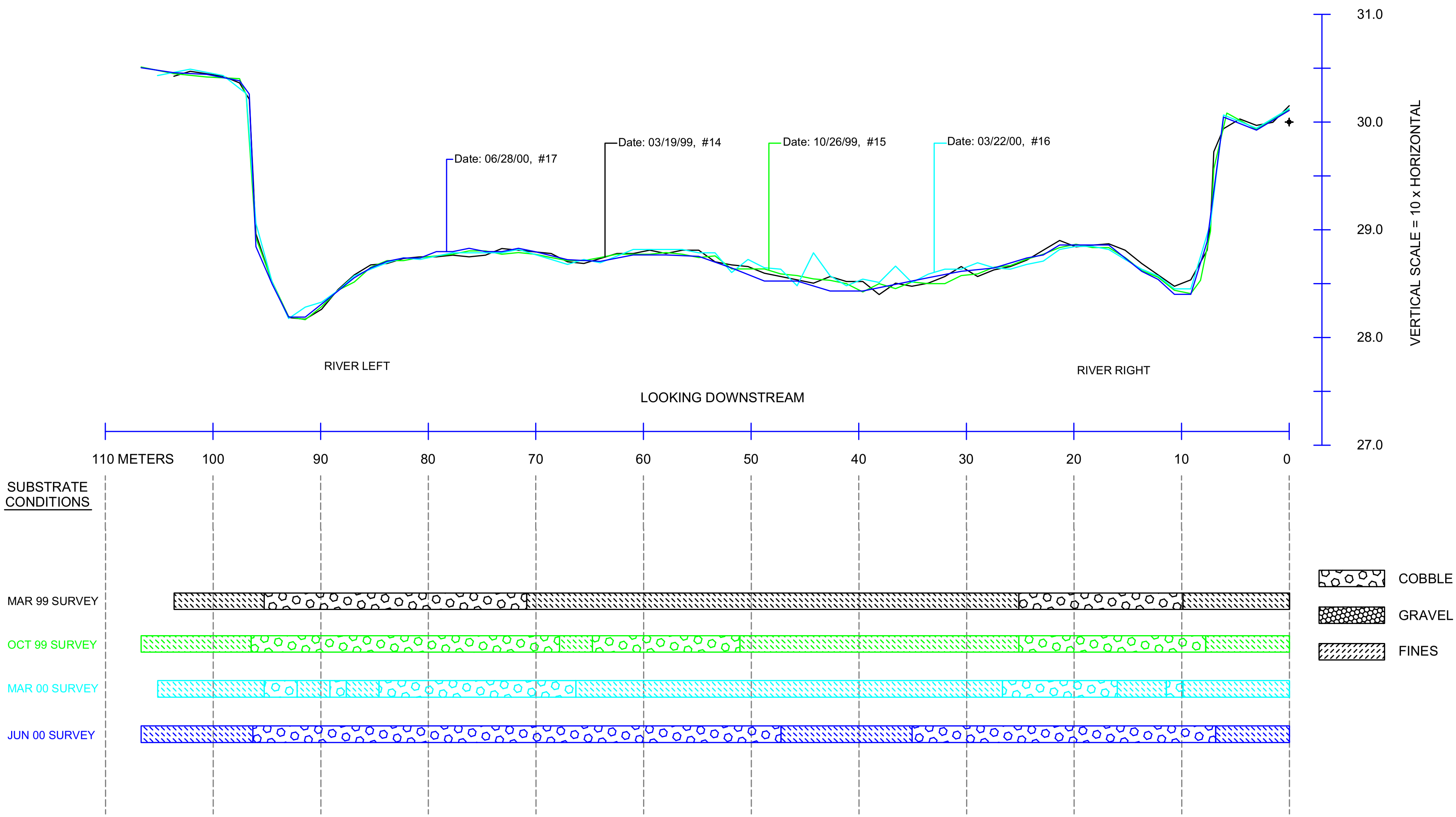


TRANSECT CS6-03 (RT02)
PHOTO 357-46 NHAP
QUAD: CHIMNEY ROCK

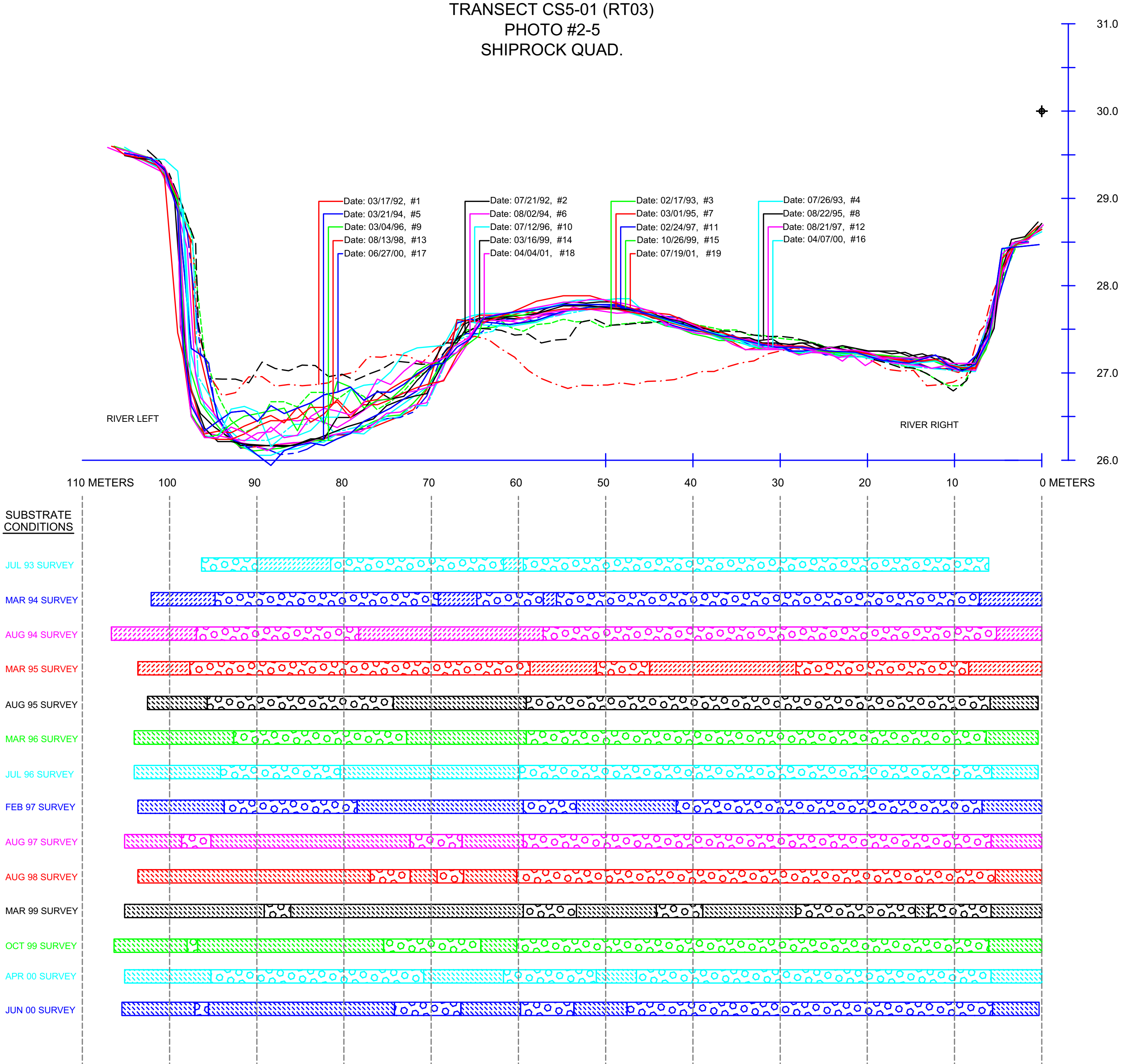


FILE: RT02-GIS.DWG DATE: 09/04/01

TRANSECT CS6-03 (RT02)
PHOTO 357-46 NHAP
QUAD: CHIMNEY ROCK

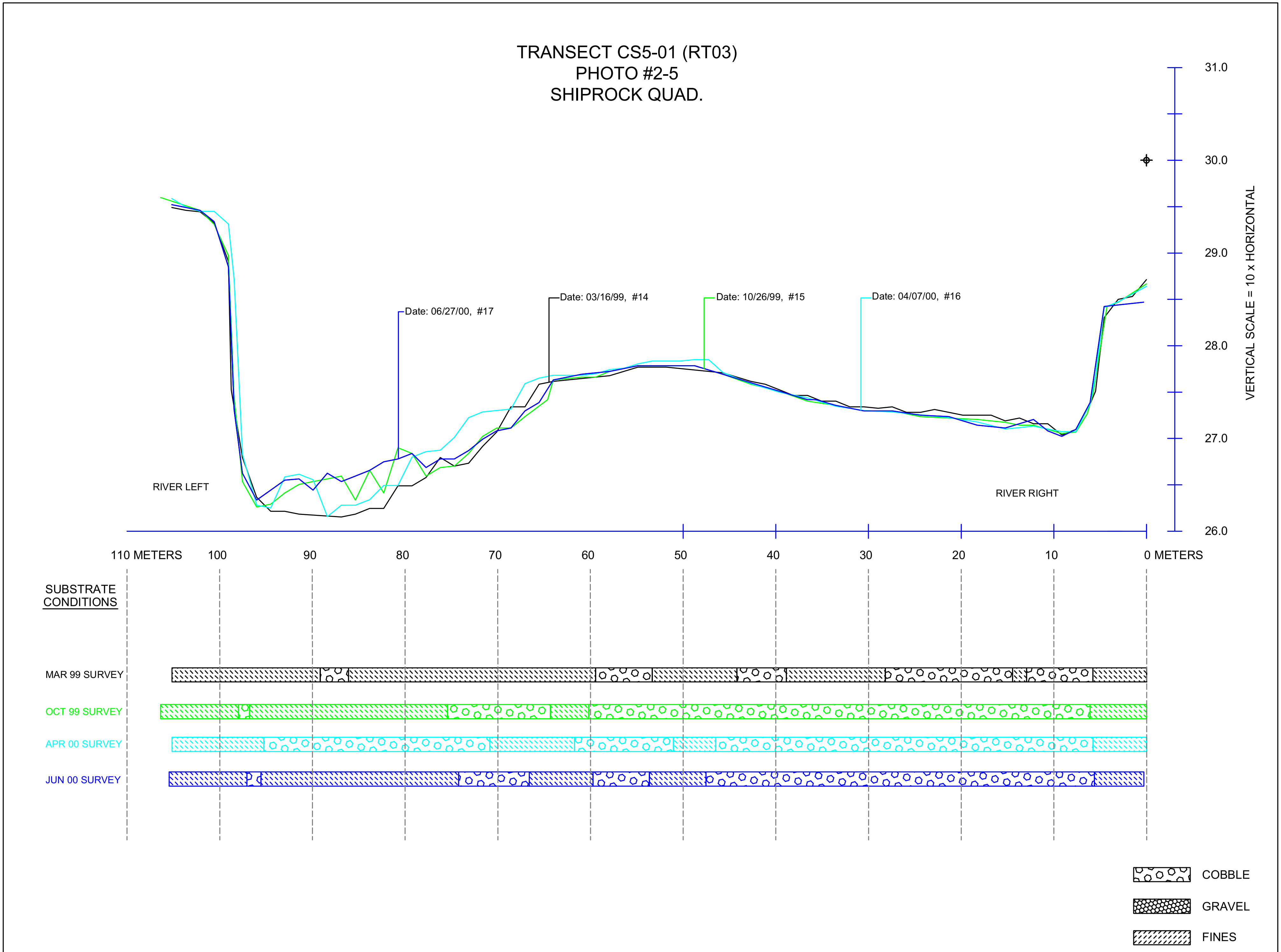


TRANSECT CS5-01 (RT03)
PHOTO #2-5
SHIPROCK QUAD.



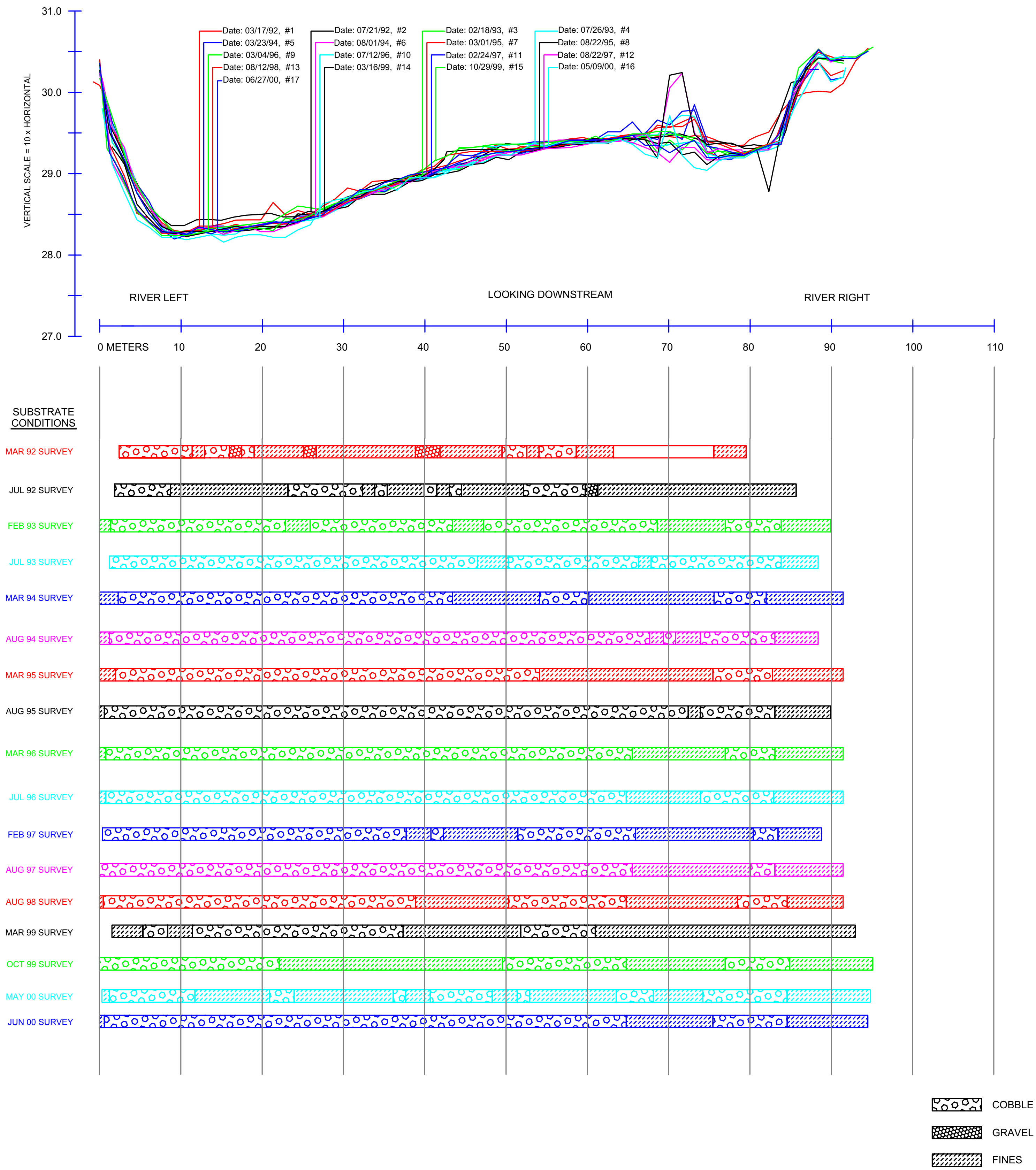
COBBLE
GRAVEL
FINES

FILE: RT03-GIS.DWG DATE: 09/04/01



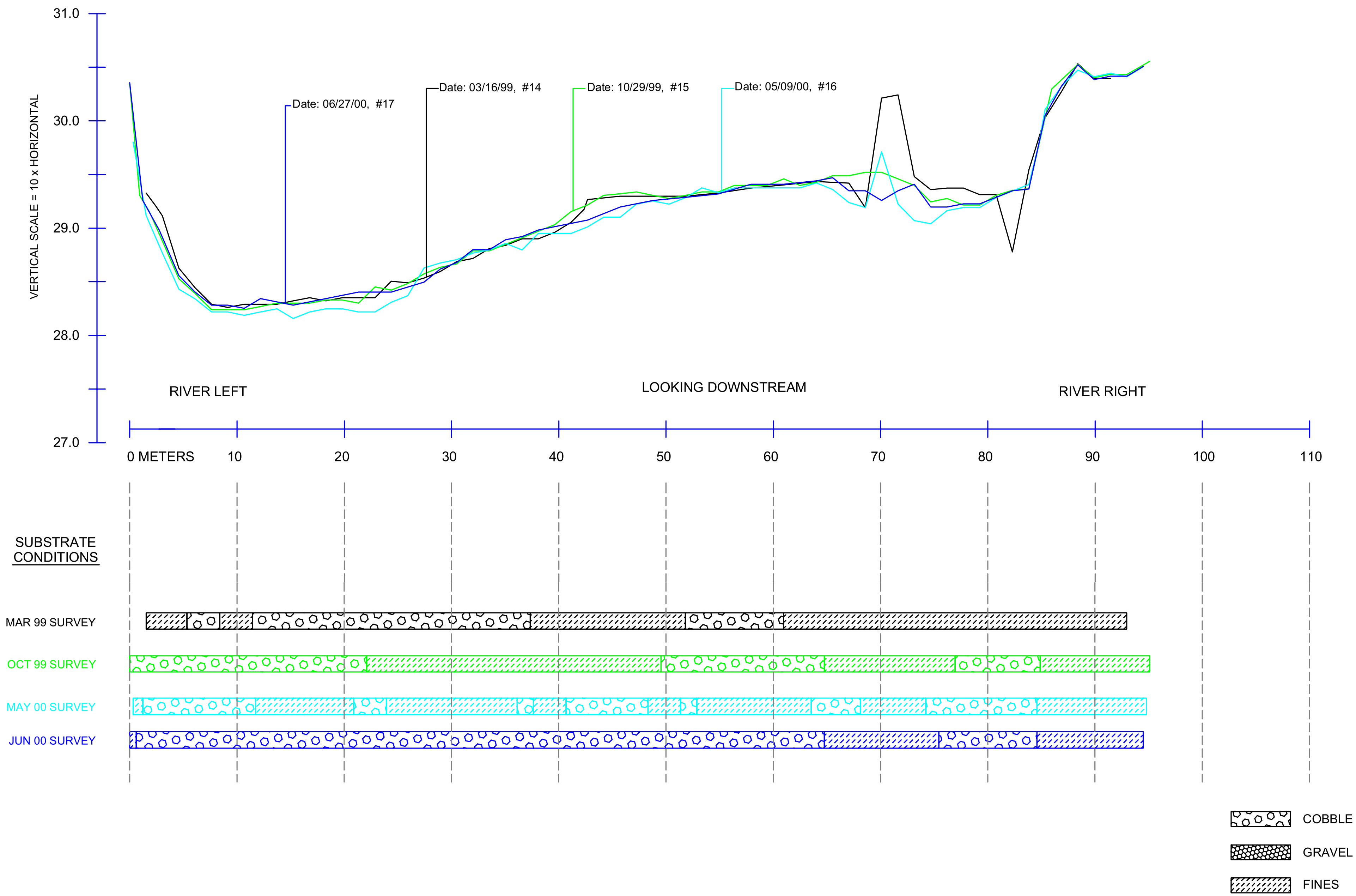
TRANSECT CS5-01 (RT03)
PHOTO #2-5
SHIPROCK QUAD.
31.0
30.0
29.0
28.0
27.0
26.0
VERTICAL SCALE = 10 x HORIZONTAL
Date: 06/27/00, #17
Date: 03/16/99, #14
Date: 10/26/99, #15
Date: 04/07/00, #16
RIVER LEFT
RIVER RIGHT
110 METERS
100
90
80
70
60
50
40
30
20
10
0 METERS
SUBSTRATE CONDITIONS
MAR 99 SURVEY
OCT 99 SURVEY
APR 00 SURVEY
JUN 00 SURVEY
COBBLE
GRAVEL
FINES

TRANSECT CS5-02 (RT04)
PHOTO 3-7
CANAL CREEK QUAD.

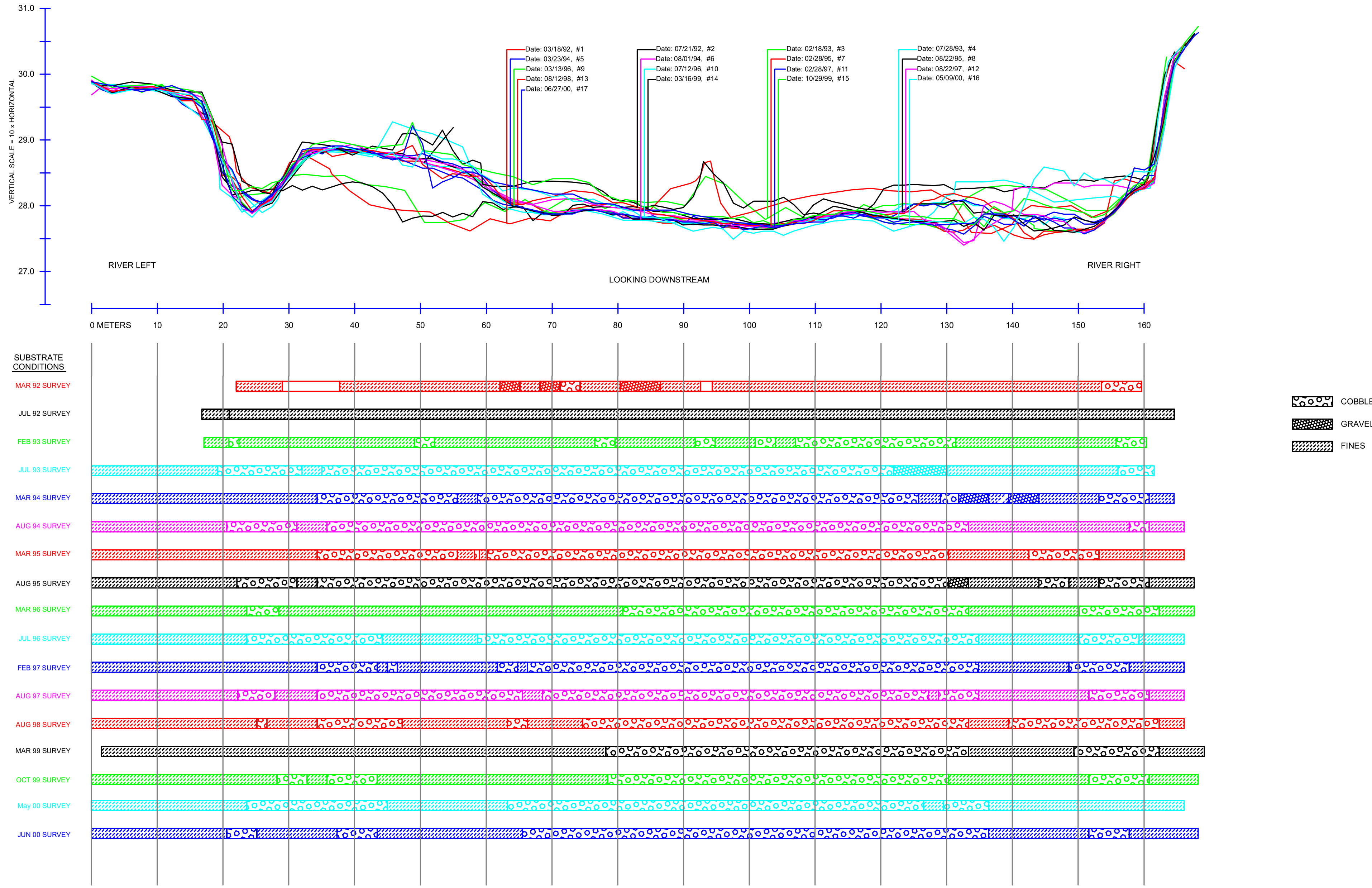


FILE: RT04-GIS.DWG DATE: 09/04/01

TRANSECT CS5-02 (RT04)
PHOTO 3-7
CANAL CREEK QUAD.

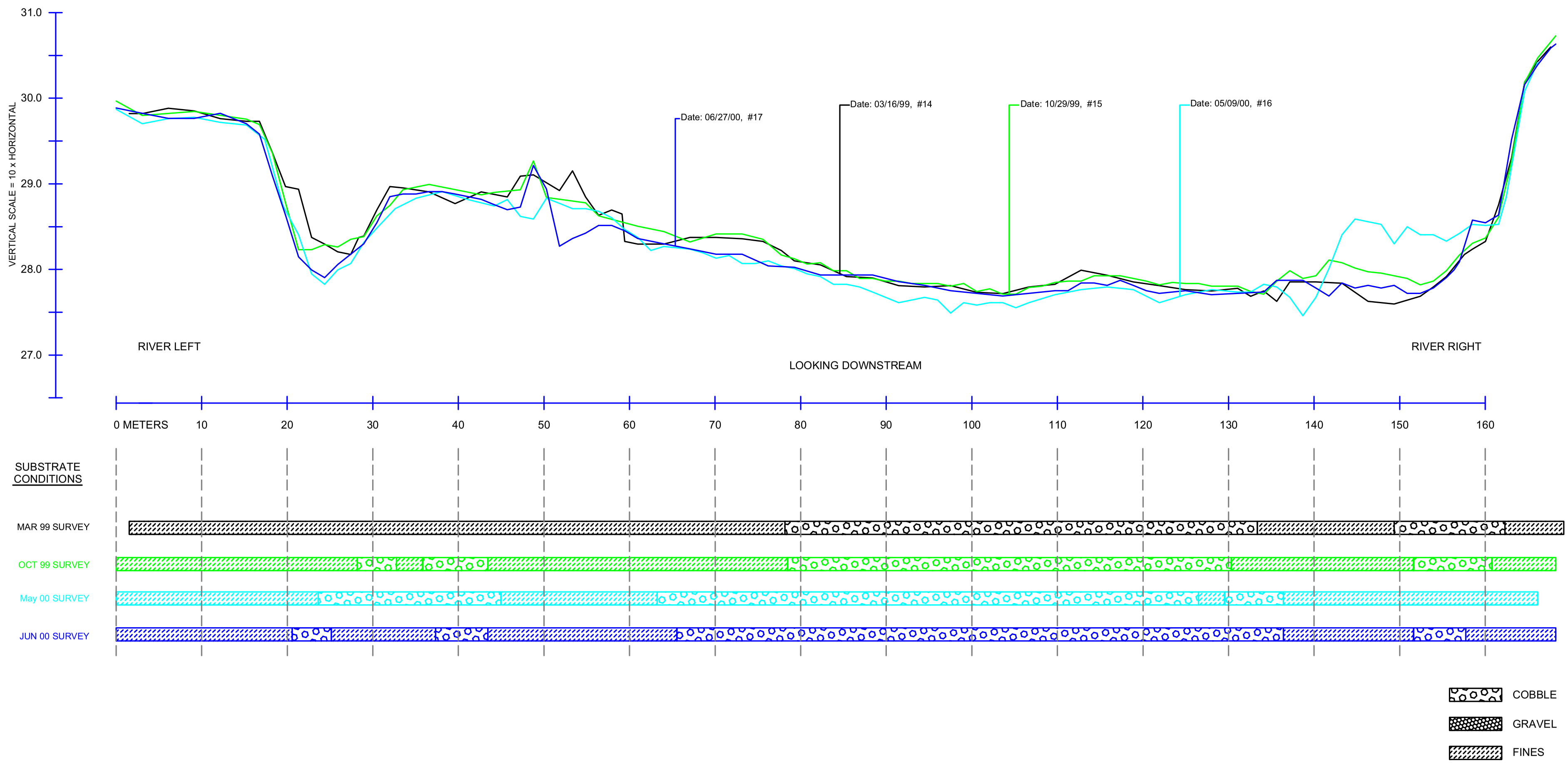


TRANSECT CS5-03 (RT05)
PHOTO 4-1
SALLIES SPRING QUAD.

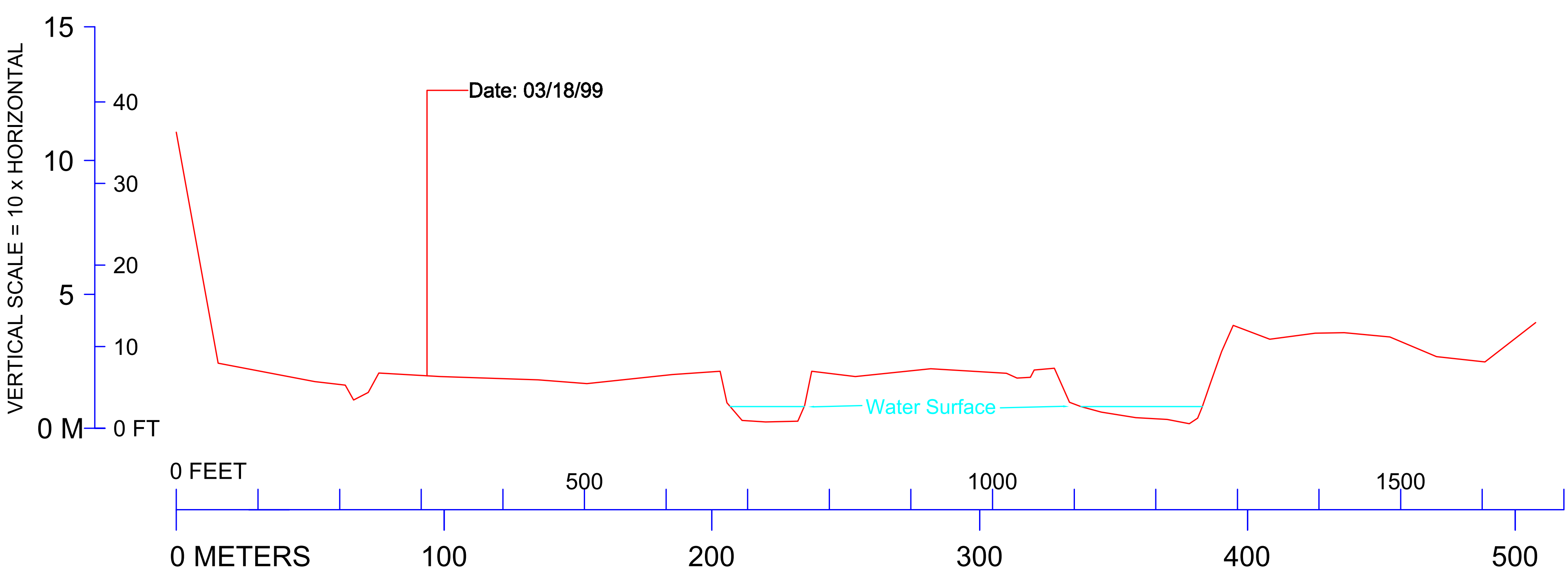


FILE: RT05-GIS.DWG DATE: 09/04/01

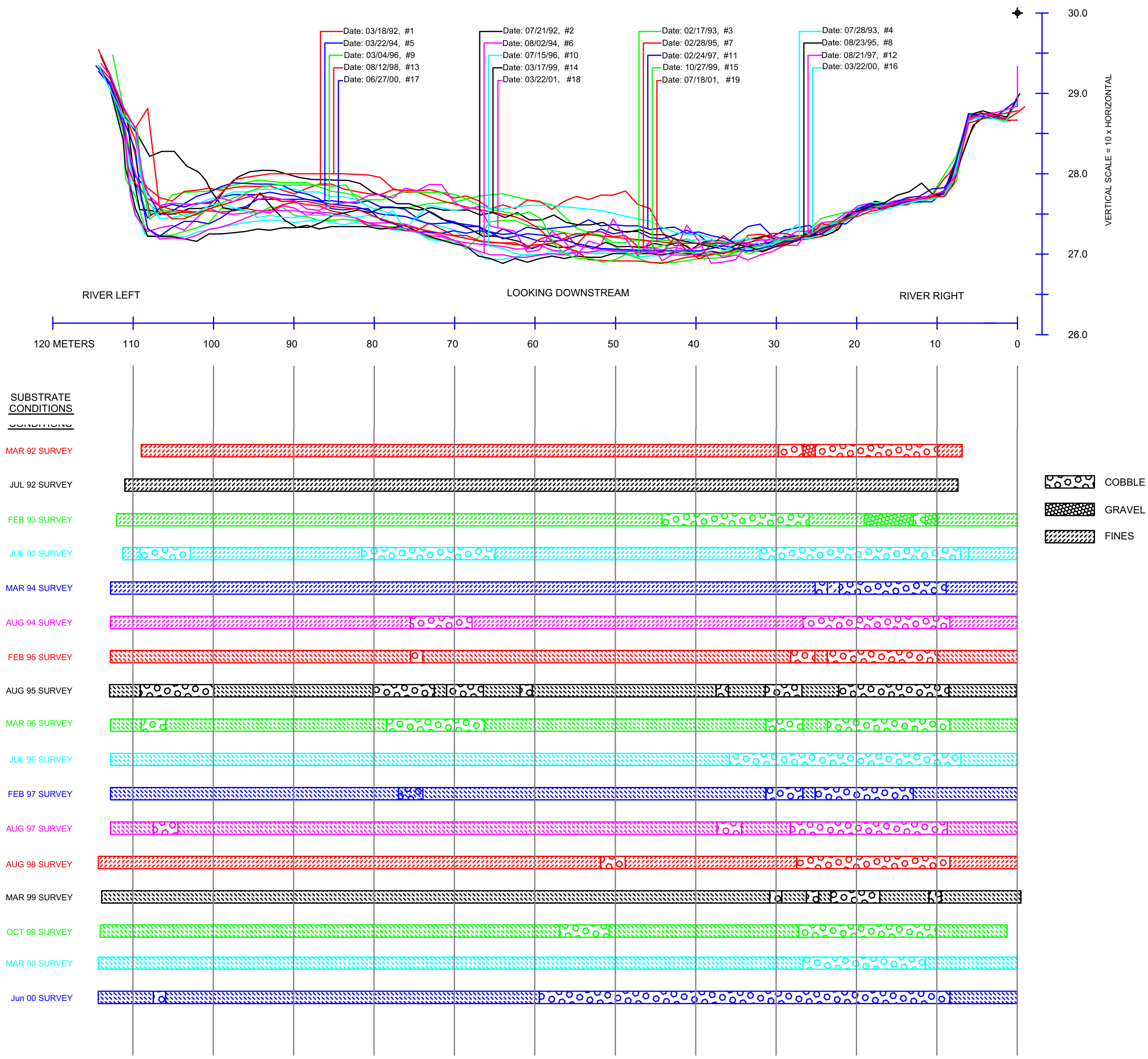
TRANSECT CS5-03 (RT05)
PHOTO 4-1
SALLIES SPRING QUAD.



Valley Wide Cross-Section CS3-02 (RM 82.2)
USGS 7.5 Min Quadrangle: Bluff, UT

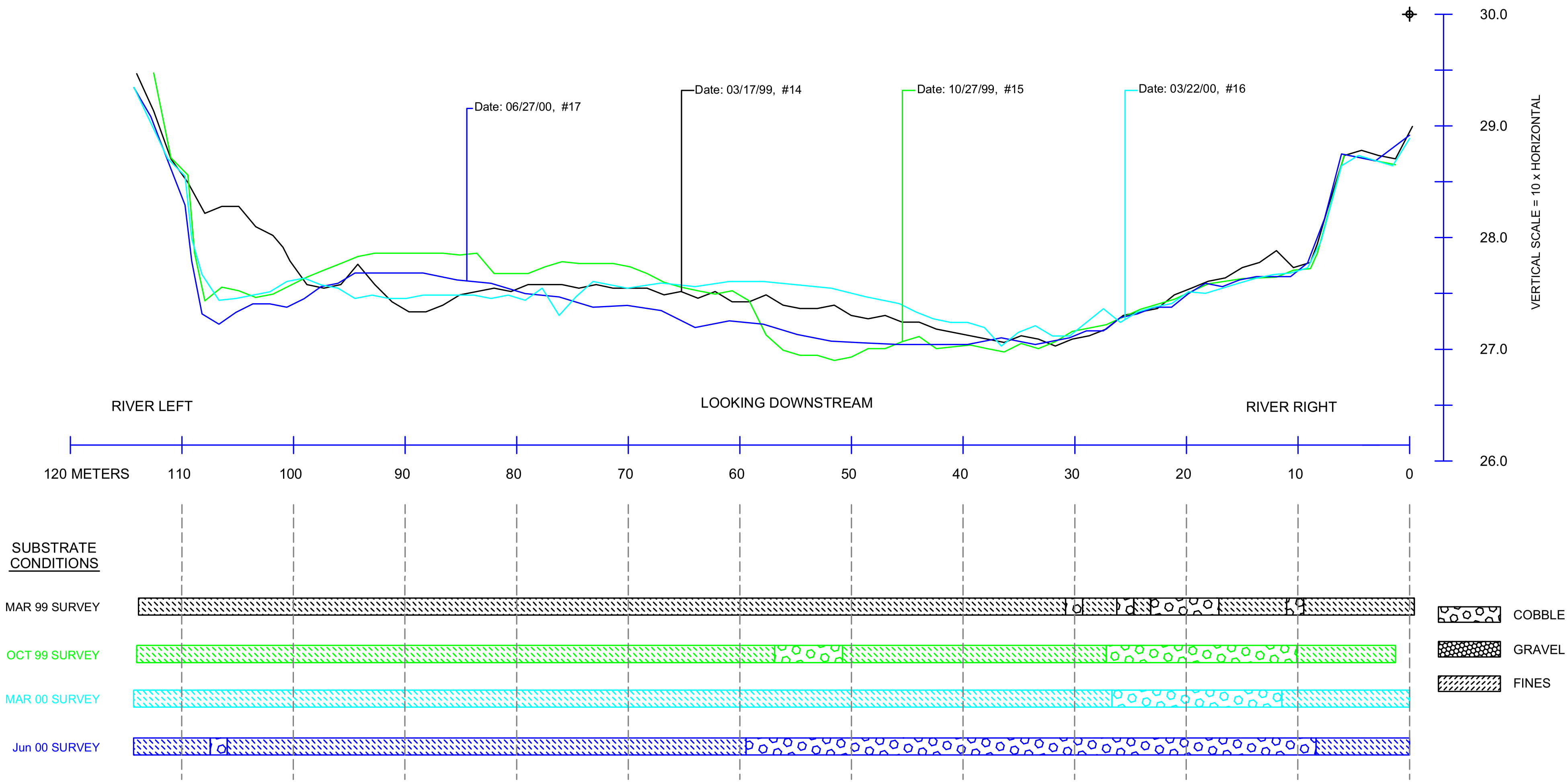


TRANSECT CS4-01 (RT06)
PHOTO 4-11
SALLIES SPRING QUAD.

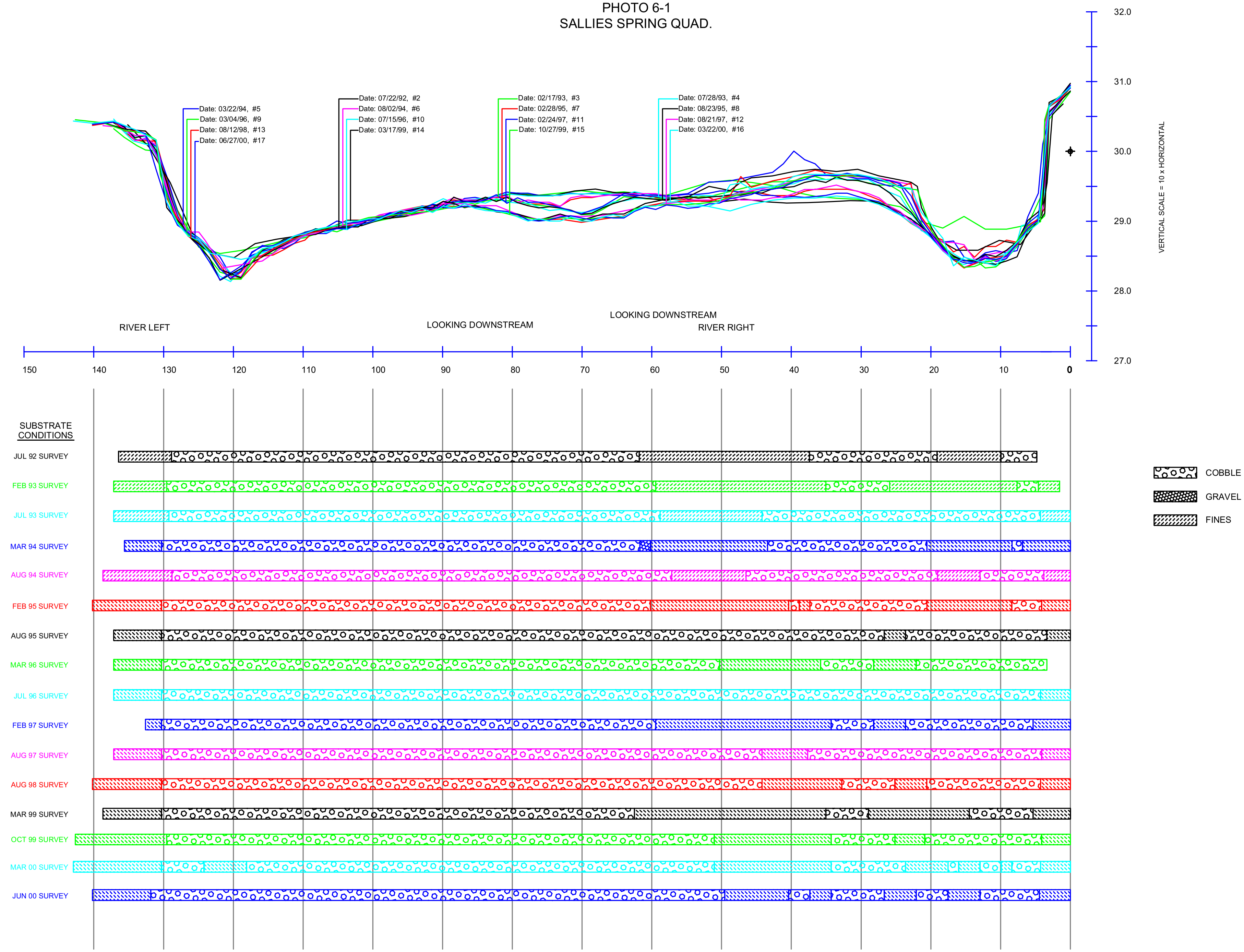


FILE: RT06-GIS.DWG DATE: 09/04/01

TRANSECT CS4-01 (RT06)
PHOTO 4-11
SALLIES SPRING QUAD.

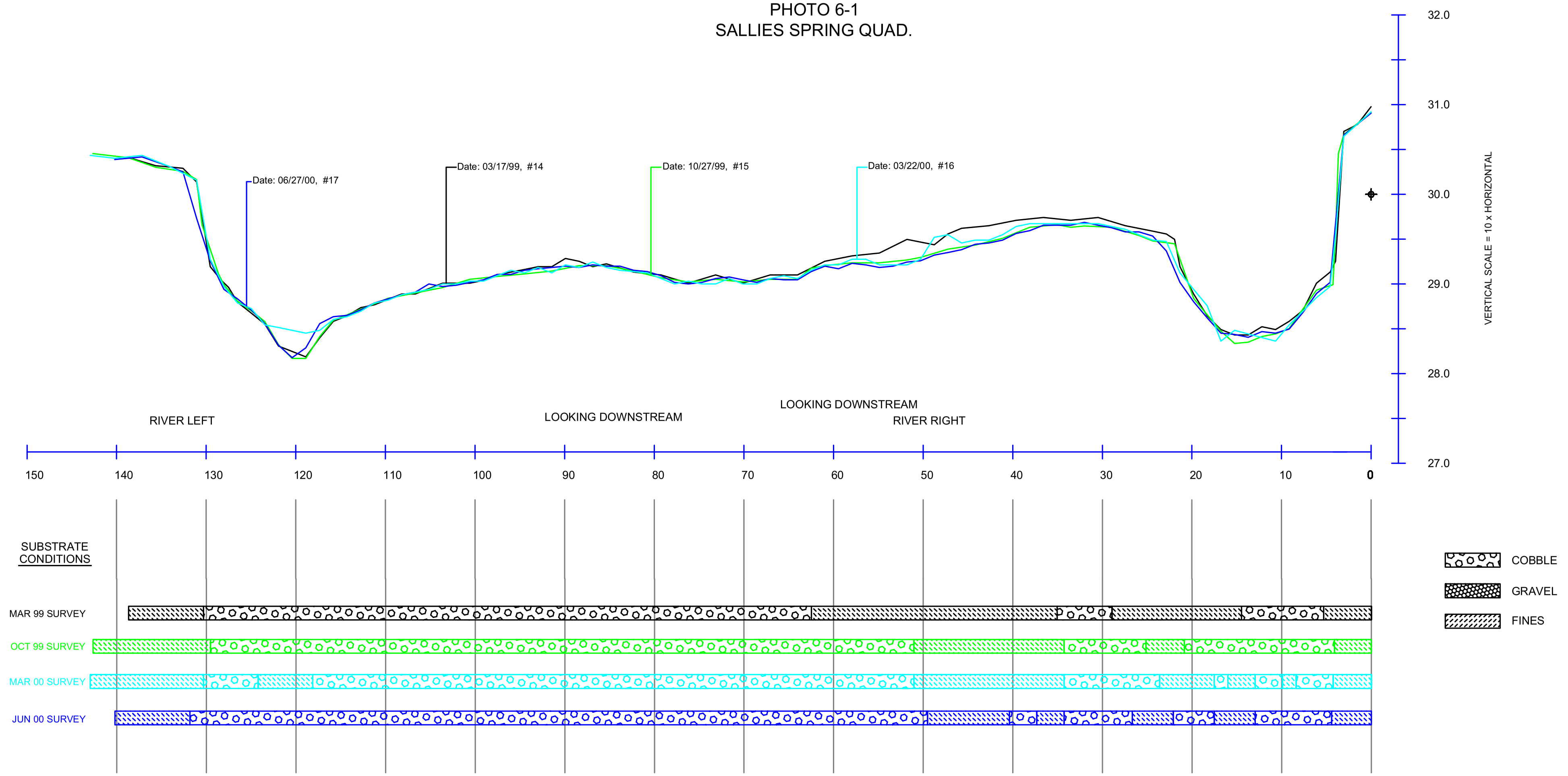


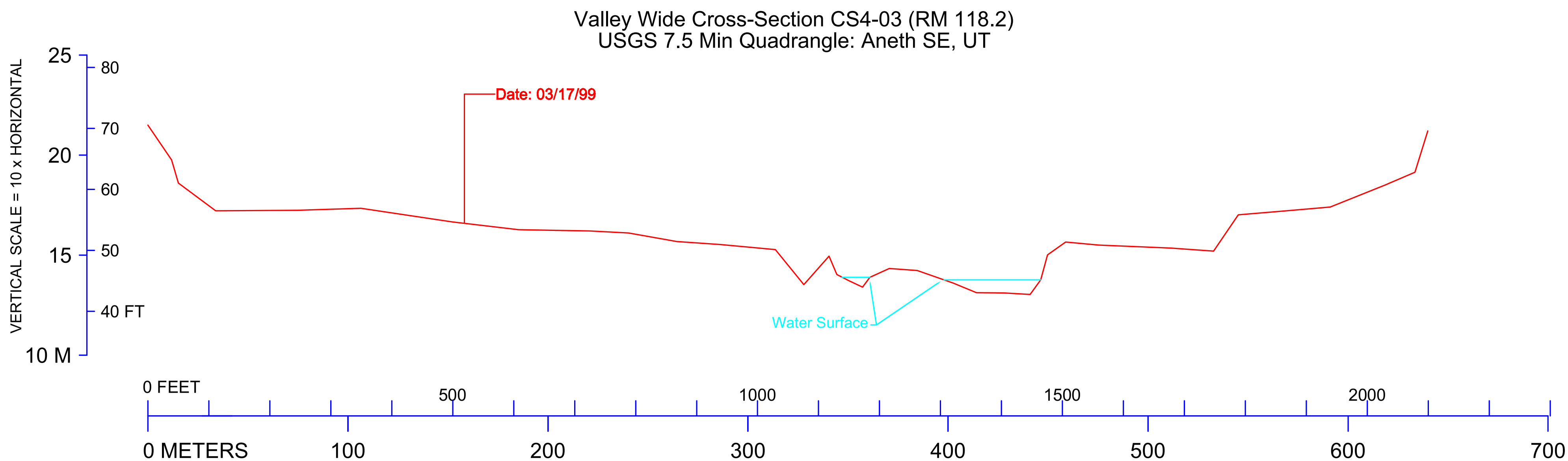
TRANSECT RT07
PHOTO 6-1
SALLIES SPRING QUAD.



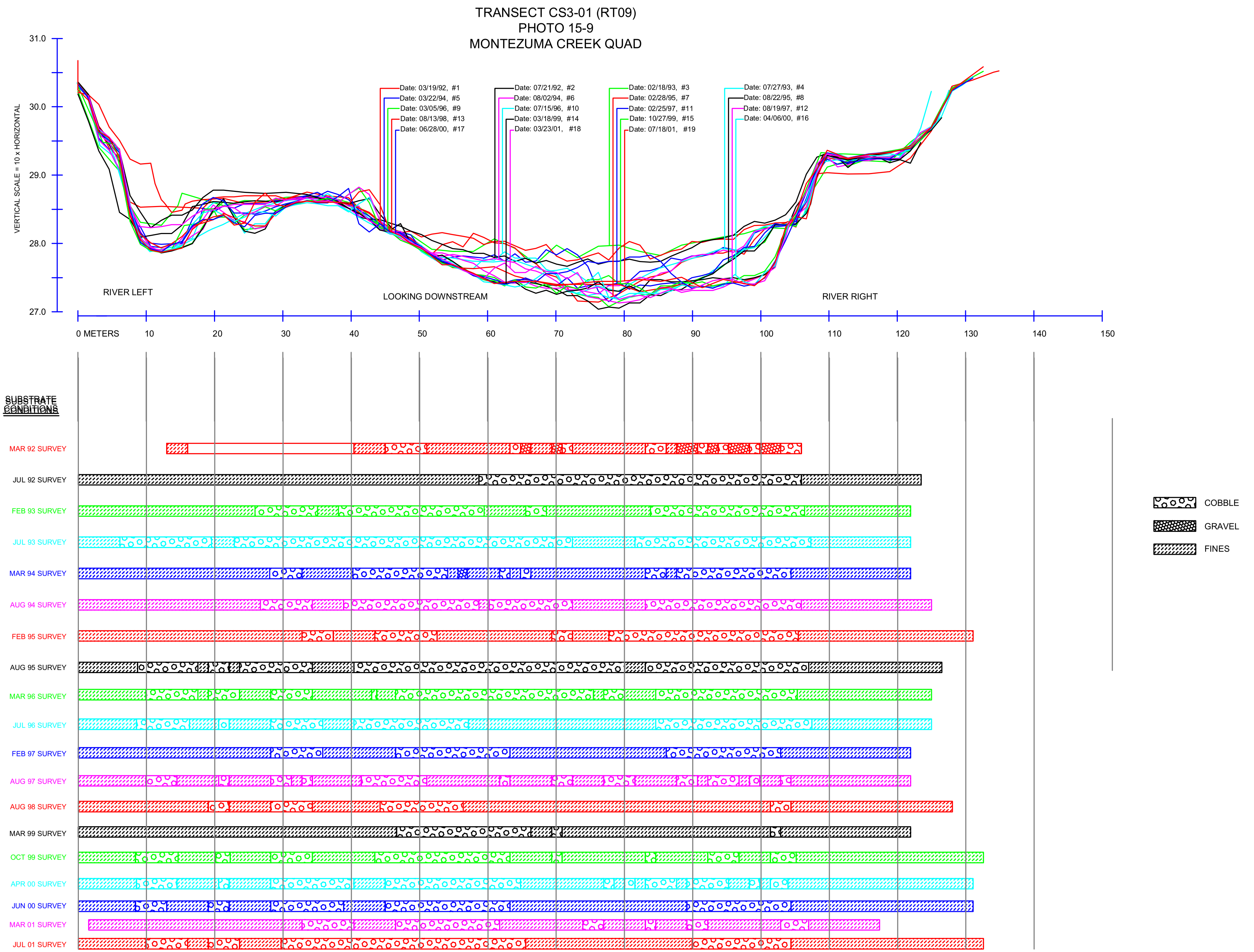
FILE: RT07-GIS.DWG DATE: 09/05/01

TRANSECT RT07
PHOTO 6-1
SALLIES SPRING QUAD.



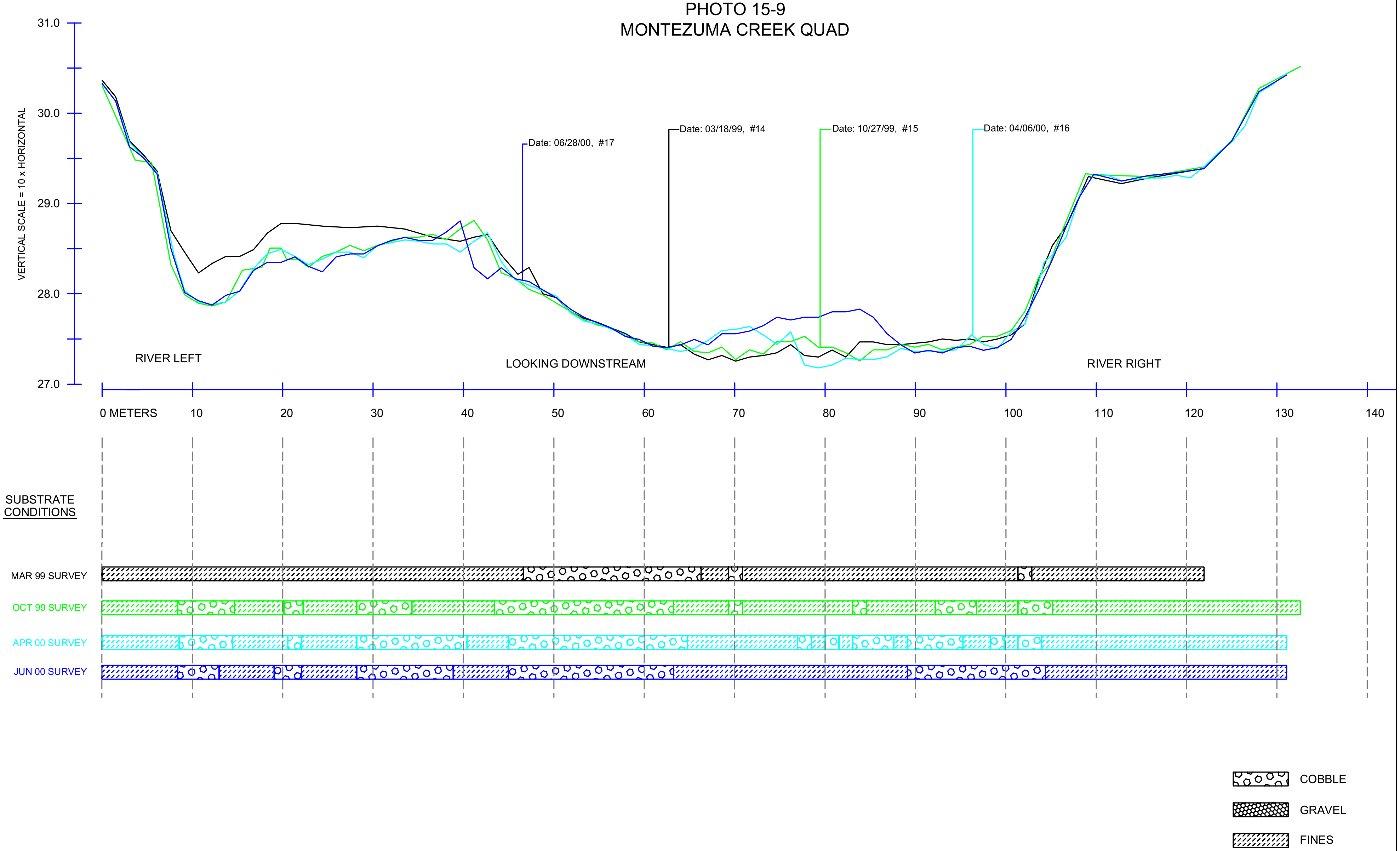


Valley Wide Cross-Section CS4-03 (RM 118.2)
USGS 7.5 Min Quadrangle: Aneth SE, UT
Date: 03/17/99
Water Surface
VERTICAL SCALE = 10 x HORIZONTAL
25
20
15
10 M
80
70
60
50
40 FT
0 FEET
500
1000
1500
2000
0 METERS
100
200
300
400
500
600
700

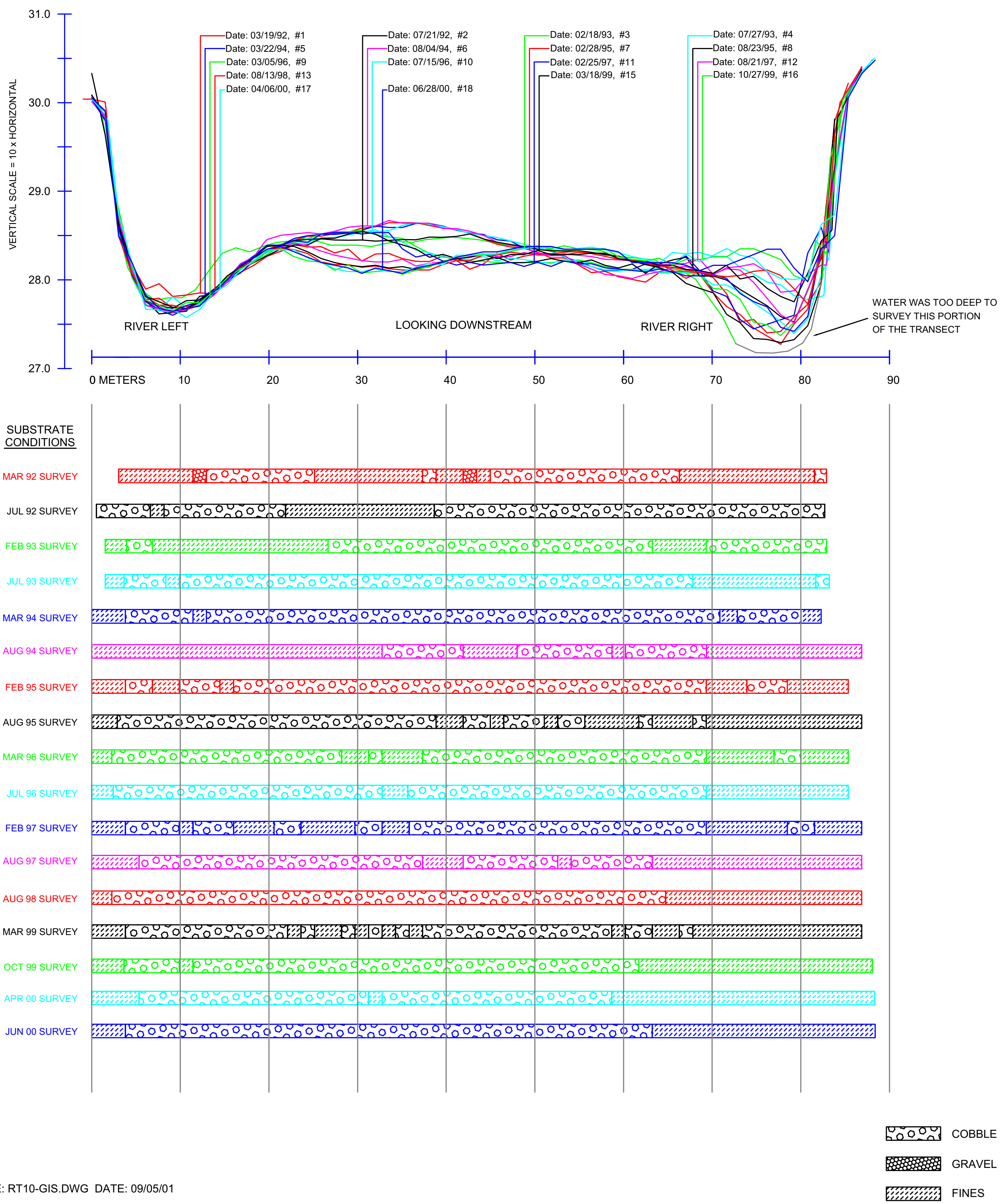


FILE: RT09-GIS.DWG DATE: 09/05/01

TRANSECT CS3-01 (RT09)
PHOTO 15-9
MONTEZUMA CREEK QUAD

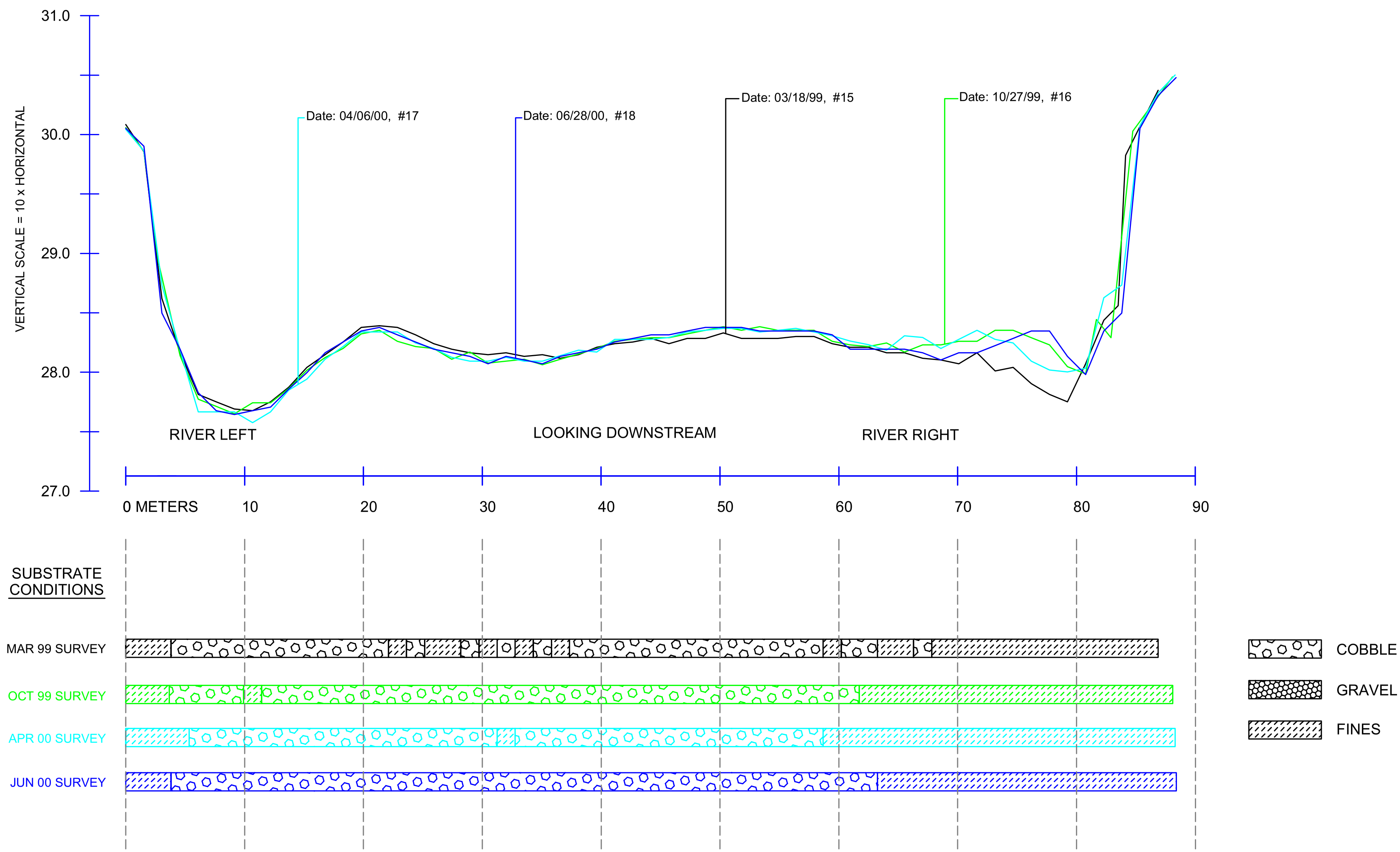


TRANSECT CS3-02 (RT10)
PHOTO 16-5
BLUFF QUAD.

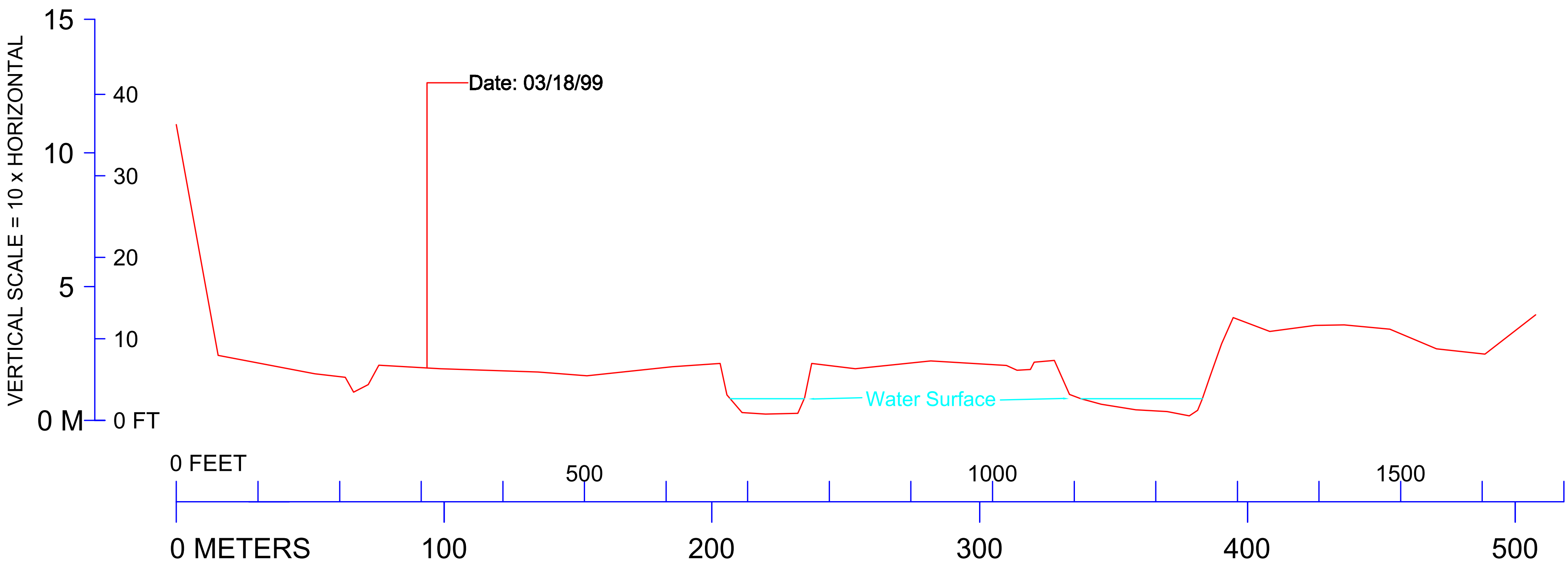


FILE: RT10-GIS.DWG DATE: 09/05/01

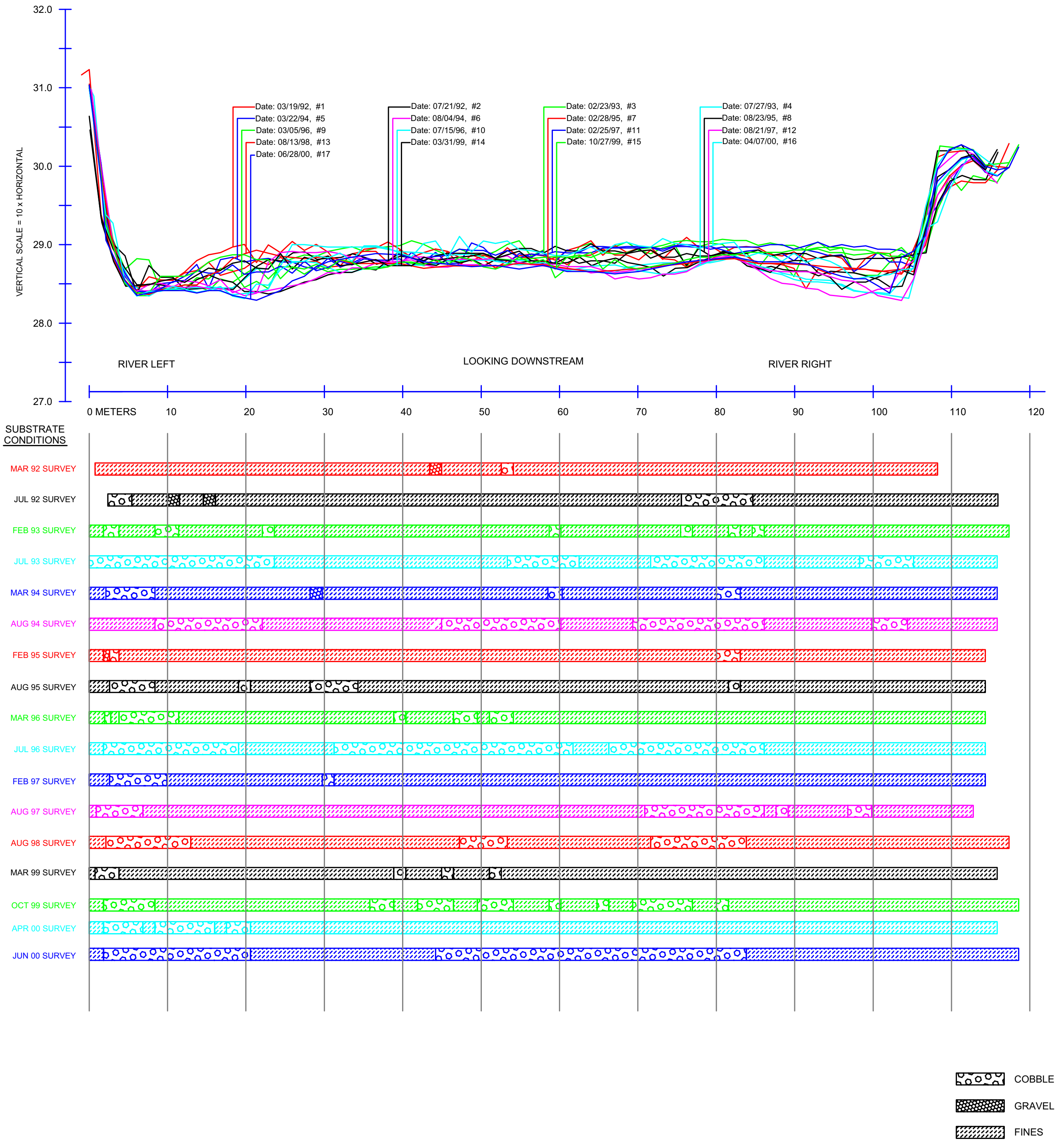
TRANSECT CS3-02 (RT10)
PHOTO 16-5
BLUFF QUAD.



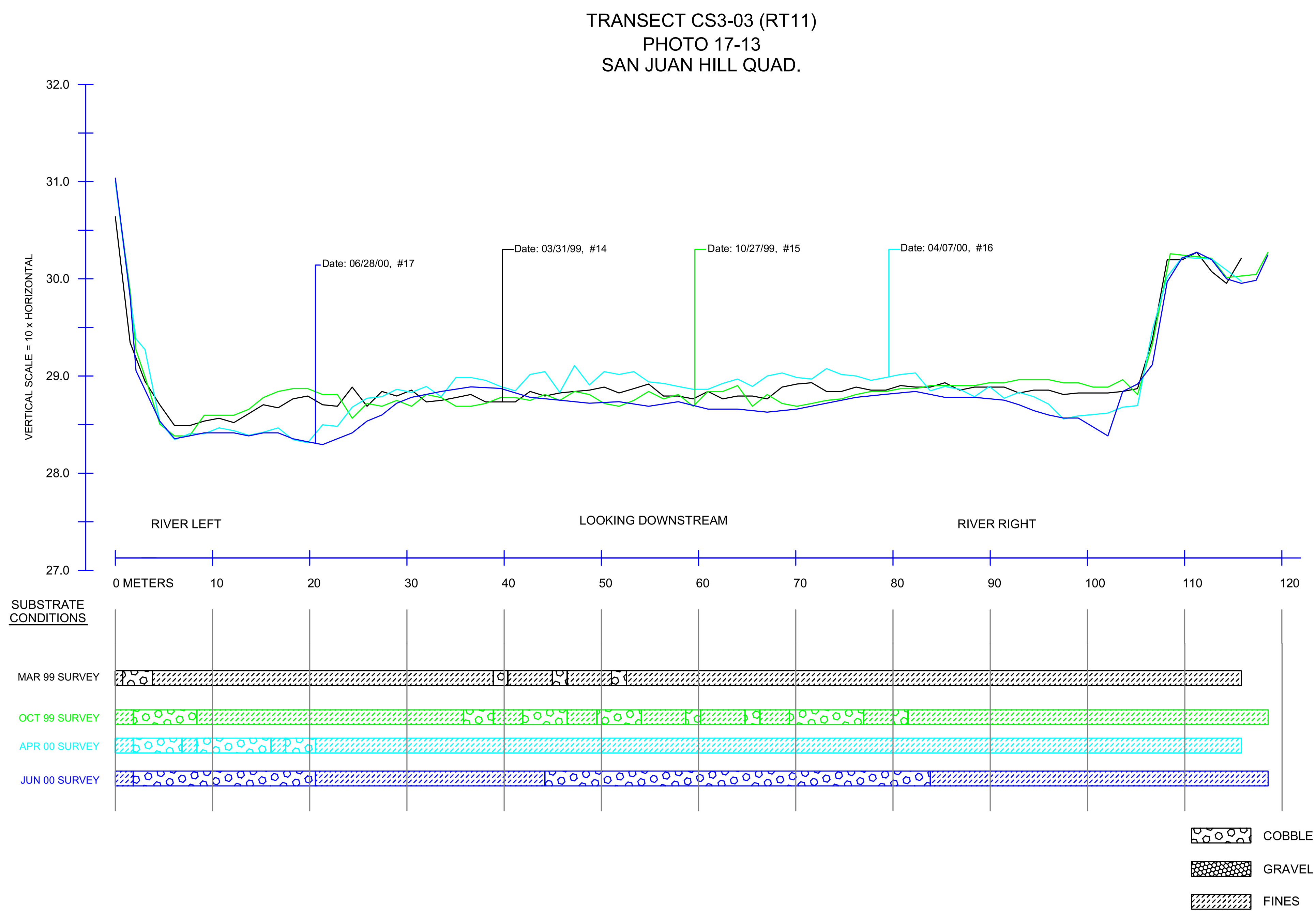
Valley Wide Cross-Section CS3-02 (RM 82.2)
USGS 7.5 Min Quadrangle: Bluff, UT



TRANSECT CS3-03 (RT11)
PHOTO 17-13
SAN JUAN HILL QUAD.

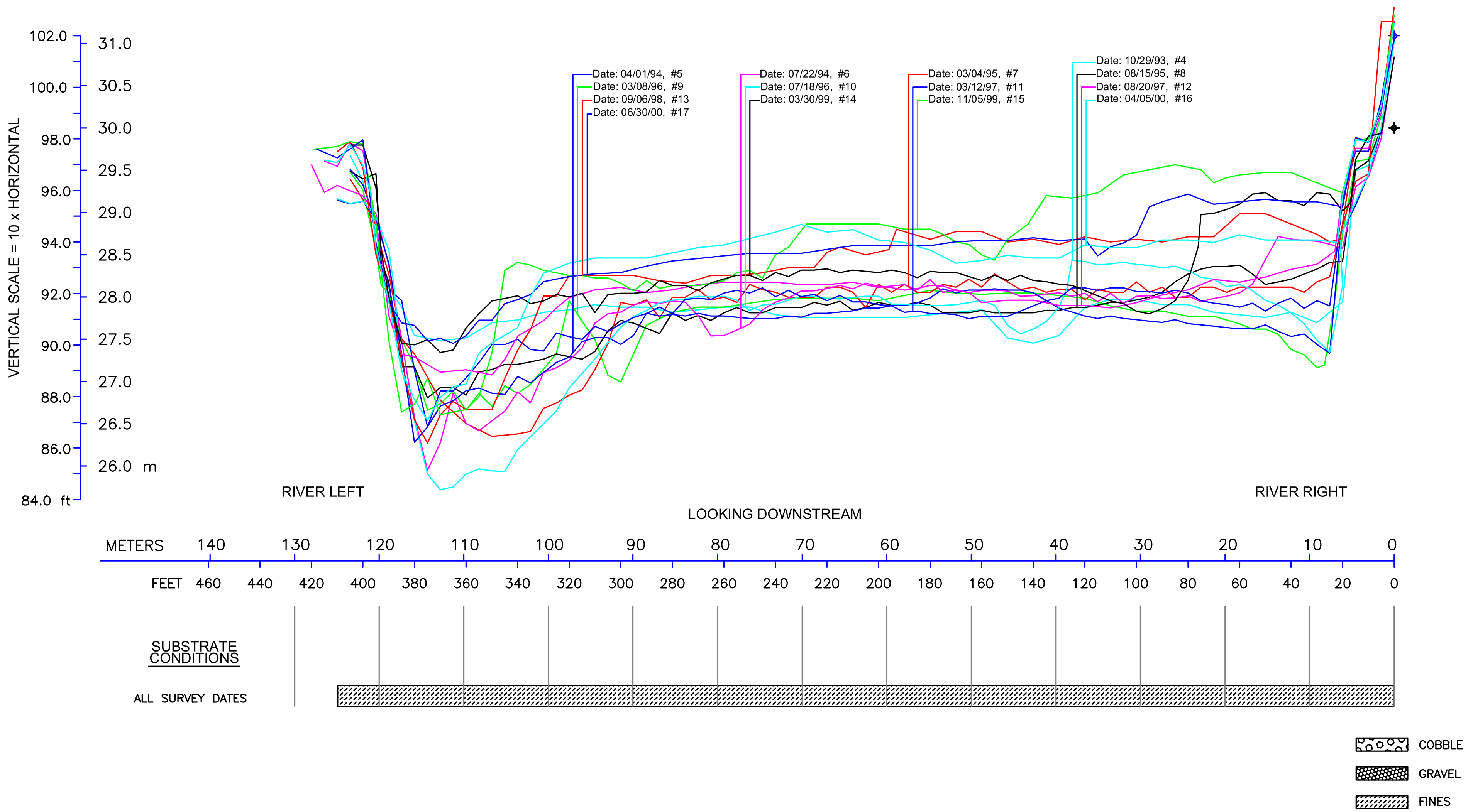


FILE: RT11-GIS.DWG DATE: 09/05/01



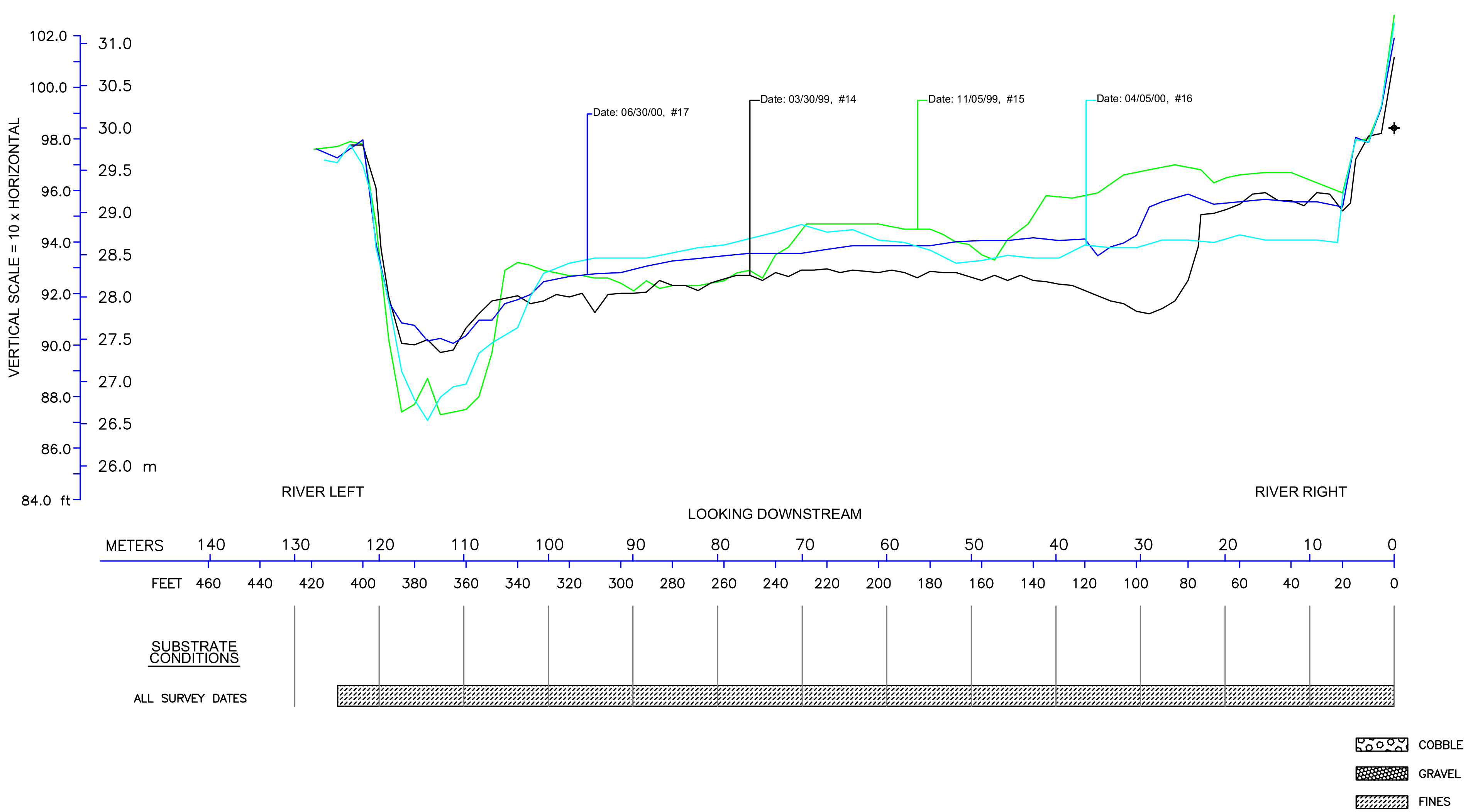
TRANSECT CS3-03 (RT11)
PHOTO 17-13
SAN JUAN HILL QUAD.
32.0
31.0
30.0
29.0
28.0
27.0
VERTICAL SCALE = 10 x HORIZONTAL
Date: 06/28/00, #17
Date: 03/31/99, #14
Date: 10/27/99, #15
Date: 04/07/00, #16
RIVER LEFT
LOOKING DOWNSTREAM
RIVER RIGHT
0 METERS
10
20
30
40
50
60
70
80
90
100
110
120
SUBSTRATE CONDITIONS
MAR 99 SURVEY
OCT 99 SURVEY
APR 00 SURVEY
JUN 00 SURVEY
COBBLE
GRAVEL
FINES

TRANSECT CS1-01 (CLAY HILLS 1)



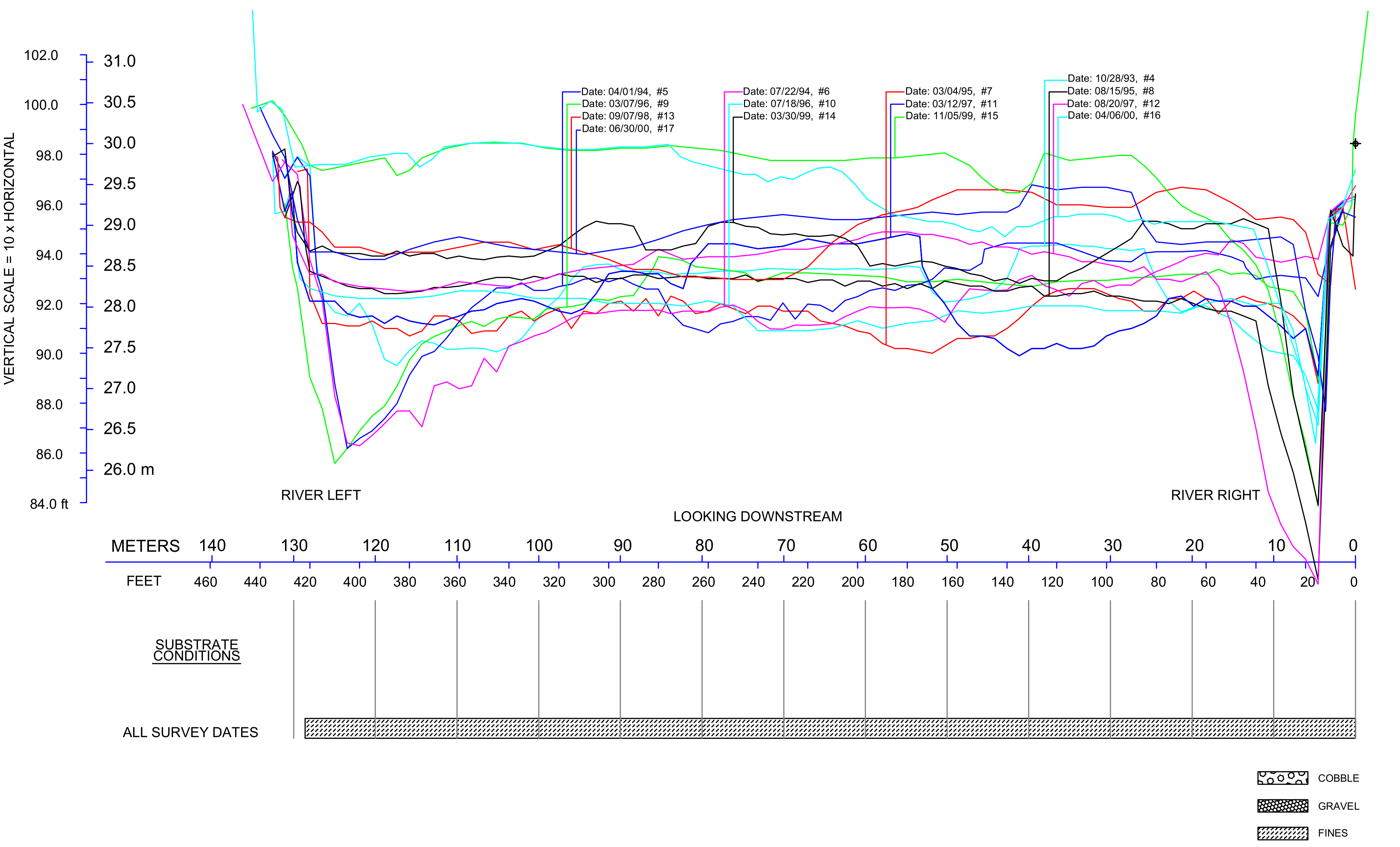
FILE: CH1-GIS.DWG DATE: 10/13/00

TRANSECT CS1–01 (CLAY HILLS 1)



FILE: CH1–GIS.DWG DATE: 10/13/00

TRANSECT CS1-02 (CLAY HILLS 2)



TRANSECT CS1-02 (CLAY HILLS 2)