APPENDIX

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Appendix A- Lithologic descriptions

Appendix A gives the full lithologic descriptions of rock units mapped in the Pinole Creek watershed. All information is from:
Graymer, R.W., Jones, D.L., and Brabb, E.E., 1994. Preliminary geologic map emphasizing bedrock formations in Contra Costa County, California: A digital database. U.S. Geological Survey Open-file Report 94-622. http://wrgis.wr.usgs.gov/open-file/of94-622/

Description of Units:
Qu Surficial deposits, undivided (Pleistocene and Holocene).
Tn Neroly Sandstone (Miocene) -- Blue, volcanic-rich, shallow marine sandstone, with minor shale, siltstone, tuff, and andesitic conglomerate.
Tc Cierbo Sandstone (Miocene) -- Blue, brown, gray, and white marine sandstone, minor conglomerate, tuff, and shale.
Tbr Briones Formation (Miocene) -- Sandstone, siltstone, conglomerate and shell breccia. The Briones Formation in this assemblage contains a tuffaceous layer with a K/Ar age of 14.5+0.4 Ma (Lindquist and Morganthaler, 1991).

In the southern part of the assemblage, divided locally into:

Tbg G member of Wagner (1978) -- Massive sandstone, pebble conglomerate, and shell breccia.
Locally subdivided into:
Tbf F member of Wagner (1978) -- Fine -grained feldspathic sandstone and locally prominent brown shale.
Tbe E member of Wagner (1978) -- Medium-grained sandstone with abundant shell breccia beds; lithologically similar to unit Tbg.
Tbd D member of Wagner (1978) -- Massive, medium-grained sandstone with local conglomerate layers.

In the northern part of the assemblage, divided locally into:

Tbu Upper sandstone and shale member.
Tbh Hercules Shale Member; gray shale and siltstone.
Tbl Lower sandstone and siltstone member.

Tro Rodeo Shale, Hambre Sandstone, Tice Shale, and Oursan Sandstone, undivided (Miocene)
Tr Rodeo Shale (Miocene) -- Brown siliceous shale with yellow carbonate concretions.
Th Hambre Sandstone (Miocene) -- Massive, medium-grained sandstone, weathers brown.
Tt Tice Shale (Miocene) -- Brown siliceous shale.

To Oursan Sandstone (Miocene) -- Greenish gray, medium-grained sandstone with calcareous concretions.
Tcs Claremont Shale (Miocene) -- Brown siliceous shale with yellow carbonate concretions and minor interbedded chert.
Ts Sobrante Sandstone (Miocene) -- Massive white, medium-grained calcareous sandstone.
Tts Tuffaceous sandstone (Oligocene or Miocene?) -- Light-gray tuffaceous sandstone, minor conglomerate and siltstone, marine. May be equivalent to Kirker Tuff in Assemblage VI.
Tsr San Ramon Sandstone (Oligocene and/or Miocene) -- Massive, medium to coarse-grained, fossiliferous, marine sandstone.
Tshc Shale and claystone (Eocene) -- Also contains minor sandstone.

Tcgl Conglomerate, sandstone, siltstone (Miocene and Pliocene) -- Contains abundant clasts of Claremont chert. Includes rhyolite tuff and tuff breccia (Tcglt), correlated with the 5.7 to 6.1 Ma Roblar tuff of Sonoma County (Sarna-Wojcicki, written communication,1990).
Tcglt Rhyolite tuff and tuff breccia
Tut Tuff (Miocene) -- Tuffaceous sandstone containing pumice fragments.
Tdi Diatomite (Miocene) -- Light gray to white with minor brown shale.
Tsa Sandstone (Miocene) -- Massive, light gray, fine to medium - grained.
Tmu Mudstone, shale, and siltstone (Miocene).

Appendix B- Rainfall data

This section tabulates the raw rainfall data collected and analyzed in the Rainfall and Pinole Creek Flow section of this report.

Table B-1. Duncan Canyon Rainfall totals for Water Year 2004.

Duncan Canyon Rainfall 2003-2004

Date	Rainfall	Storm number	Storm total	Year-to-date
11/2/2003	0.15			0.15
11/7-9/03	0.85			1
11/13-14/03	0.5			1.5
11/29-30/03	1.5	1	1.5	3
12/4-6/03	1.3	2	1.3	4.3
12/9-10/03	1.5	3	1.5	5.8
12/13/2003	0.6			6.4
12/19-20/03	0.85	4	0.85	7.25
12/23-25/03	1.25	5	1.25	8.5
12/29/2003	3	6	3	11.5
1/1/2004	2.50	7	2.5	14
1/5-9/04	0.65			14.65
1/23/2004	0.25			14.9
1/26/2004	0.15			15.05
1/30/2004	0.1			15.15
2/2/2004	1.5	8	1.5	16.65
2/13/2004	0.05			16.7
2/15-17/04	3.15	9	3.15	19.85
2/20-22/04	0.35			20.2
2/24/2004	0.1			20.3
2/25/2004	2			22.3
2/26/2004	0.2			22.5
2/27/2004	0.05	10	2.25	22.55
3/1/2004	0.15			22.7
3/25/2004	0.5			23.2
4/18/2004	0.15			23.35
4/20/2004	0.25			23.6
5/28/2004	0.15			23.75

Table B-2. Briones and Richmond daily rainfall totals for November and December 2003.

Day	Briones (in)	Richmond (in)	Day	Briones (in)	Richmond (in)
11/1/2003	0	0	12/1/2003	0.21	0.96
11/2/2003	0.01	0.1	12/2/2003	0.08	0.2
11/3/2003	0.09	0.1	12/3/2003	0	0
11/4/2003	0	0	12/4/2003	0.17	0.08
11/5/2003	0	0	12/5/2003	0.12	0.63
11/6/2003	0.11	0	12/6/2003	0.63	0.7
11/7/2003	0.03	0.03	12/7/2003	0.01	0.64
11/8/2003	0.63	0	12/8/2003	0	0
11/9/2003	0.11	0.71	12/9/2003	0.27	0.2
11/10/2003	0	0	12/10/2003	0.63	0.98
11/11/2003	0	0	12/11/2003	0.01	0.53
11/12/2003	0	0	12/12/2003	0.04	0
11/13/2003	0	0	12/13/2003	0.04	0.07
11/14/2003	0.29	0.19	12/14/2003	0.66	0.4
11/15/2003	0.09	0.4	12/15/2003	0	0
11/16/2003	0	0	12/16/2003	0	0
11/17/2003	0.03	0	12/17/2003	0	0
11/18/2003	0	0	12/18/2003	0	0
11/19/2003	0	0	12/19/2003	0.33	0.24
11/20/2003	0	0	12/20/2003	0.32	0.71
11/21/2003	0	0	12/21/2003	0.04	0.09
11/22/2003	0	0	12/22/2003	0	0
11/23/2003	0	0	12/23/2003	0.4	0.4
11/24/2003	0	0	12/24/2003	0.68	0.73
11/25/2003	0	0	12/25/2003	0	0.03
11/26/2003	0	0	12/26/2003	0	0
11/27/2003	0	0	12/27/2003	0	0
11/28/2003	0	0	12/28/2003	0	0
11/29/2003	0	0	12/29/2003	2.57	2
11/30/2003	0.42	0.55	12/30/2003	0.01	0.3
			12/31/2003	0	0

Table B-3. Briones and Richmond daily rainfall totals for January and February 2004.

Day	Briones (in)	Richmond (in)	Day	Briones (in)	Richmond (in)
1/1/2004	2.64	2	2/1/2004	0.04	0.13
1/2/2004	0.08	0.29	2/2/2004	1.12	1.1
1/3/2004	0	0	2/3/2004	0.1	0.2
1/4/2004	0	0	2/4/2004	0.02	0
1/5/2004	0	0	2/5/2004	0	0
1/6/2004	0.04	0	2/6/2004	0.04	0
1/7/2004	0.06	0.1	2/7/2004	0	0.1
1/8/2004	0	0	2/8/2004	0	0
1/9/2004	0.14	0.31	2/9/2004	0	0
1/10/2004	0.03	0	2/10/2004	0	0
1/11/2004	0	0	2/11/2004	0	0
1/12/2004	0	0	2/12/2004	0	0
1/13/2004	0.01	0	2/13/2004	0	0.01
1/14/2004	0.04	0	2/14/2004	0	0
1/15/2004	0	0	2/15/2004	0	0
1/16/2004	0	0	2/16/2004	1.18	1.4
1/17/2004	0	0	2/17/2004	1.52	0.4
1/18/2004	0	0	2/18/2004	0.75	0.53
1/19/2004	0.01	0	2/19/2004	0	0
1/20/2004	0.01	0	2/20/2004	0	0
1/21/2004	0	0	2/21/2004	0.03	0
1/22/2004	0	0	2/22/2004	0.13	0.16
1/23/2004	0.04	0	2/23/2004	0	0
1/24/2004	0.14	0.2	2/24/2004	0.09	0
1/25/2004	0	0	2/25/2004	2.48	1.91
1/26/2004	0.03	0	2/26/2004	0.49	0.2
1/27/2004	0.16	0.2	2/27/2004	0.05	0.03
1/28/2004	0	0	2/28/2004	0	0
1/29/2004	0.01	0	2/29/2004	0	0
1/30/2004	0.08	0.1			
1/31/2004	0	0			

Table B-4. Briones and Richmond daily rainfall totals for March and April 2004.

Day	Briones (in)	Richmond (in)	Day	Briones (in)	Richmond (in)
3/1/2004	0.15	0.14	4/1/2004	0	0.13
3/2/2004	0	0.29	4/2/2004	0	0.02
3/3/2004	0	0.11	4/3/2004	0	0.06
3/4/2004	0	0.09	4/4/2004	0	0.05
3/5/2004	0	0.16	4/5/2004	0	0.09
3/6/2004	0	0.07	4/6/2004	0	0.07
3/7/2004	0	0.12	4/7/2004	0	0.04
3/8/2004	0	0.15	4/8/2004	0	0.06
3/9/2004	0	0.12	4/9/2004	0	0.01
3/10/2004	0	0.18	4/10/2004	0	0.09
3/11/2004	0	0.04	4/11/2004	0	0.09
3/12/2004	0	0.17	4/12/2004	0	0.04
3/13/2004	0	0.22	4/13/2004	0	0.03
3/14/2004	0	0.06	4/14/2004	0	0.03
3/15/2004	0	0.17	4/15/2004	0	0.05
3/16/2004	0	0.16	4/16/2004	0	0.04
3/17/2004	0	0.12	4/17/2004	0	0.05
3/18/2004	0	0.07	4/18/2004	0.1	0.03
3/19/2004	0	0.02	4/19/2004	0.06	0.08
3/20/2004	0	0.12	4/20/2004	0.07	0.02
3/21/2004	0	0.11	4/21/2004	0	0.02
3/22/2004	0	0.1	4/22/2004	0	0.01
3/23/2004	0	0.09	4/23/2004	0	0.07
3/24/2004	0	0.06	4/24/2004	0	0.07
3/25/2004	0.79	0.15	4/25/2004	0	0.06
3/26/2004	0	0.12	4/26/2004	0	0.02
3/27/2004	0.01	0.08	4/27/2004	0	0.01
3/28/2004	0	0.06	4/28/2004	0	0.01
3/29/2004	0	0.05	4/29/2004	0	0
3/30/2004	0	0.05	4/30/2004	0	0.02
3/31/2004	0	0.13			

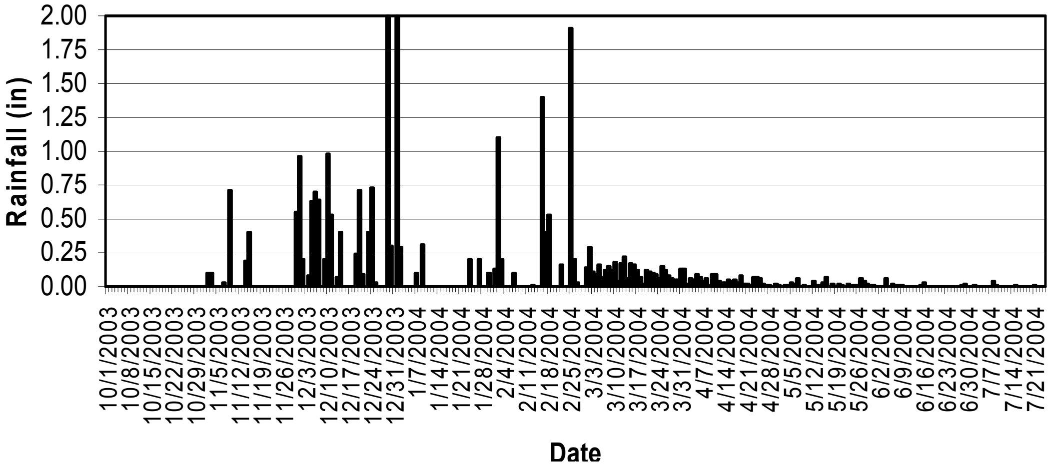

Figure B-1. Daily rainfall totals for Richmond, October, 2003 to July, 2004.

Table B-5. Monthly rainfall totals for Richmond, November 2003 to October 2004.

Month	Rainfall (in)	Percentage
Nov	3.1	13
Dec	4.44	19
Jan	4.86	21
Feb	3.86	17
Mar	3.07	13
Apr	1.54	7
May	0.5	2
Jun	0.17	1
Jul	0.04	0
Aug	0.08	0
Sep	0.24	1
Oct	1.24	5

Appendix C- Stream flow data

Table C-1. Historic monthly mean stream flow at the USGS Pinole Creek gauge number 11182100.

YEAR	Monthly mean streamflow, in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1938												0.72
1939	0.73	0.85	1.01	0.43	0.22	0.027	0	0	0	0	0	0.018
1940	9.07	47.5	25	7.82	2.3	1	0.61	0.38	0.24	0.34	0.56	2.63
1941	19.1	37.9	24.1	28.5	3.84	1.71	0.89	0.57	0.43	0.38	0.72	7.54
1942	18.2	36.9	9.16	7.75	3.01	1.59	1.14	0.74	0.7	0.85	1.01	1.21
1943	20.4	5.32	7.32	2.75	1.26	0.92	0.85	0.45	0.33	0.36	0.42	0.53
1944	0.61	4.05	5.32	1.26	0.9	0.81	0.37	0.15	0.013	0.19	1.07	1.75
1945	0.88	14	4.57	1.55	0.87	0.58	0.33	0.14	0.033	0.17	0.44	6.6
1946	2.93	1.88	1.59	1.11	0.74	0.31	0.013	0.013	0	0.042	0.75	1.45
1947	0.99	0.89	1.5	0.4	0.097	0.12	0	0	0	0	0	0.006
1948	0.013	0.079	0.22	0.3	0	0	0	0	0	0	0	0.38
1949	1.4	1.78	6.19	0.32	0	0	0	0	0	0	0	0
1950	2.52	7.62	0.82	0.55	0.27	0	0	0	0	0.028	0.98	16.4
1951	13	7.3	5.3	1.85	1.17	0.62	0.35	0.19	0.19	0.23	0.65	7.73
1952	46.7	15.9	20	5.57	2.49	1.35	0.88	0.52	0.38	0.39	0.63	12
1953	19.4	4.5	3.85	2.55	1.5	0.85	0.38	0.35	0.24	0.21	0.44	0.43
1954	1.03	3.97	3.25	1.21	0.53	0.19	0.031	0.021	0	0.014	0.21	0.7
1955	2.81	2.29	1.04	0.74	0.37	0.16	0.035	0	0	0	0.018	35.1
1956	36.2	26.6	6.62	3.5	1.87	0.83	0.54	0.35	0.29	0.43	0.41	0.47
1957	0.79	2.33	2.76	0.74	0.78	0.21	0.037	0.005	0.007	0.14	0.14	0.52
1958	7.47	39.4	31.2	58.7	4.3	1.81	1.1	0.62	0.4	0.41	0.5	0.6
1959	1.06	7.45	1.34	0.77	0.27	0.075	0.003	0	0	0	0.07	0.16
1960	0.53	4.78	0.55	0.33	0.15	0	0	0	0	0	0.043	0.13
1961	0.25	0.21	0.38	0.11	0.003	0	0	0	0	0	0.003	0.006
1962	0.039	16.8	6.69	0.49	0.2	0.03	0	0	0	13.6	0.6	0.95
1963	18.3	20.7	11.2	19.2	3.56	1.33	0.61	0.41	0.29	0.39	0.77	0.61
1964	6.24	0.94	0.93	0.48	0.33	0.17	0	0	0	0	0.19	9.12
1965	22.6	3.19	2.07	4.03	0.92	0.54	0.13	0.003	0.1	0.081	0.58	3.05
1966	8.19	7.09	1.94	1.05	0.56	0.16	0.081	0.006	0.023	0.049	0.41	2.22
1967	39.2	6.15	17.1	22.9	4.05	2.29	0.81	0.25	0.24	0.31	0.53	0.68
1968	5.51	4.75	11.3	1.5	0.82	0.34	0.12	0.054	0.063	0.13	0.38	0.96
1969	35.9	43.2	17.2	7.5	2.26	1.12	0.42	0.19	0.16	0.29	0.33	5.58
1970	52.7	10.2	8.71	2.59	1.4	1.12	0.37	0.16	0.14	0.21	1.4	16.8
1971	8.86	3.23	4.97	1.96	1.15	0.61	0.21	0.079	0.083	0.18	0.31	0.8
1972	0.48	0.75	0.32	0.41	0.05	0	0	0	0	0	1.31	0.96
1973	46.1	35	11.6	3.36	1.08	0.51	0.15	0.13	0.14	0.26	3.88	8.89
1974	15.5	6.45	35.6	14.6	3.23	1.26	0.71	0.33	0.27	0.27	0.41	0.57
1975	0.65	5.47	16.3	3	1.26	0.51	0.28	0.16	0.11	0.14	0.14	0.19
1976	0.21	0.32	0.31	0.073	0	0	0	0	0	0	0	0.003
1977	0.3	0.39	0.31	0.095	0.029	0	0	0	0			
Mean of monthly streamflows	12	11.2	7.94	5.44	1.23	0.59	0.29	0.16	0.12	0.53	0.53	3.81

Table C-2. Historic peak flow measured at the USGS Pinole Creek gauge number 11182100.

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1939	Mar. 08, 1939	2.1	11	1958	Apr. 02, 1958	11.63	1,660
1940	Feb. 28, 1940	9.85	1,070	1959	Jan. 17, 1959	4.36	288
1941	Apr. 04, 1941	8.49	866	1960	Feb. 08, 1960	4.05	243
1942	Feb. 06, 1942	9.3	1,000	1961	Jan. 26, 1961	2.16	18
1943	Jan. 22, 1943	7.8	753	1962	Feb. 14, 1962	5.96	554
1944	Mar. 04, 1944	4.32	243	1963	Oct. 13, 1962	7.18	797
1945	Feb. 01, 1945	5.4	383	1964	Jan. 20, 1964	4.85	390
1946	Dec. 22, 1945	4.7	292	1965	Jan. 05, 1965	6.77	724
1947	Mar. 03, 1947	2.1	31	1966	Jan. 05, 1966	3.91	240
1948	Mar. 22, 1948	1.67	13	1967	Jan. 21, 1967	7.25	810
1949	Mar. 11, 1949	3.32	197	1968	Jan. 30, 1968	4.36	312
1950	Feb. 04, 1950	3.65	252	1969	Jan. 26, 1969	6.54	682
1951	Dec. 03, 1950	5.15	607	1970	Jan. 14, 1970	7.17	796
1952	Jan. 14, 1952	8.44	924	1971	Dec. 04, 1970	4.61	352
1953	Dec. 07, 1952	7.04	705	1972	Feb. 05, 1972	2.14	16
1954	Feb. 17, 1954	4.04	226	1973	Jan. 18, 1973	7.59	871
1955	Feb. 26, 1955	3.35	145	1974	Mar. 01, 1974	7.07	778
1956	Dec. 22, 1955	6.99	697	1975	Mar. 21, 1975		208[1,8]
1957	Feb. 28, 1957	3.47	162	1976	Feb. 29, 1976	1.86	5.7
				1977	Feb. 21, 1977	2.08	13

Table C-3. Estimated return interval discharges (in cubic feet per second) for Pinole Creek (Rantz, 1971). Q = discharge at the return interval (years).

Pinole Creek USGS 11182100	Discharge (cfs)
Q2	245
Q5	700
Q10	1086
Q25	1583
Q50	2375
Mean annual runoff (in)	4.8
Mean annual precipitation (in)	22
Runoff coefficient	22%

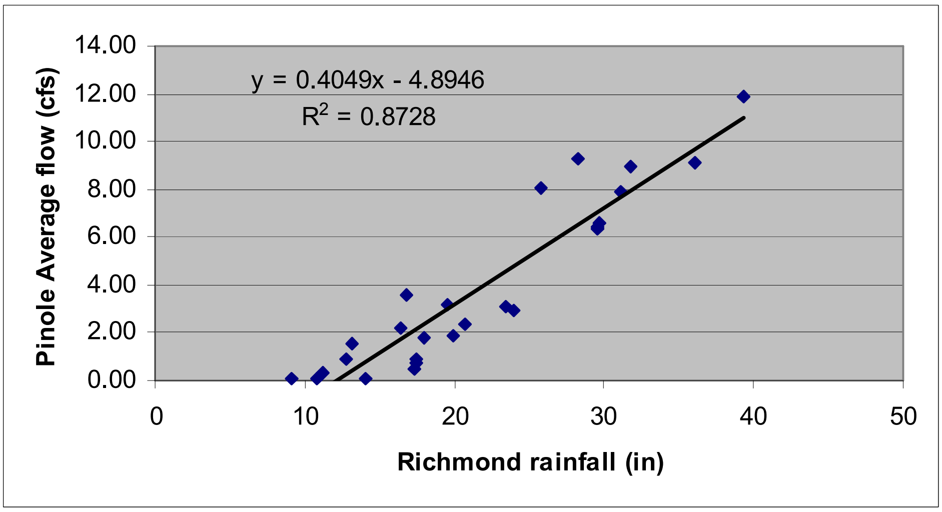

Figure C-1. Relationship between rainfall at the Richmond gauge and historic USGS measured flow in Pinole Creek.

This study measured stage and discharge at Pinole Valley Road bridge number 5, just downstream of the historic USGS gauge. The following data are from Water Year 2004.

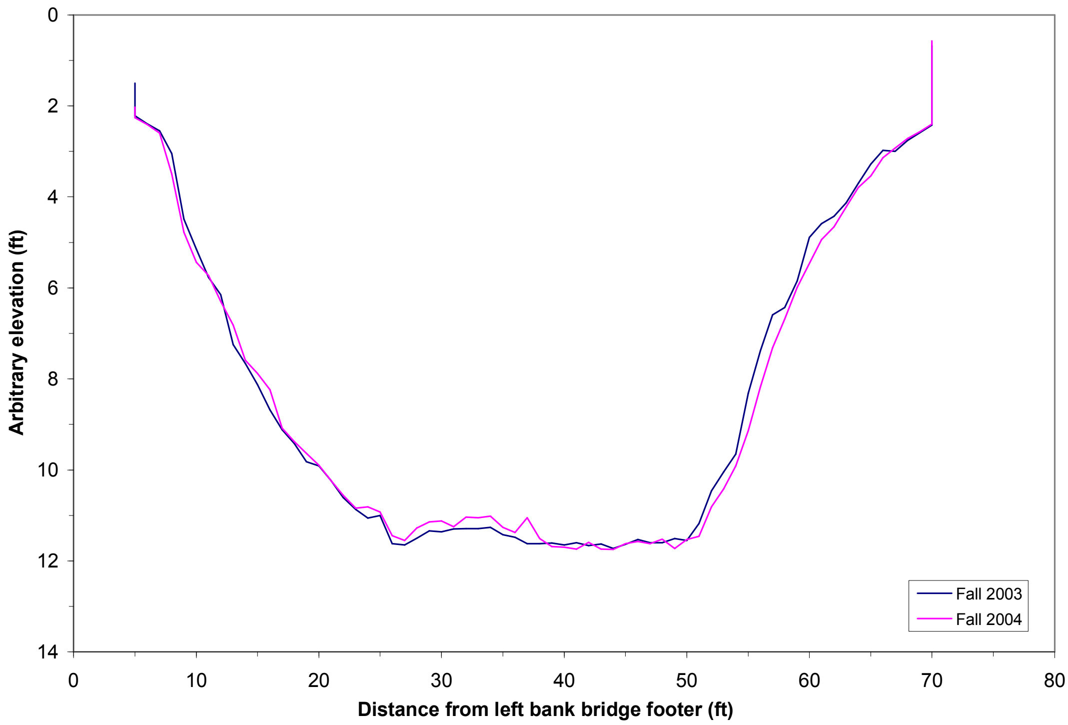

Figure C-2. Measured cross sections from the Fall of 2003 and the Fall of 2004 at the gauge location under Pinole Valley Road bridge number 5. These sections show no appreciable change in cross-sectional area over the study period.

Table C-4. Raw data for each of the surveyed cross sections in Figure C-2.

Cross-section, 11/4/03		Cross-section, 10/16/04		
Note: 5 ft is placed at base of LB bridge footer				
Foot	Height (ft)	Foot	Height (ft)	adjusted height
5	1.5	5	2.03	1.68
5	2.22	5	2.26	1.91
6	2.39	6	2.41	2.06
7	2.55	7	2.6	2.25
8	3.05	8	3.5	3.15
9	4.49	9	4.78	4.43
10	5.15	10	5.44	5.09
11	5.77	11	5.73	5.38
12	6.15	12	6.3	5.95
13	7.25	13	6.82	6.47
14	7.66	14	7.59	7.24
15	8.13	15	7.88	7.53
16	8.68	16	8.24	7.89
17	9.12	17	9.08	8.73
18	9.42	18	9.38	9.03
19	9.82	19	9.64	9.29
20	9.91	20	9.9	9.55
21	10.24	21	10.24	9.89
22	10.61	22	10.56	10.21
23	10.87	23	10.84	10.49
24	11.06	24	10.81	10.46
25	11	25	10.93	10.58
26	11.62	26	11.45	11.1
27	11.65	27	11.55	11.2
28	11.5	28	11.28	10.93
29	11.34	29	11.14	10.79
30	11.36	30	11.12	10.77
31	11.3	31	11.25	10.9
32	11.29	32	11.04	10.69
33	11.29	33	11.05	10.7
34	11.26	34	11.02	10.67
35	11.42	35	11.26	10.91
36	11.48	36	11.38	11.03
37	11.62	37	11.05	10.7
38	11.62	38	11.51	11.16
39	11.61	39	11.68	11.33
40	11.65	40	11.7	11.35
41	11.6	41	11.74	11.39
42	11.66	42	11.59	11.24
43	11.63	43	11.74	11.39
44	11.73	44	11.75	11.4
45	11.64	45	11.62	11.27
46	11.53	46	11.57	11.22
47	11.6	47	11.62	11.27
48	11.6	48	11.52	11.17
49	11.51	49	11.73	11.38
50	11.55	50	11.53	11.18
51	11.18	51	11.46	11.11
52	10.46	52	10.81	10.46
53	10.05	53	10.42	10.07
54	9.65	54	9.91	9.56
55	8.32	55	9.14	8.79
56	7.38	56	8.17	7.82
57	6.59	57	7.32	6.97
58	6.43	58	6.68	6.33
59	5.85	59	5.99	5.64
60	4.89	60	nd	nd
61	4.59	61	4.94	4.59
62	4.43	62	4.66	4.31
63	4.13	63	4.22	3.87
64	3.7	64	3.79	3.44
65	3.28	65	3.54	3.19
66	2.98	66	3.14	2.79
67	3	67	2.93	2.58
68	2.76	68	2.72	2.37
69	2.59	69	2.57	2.22
70	2.42	70	2.4	2.05
70	0.67	70	0.57	0.22

nd = no data

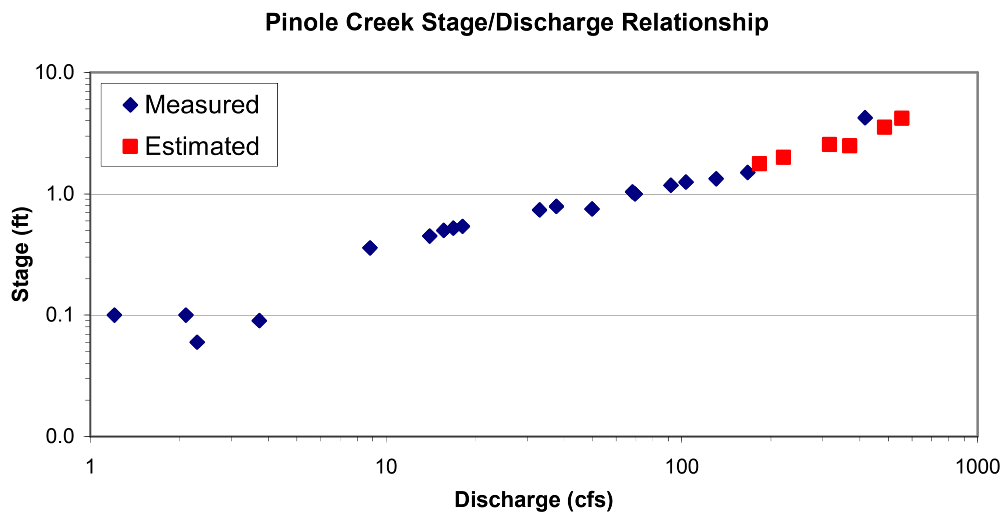

Figure C-3. Pinole Creek stage-discharge relationship. Discharge is measured in cfs, and stage is measured in feet. Data is from the gauge location under Pinole Valley Road bridge number 5.

Table C-5. Data to develop the stage-discharge relationship. Red indicates the estimated values.

Date	Start Time	Stage (ft)	Discharge (cfs)
11/8/2003	7:00 PM	0.09	3.73
11/8/2003	8:35 PM	0.06	2.30
12/6/2003	9:20 PM	0.10	2.11
12/9/2003	3:08 PM	0.10	1.21
12/9/2003	11:28 PM	0.79	37.75
12/10/2003	9:10 PM	0.45	14.05
12/10/2003	9:37 PM	0.50	15.67
12/10/2003	10:48 PM	0.54	18.14
12/29/2003	9:31 AM	0.52	16.91
12/29/2003	11:00 AM	0.74	33.07
12/29/2003	2:43 PM	1.00	69.65
12/29/2003	3:20 PM	1.33	130.78
12/29/2003	5:00 PM	1.25	103.33
1/1/2004	12:36 PM	3.53	485.82
1/1/2004	1:55 PM	2.55	316.31
1/1/2004	4:11 PM	1.50	167.12
1/1/2004	10:42 AM	4.20	555.89
2/2/2004	8:32 AM	0.36	8.84
2/2/2004	9:08 AM	0.75	49.73
2/2/2004	1:08 PM	1.18	91.92
2/2/2004	2:17 PM	1.04	68.27
2/17/2004	5:00 PM	2.00	221.42
2/17/2004	10:00 PM	2.50	370.25
2/18/2004	7:25 AM	1.77	183.32
2/25/2004	1:09 PM	4.25	416.48

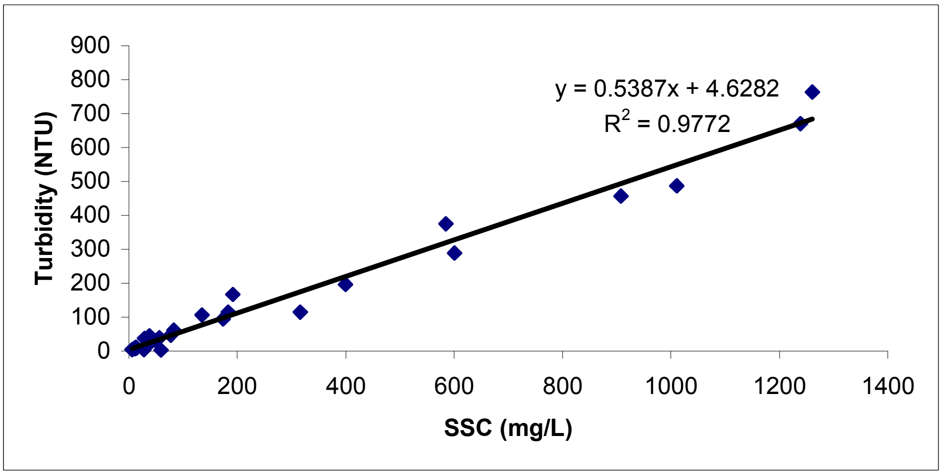

Figure C-4. Suspended sediment concentration (SSC) and turbidity relationship measured in Pinole Creek during Water Year 2004.

Appendix D- Landslides and gullies methods and data

Landslide classification

An assessment of landslide type and level of activity was made utilizing a classification scheme initially proposed by Varnes (1978). The classification scheme assigns a four-digit code to each slide; the first digit describes the state of activity, the second describes the level of certainty of identification, the third describes the dominant type of movement, and the fourth digit describes the thickness of slide deposit. See the main text for figure. This section will give a full description and definition of each term.

State of Activity

Active- A slide that is currently moving or shows evidence of movement that has occurred in the past 50 years.

Dormant- A slide that shows evidence of movement that occurred in the past 50 to 100 years.

Holocene- A slide that shows evidence of movement that occurred more than 100 years ago. However, most of these slides likely were initiated hundreds to thousands of years ago when the climate was wetter than it is today.

Certainty of Identification

Definite- Clear observation of landslide features (sharp head scarp, cracks, toe, etc), verbal descriptions from landowners, or observation of other features (leaning telephone poles, etc).

Probable- Observation of muted landslide features (a change in topography, hummocky topography, a change in vegetation type, a possible head scarp, etc). This slide type typically has many features suggesting a landslide, but no clear substantiating evidence.

Questionable- Observation of possible landslide features (smooth vegetated scarp, smooth rolling topography, disturbed drainage network, vague margins)

Dominant Type of Movement

Earth flow / soil slip- A spatially continuous movement in which surfaces of shear are short-lived and closely spaced. The displacing mass resembles a viscous liquid. Earth flows are somewhat drier and slower flows in plastic earth common wherever there is clay or weathered clay-bearing rocks, moderate slopes, and adequate moisture. The dominant material before movement consisted of soil with 80% of particles finer than 2 mm.

Debris slide- The downslope movement of a soil or rock mass occurring dominantly on surfaces of rupture or on relatively thin zones of intense shear strain. These slides typically are translational, in which the mass displaces along a planar or undulating surface of rupture, sliding out over the original ground surface. The dominant material before movement consisted of soil with 20 to 80% of the material larger than 2 mm.

Debris flow- Similar to earth flows, except the material is more coarse and heterogeneous, and may displace on a deeper rupture surface.

Slump / rotational- Movement occurs along a surface of rupture that is curved and concave. The mass may move with little internal deformation. The head of the displaced material may move almost vertically downward, whereas the upper surface of the displaced material tilts backward toward the scarp.

Translational- a large slide occurring on a single discontinuity in which the displaced mass remains as a block. The surface of rupture is often a clay layer, and remains intact after movement has ceased.

Gully / headcut- Extension of the channel network through concentration of surface flows, forming relatively steep, V-shaped channels. Gullies are very dynamic, often without any bank vegetation or standard fluvial features such as bars or pools.

Channel bank slump- Similar to slump/rotational slide class, however occurs immediately adjacent to a channel. Involves fluvially-worked materials of the channel bank. Typically moves as a block, with material remaining intact at the base of the slump.

Thickness of Deposit

The average thickness of deposit was estimated and placed into three categories: less than 2 meters, 2 to 5 meters, or greater than 5 meters. This was typically determined from observations of the thickness of the toe, the height of the head scarp, or mental reconstructions of the hillslope and approximation of depth to the failure plane. This is somewhat subjective, and relies upon professional judgment.

Mapping error

A handful of sources of error exist in the landslide mapping task. First, the mapping is based upon interpretation of aerial photographs. The quality and scale of the photographs dictate what is and what is not observable. Also, interpretation involves professional judgment in determining which locations are landslides, as well as determining the many classifications of the landslide. Secondly, each of the mapped landslides has an error of approximately ±10 m in aerial extent (width and length). This error creates part of the error in volume calculations discussed in the Synthesis section of the main text. And thirdly, error exists in determining the depth of a slide solely from aerial photographs. Although the stereo photographs allow some estimation of elevation and topography, nothing substitutes for direct field measurement. We believed that we have accurately portrayed the error inherent with estimating depth, but additional field work and field checking would reduce this amount of error.

Field-checked landslides raw data

All of the information collected on landslides that were field-checked is contained in the table below.

Table D-1. Raw data for field-checked landslides.

Field Date	Unique ID	Old Field ID	Field Checked	Photo Code	Field Code	Total field Length	Displaced Length	Rupture Length	Field Width	Field Area (m^2)	Depth Class	Actual Depth	Field Volume (m^3)	% material stored	Connectivity	Age	Trigger	Priority	Notes
7/20/2004	1071		y	1211	2221	52.2			35	1827	<2		0	80	H	10-20		L	
7/20/2004	3		y	1161	1161					0			0	0	H	10-20		M	
7/20/2004	1429	1071B	y		2111	40.9	16	24.9	14	572.6	<2		0	100	L	1-10		L	
7/20/2004	1431	1071C	y		1111	14.7	7	7.7	7.3	107.31	<2		0	100	L	1-10		L	
7/20/2004	1430	1071D	y		1111					0	<2		0	100	L	1-10		L	
7/20/2004	1072		y							0			0						
7/20/2004	4		y	1161	1162	78			15.7	1224.6	2-5	2.5	3061.5	0	H	1-10	grazing	H	
7/20/2004	2013		y	9999	1122	32.7			15.5	506.85	2-5	3	1520.55	40	H	10-20		M	
7/20/2004	1075		y	1211	1112	54	25	29	22.1	1193.4	2-5		0	80	M	10-20	seep?	M	
7/20/2004	1330		y	2222	2222					0	2-5		0	20	H	20-50		L	
7/20/2004	1335		y	2221	2112	30.5			21.7	661.85	2-5		0	80	M	10-20		L	
7/20/2004	1331		y	1211	2111	34	12	22	29	986	<2		0	100	M	20-50		L	
7/20/2004	1334	1331A	y		1111	15	2	13	7	105	<2		0	100	M	10-20		L	
7/20/2004	1332	1331B	y		1111	22	12	10	5	110	<2		0	80	M	1-10		L	
7/20/2004	1333		y	1211	1111	20			7	140	<2		0	100	L	10-20		L	
7/20/2004	1432	1331C	y		1111	10	1	9	12.3	123	<2		0	20	M	10-20		L	
7/20/2004	2127		y	3311	3213	110			29.5	3245	>5		0	80	M	>100		L	
7/20/2004	1337		y	1111	1111	20	13	7	5	100	<2		0	100	M	1-10		L	
7/20/2004	2162	2127B	y		1112	48	28	20	12.3	590.4	2-5		0	80	M	1-10		L	
7/20/2004	2163	2127C	y		2112	40			15	600	2-5		0	100	L	20-50		L	
7/20/2004	2164	2127D	y		2112	24.5			12.7	311.15	2-5		0	100	L	20-50		L	
7/20/2004	2165	2127E	y		1111	18.5			21.2	392.2	<2		0	100	L	10-20		L	
7/20/2004	2126		y	3311	3212					0			0			>100			
7/20/2004	1336		y	1211	2211					0			0						
7/20/2004	1338		y	1111	1111	25			10	250	<2		0	100	L	10-20		L	
7/20/2004	1327		y	2222	1122					0	2-5		0		M	1-10		L	
7/20/2004	1448	1307B	y		2122	55			50	2750	2-5		0		M	50-100		L	
7/20/2004	1450	1306B	y	2221	1111	10			5	50	<2		0		L	1-10		L	
7/20/2004	1451	1305B	y		1111	10			5	50	<2		0		L	1-10		L	
7/20/2004	1449	1306C	y		1112	59	44	15	20.3	1197.7	2-5		0	100	L	1-10		L	
7/20/2004	1291		y	1121	1122	64.4	12	52.4	38	2447.2	2-5	3	7341.6	60	M	1-10	seep?	L	
7/20/2004	1289		y	2212	2212	100			50	5000	2-5	4	20000	90	L	50-100		L	
7/20/2004	1290		y	1222	2211	50	20	30	30	1500	<2	2	3000	100	L	>100		L	
7/20/2004	13		y	1161	1161				6	0	2-5	2.5	0		H	20-50	baselevel	L	
7/20/2004	14		y	1161	1161					0			0		H	20-50			
7/20/2004	1203		y	1171	2161	25			4	100	<2	1.5	150		H	10-20		M	
7/20/2004	2086		y	3311						0			0						
7/20/2004	15		y	1161						0			0						
7/21/2004	1100		y	2122	2112	75.2	16	59.2	25.2	1895.04	2-5	3	5685.12	50	M	1-20		M	
7/21/2004	1099		y	2211	2112	49.5			13	643.5	2-5	2	1287	50	M	20-50		M	
7/21/2004	2024		y	9999	2112	50			20	1000	2-5	5	5000		M	20-50		M	
7/21/2004	1101		y	1211						0			0	0		20-50		L	
7/21/2004	1103		y	1261	2161					0			0	0	H	50-100		L	
7/21/2004	2026		y	9999	3312					0			0	0	L	>100		L	
7/21/2004	2021		y	9999						0			0	0					
7/21/2004	2022		y	9999						0			0	0					
7/21/2004	2020		y	3312						0			0	0					
7/21/2004	1110		y	2212	3211	120			15	1800	<2		0	0	L			L	

7/21/2004	1108		y	2112	1111	50.7	22	28.7	37.3	1891.11	<2		0		M	10-20		L	
7/21/2004	1107		y	2112						0			0	0				L	
7/21/2004	1109		y	2112						0			0	0				L	
7/21/2004	1111		y	2212	2111					0			0	0	L	20-50		L	
7/21/2004	1112		y	1211	2112	115	40	75		0	2-5	4	0	0	H	20-50		L	
7/21/2004	1095		y	1121	2211					0	<2		0			50-100			
7/21/2004	1		y		1161	300			5	1500	>5	6	9000	20	H	50-100		M	
7/21/2004	1116		y	2242	2112	63	42	21	55	3465	2-5	4	13860		H	20-50		L	
7/21/2004	1117		y	2271	2221	30			40	1200	<2		0		H	20-50		M	
7/21/2004	1027		y	9999	3113	200			59.2	11840	>5	8	94720	30	H	20-50	reactivation	M	
7/21/2004	1119		y	1212		98			53	5194			0						
7/21/2004	1118		y	1212	2112	116	77	39	45	5220	2-5	5	26100						
7/21/2004	1419	1026B	y		2111	100			70	7000	<2		0		M	20-50		L	
7/21/2004	1021		y	2222	3213	100			60	6000			0	0	H	>100		L	
7/21/2004	1016		y	1211	3212	35			25	875	2-5	2.5	2187.5		H	20-50		L	
7/21/2004	1017		y	1211	2112	69	49	20	44	3036	2-5		0		H	20-50		L	
7/21/2004	1018		y	1211	2112	72	44	28	15	1080	2-5		0		H	20-50		L	
7/21/2004	1030		y	2112	2212	90	70	20	60	5400	2-5	2.5	13500		H	20-50		L	
7/21/2004	1002		y	9999						0			0						
7/21/2004	1001		y	9999						0			0	100	H	10-20		M	deposited into a swamp
7/21/2004	1003		y	2211						0			0						behind senior housing
7/21/2004	1004		y	3311						0			0						graded now, new home built
7/21/2004	1005		y	9999	2143	222	100	122	121	26862	>5	20	537240	80	H	50-100	water tank	M	
7/21/2004	1026		y	2312	3213					0	>5	8	0		H	>100		L	
													0						
7/23/2004	1481	1383B	y		1141	52.1	43	9.1	35.6	1854.76	<2	1.5	2782.14	90	M	1-10		L	
7/23/2004	1483	1383C	y		1111	20.8			22	457.6	<2	1.5	686.4	60	H	1-10		M	
7/23/2004	1482	1383D	y		1122	150			75	11250	2-5	4	45000	70	H	1-10		L	
7/23/2004	2151		y	3311	2122	94.1	75	19.1	33.4	3142.94	2-5	5	15714.7	90	M	20-50		L	
7/23/2004	2150		y	3311	1122	88.5	42	46.5	39.7	3513.45	2-5	5	17567.25	70	M	1-50		L	
7/23/2004	2172	2150B	y		1111	53.8	35.5	18.3	19.8	1065.24	2-5	2	2130.48	90	L	1-10		L	
7/23/2004	2171	2150C	y		1112	56.7	13.2	43.5	10	567	2-5	3	1701	80	M	1-10		L	
7/23/2004	2149		y	3311	1112	49.3	23.3	26	24.3	1197.99	2-5	4	4791.96	80	M	1-10		M	BR outcrop in scarp
7/23/2004	2174	2149B	y		1111	33.5			11	368.5	<2	1.5	552.75	90	M	1-10		L	
7/23/2004	2173	2149C	y		1111	37.2	19	18.2	39	1450.8	<2	2	2901.6	90	M	1-10		L	
7/23/2004	71	1219B	y		1162	124			4.4	545.6	2-5	2.3	1254.88	10	H	1-50		H	Deposited into pond
7/23/2004		1219B2	y		1162	52			2.8	145.6	2-5	3	436.8						
7/23/2004	72	1219C	y		1162	80			3	240	2-5	2.1	504	10	H	1-50		H	
7/23/2004	1217		y	9999						0			0						
7/23/2004	1221		y	1212						0			0						
7/23/2004	1222		y	1211	3211	60			35	2100	<2	2	4200	80	M	50-100		L	Bare soil from horses
7/23/2004	2071	2071B	y		1221	100			40	4000	<2	1.5	6000	100	L	10-20		L	
7/23/2004	1207		y	1312	1112	150			60	9000	2-5	5	45000	95	M	1-10		L	
7/23/2004	1205		y	9999	2311					0	2-5	3	0			50-100			
7/23/2004	2076		y	3312	2211	100			250	25000	<2	2	50000	90	M	50-100		L	
7/23/2004	2095		y	3342	2212	130			50	6500	2-5	3	19500	90	L	50-100		L	
7/23/2004	17		y	1161						0			0						
7/23/2004	1475	1237B	y		2112	120			60	7200	2-5	4	28800	90	M	50-100		M	
8/24/2004	2087		y	3313	2112	300	250	50	50	15000	2-5	5	75000	60	H	20-50	natural	M	
8/24/2004	1472	2087B	y		1112	16	9	7	13.5	216	2-5	5	1080	50	M	10-20	spring?	L	BR exposed
8/24/2004	1257		y	9999	2111	150	100	50	30	4500	<2	1.5	6750	80	H	20-50	natural	L	
8/24/2004	1231		y	1111	1143	44	38	6	26	1144	>5	6	6864	90	M	10-20	reactivation	L	
8/24/2004	69	18B	y		1162	100			6	600	2-5	5	3000	10	H	1-20	grazing?	M	
8/24/2004	1470	2093B	y		1111	25			50	1250	<2	1	1250	20	H	1-10	gully	M	

8/24/2004	1471	2093C	y		1111	30	15	15	5.5	165	<2	2	330	90	L	1-10	natural	L	
8/24/2004	1469	2093D	y		1111	19	13.4	5.5	10.5	199.5	<2	2	399	20	H	10-20	natural	L	
8/24/2004	2105		y	2311	2211	80			40	3200	<2	1	3200	70	M	50-100	natural	L	
8/24/2004	1464	2105B	y		1211	60	46.8	12	28.6	1716	<2	1	1716	90	L	10-20	natural	L	
8/24/2004	1468	2105C	y		1111	30.7	18.9	11.8	20.9	641.63	<2	2	1283.26	90	L	10-20	natural	L	
8/24/2004	1466	2105D	y		1111	28	14.8	13.2	10.6	296.8	<2	2	593.6	90	L	1-20	natural	L	
8/24/2004	1465	2105E	y		1111	62	48	14	9.9	613.8	<2	1.5	920.7	100	L	10-20	natural	L	
8/24/2004	1463	2105F	y		1111	15	10	5	7	105	<2	1.5	157.5	70	M	1-20	road	L	
8/24/2004	1259		y	2122	3213	200			25	5000	>5	6	30000	80	M	>100	natural	L	
8/24/2004	1467	1259B	y		2112	120			35	4200	2-5	3.5	14700	80	M	50-100	natural	L	
8/24/2004	1260		y	2112	2311	65			40	2600	<2	2	5200	90	L	50-100	natural	L	
8/24/2004	1460	1260B	y		1111	36	17.1	18.9	11.5	414	<2	2	828	100	L	1-20	natural	L	
8/24/2004	1261		y	2311	1111	90	60	30	40	3600	<2	2	7200	100	L	10-20	natural	L	
8/24/2004	1262		y	1211	2212	80			45	3600	2-5	4	14400	100	L	50-100	natural	L	
8/24/2004	1459	1262B	y		1112	120	100	20	15	1800	2-5	3	5400	100	L	10-20	natural	L	
8/24/2004	1281		y	1211	1111	19.1			10	191	<2	1	191	100	L	10-20	natural	L	
8/24/2004	1282		y	1212	1121	6			5	30	<2	0.5	15	20	H	1-10	grazing	L	
8/24/2004	1277		y	1111	2112	152	107	44.8	95	14440	2-5	5	72200	40	H	20-50	natural	L	
8/24/2004	1279		y	1121	1111	25			6	150	<2	1	150	60	H	1-10	grazing	L	
8/24/2004	19		y	1161	1161				4	0	2-5	3.5	0	10	H	10-20	grazing	M	
8/24/2004	1276		y	2112	1112	92	59	33	30	2760	2-5	3	8280	70	H	20-50	natural	L	
8/24/2004	1275		y	1121	1111	30			20	600	<2	1	600	20	H	1-10	natural	M	
8/24/2004	1271	1269C	y		1121	25			25	625	<2	1	625	70	M	1-10	natural	L	
8/24/2004	1454	1269B	y		1111	20	10	10	4	80	<2	1	80	80	H	10-20	natural	L	
8/24/2004	68	19B	y		1161				6	0	2-5	3	0	10	H	20-50	US pond	M	
8/24/2004	1270		y	2212	2111	30	15	15	10	300	<2	2	600	90	L	50-100	natural	L	
8/24/2004	1267		y	2211	1122	60	15	45	20	1200	2-5	2.5	3000	90	M	10-20	natural	L	
8/24/2004	2085		y	3312	3213	150			50	7500	>5	7	52500	80	M	>100	natural	L	
8/24/2004	2083		y	3312	3213	150			35	5250	2-5	5	26250	80	M	>100	natural	L	
8/24/2004	2084		y	3312	3212	150			40	6000	2-5	5	30000	80	M	>100	natural	L	
8/24/2004	2082		y	3312	3212	130			55	7150	2-5	5	35750	80	M	>100	natural	L	
8/24/2004	2080		y	3312	3212	130			40	5200	2-5	5	26000	80	M	>100	natural	L	
8/24/2004	2081		y	3312	3212	100			50	5000	2-5	3	15000	90	M	>100	natural	L	
8/24/2004	2079		y	3312	3212	90			30	2700	2-5	3	8100	90	M	>100	natural	L	
8/24/2004	6		y	1161	1162				11.3	0	2-5	3.2	0	10	H	1-10	houses	H	
8/24/2004	1055		y	1111	2111	42.2			8	337.6	<2	2	675.2	90	L	20-50	natural	L	
8/24/2004	1056		y	1111	1161	27			3.5	94.5	<2	1	94.5	90	L	10-20	natural	L	
8/24/2004	1428	1056B	y		1112	18.6	10	8.6	14.5	269.7	2-5	2.5	674.25	100	L	10-20	natural	L	
			y										0						
8/27/2004	1351		y	9999	2212	55			40	2200	2-5	2.5	5500	90	M	20-50	natural	L	
8/27/2004	1480	1351B	y		1111	15			5	75	<2	0.5	37.5	100	L	1-10	natural	L	
8/27/2004	1350		y	1113	2112	300			100	30000	2-5	4	120000	80	M	50-100	natural	M	
8/27/2004	1352		y	2311	2211	50			30	1500	<2	1.5	2250	90	L	50-100	natural	L	
8/27/2004	1362		y	9999						0			0						
8/27/2004	73	42B	y							0			0						
8/27/2004	2139		y	3313	2212	65			35	2275	2-5	3	6825	60	H	>100	natural	L	
8/27/2004	42		y	1161	1162				15	0	>5	6	0	20	H	1-20	natural	M	revtetted now
8/27/2004	43		y							0			0						
8/27/2004	44		y	1161	1162				12	0	<2	1.5	0	20	H	1-20	anthro/ horses	H	
8/27/2004	2136		y							0			0			>100			

8/27/2004	1354		y							0									now a pond
8/27/2004	1356		y	2212	2212	70			35	2450	2-5	2.5	6125	80	M	50-100	natural	L	
8/27/2004	1358		y	1322	1142	25			45	1125	2-5	5	5625	90	M	10-20	natural	M	
8/27/2004	1357		y	2311	3212	90			40	3600	2-5	2	7200	100	L	>100	natural	L	
8/27/2004	2138		y	3212	1221	40			40	1600	<2	1	1600	100	L	1-20	cows	M	
8/27/2004	2169	2138B	y		3213	70			70	4900	>5	7.5	36750	80	M	>100	natural	L	
8/27/2004	1371		y	9999	1112	50			30	1500	2-5	2	3000	100	L	5-10	natural	M	
8/27/2004	1490	1371B	y		1112	70			30	2100	2-5	3	6300	70	H	5-10	natural	H	
8/27/2004	1369		y	9999	1113					0	>5	10	0	50	H	20-50	natural	H	
8/27/2004	50		y	1161	1161				5	0	2-5	3	0	50	H	20-50	natural	M	
8/27/2004	1346		y	2312	2212	80			30	2400	2-5	3	7200	90	L	50-100	natural	L	
8/27/2004	1350		y	1113						0			0						
8/27/2004	54		y	1161	1161				7	0	<2	0.2	0	40	H	20-50	road and house	L	
8/27/2004	2043		y	3312	2212	120			40	4800	2-5	3	14400	90	L	>100	natural	L	
8/27/2004	1129		y	2212	1211	155	80	75	23.1	3580.5	<2	1.5	5370.75	90	L	20-50	natural	L	
8/27/2004	1132		y	2212	1111	75	65	10	20	1500	<2	1	1500	80	M	20-50	natural	L	
8/27/2004	1131		y	2212	2212	48.4	36.4	12	30.6	1481.04	2-5	4	5924.16	90	M	50-100	natural	L	
8/27/2004	1130		y	2212	2212	40.2	27.2	13	17.4	699.48	2-5	4	2797.92	90	M	50-100	natural	L	
8/27/2004	1500	1132B	y		1111	10			9.8	98	2-5	1.5	147	40	H	20-50	natural	L	
8/27/2004	2042		y	3312	3212	130			60	7800	2-5	5	39000	80	H	>100	natural	L	
8/27/2004	2041		y	3312	3212	100			35	3500	2-5	4	14000	80	H	>100	natural	L	
8/27/2004	1426	1134B	y		2111	14			4	56	<2	1.5	84	60	H	20-50	natural	L	
8/27/2004	1134		y	2112	2112	68	37.4	30.6	12.3	836.4	2-5	2.5	2091	60	H	20-50	natural	L	
8/27/2004	2040		y	3312	2211	20			8	160	<2	1.5	240	80	H	50-100	natural	L	
8/27/2004	1422	1129B	y		1111	4			2	8	<2	0.5	4	100	M	1-10	natural	L	
8/27/2004	2036		y	9999	1161				13	0	2-5	3	0	50	H	1-10		L	
9/1/2004	9		y	1162	1162				12	0	2-5	5	0	30	H	10-20	houses?	H	
9/1/2004		9B	y		1162	40			5	200	2-5	5	1000	10	H	10-20	culvert	H	culvert is 1 ft diameter, riprap has
9/1/2004		9C	y		1161	30			8	240	2-5	3	720	10	H	10-20	development?	M	moved 6m DS
9/1/2004		9D	y		1162	50			5.4	270	2-5	4.5	1215	10	H	10-20	previous modification	H	concrete pillars, drain, old foundati
9/1/2004		9E	y		1171	15			15	225	<2	1	225	80	H	5-10	natural	M	a concrete V ditch
9/1/2004	1145		y	2211	1211	25			55	1375	<2	1.5	2062.5	100	L	20-50	natural	L	along the road feeding
9/1/2004	1144		y	2211	1112	60	40	20	35	2100	2-5	2.5	5250	80	M	50-100	natural	L	it
9/1/2004	1436	1144B	y		1212	50	35	15	40	2000	2-5	2	4000	80	M	50-100	natural	L	
9/1/2004	1437	1144C	y		1142	60			48	2880	2-5	5	14400	60	H	20-50	natural	M	lakes in depressions, a series of 4
9/1/2004	11		y	1161	1162				8.5	0	2-5	2	0	10	H	20-50		M	headcut is 5m wide, 1.5m deep,
9/1/2004	59	11B	y		1141	35			25	875	<2	2	1750	50	H	10-20	natural	M	20 m DS is a second
9/1/2004		11D	y		1162	100			7	700	2-5	3	2100	20	H	20-50	natural	M	headcut, 3m wide and
9/1/2004	1438	1143B	y		2212	40			30	1200	2-5	3	3600	50	H	20-50	natural	L	1m deep, here the
9/1/2004	1440	1142B	y		1121	21	9	12	12	252	<2	0.5	126	30	H	10-20	natural	M	valley is 18m wide
9/1/2004	1441	1142C	y		1211	60			10	600	<2	1.5	900	30	H	10-20	natural	L	
9/1/2004	1439	1142D	y		1142	26	10	16	33	858	2-5	2.5	2145	70	H	10-20	natural	M	
9/1/2004	61	7B	y		1162				7	0	2-5	4	0	10	H	10-20	natural	M	
9/1/2004	1442	1142E	y		1171	22			21	462	<2	1	462	70	H	10-20	natural	L	
9/1/2004	62	8B	y		1161				5.5	0	2-5	3	0	40	H	10-20	natural	M	
9/1/2004	1150		y	1111	1143	96	46	50	130	12480	>5	6	74880	80	H	20-50	natural	M	
9/1/2004	1151		y	check photo						0			0						
9/1/2004	1443	1150B	y		1242	65			45	2925	2-5	3	8775	90	M	20-50	natural	L	
9/1/2004	1501	1150C	y		1142	17			26.5	450.5	2-5	3	1351.5	80	H	20-50	natural	L	
9/1/2004	63	8C	y		1161	50			1.5	75	<2	2	150	80	M	20-50	natural	L	
9/1/2004	64	8D	y		1161					0			0	80	L				

9/1/2004	65	8E	y		1161	20			1.5	30	<2	2	60	50	H	20-50	natural	L	
9/1/2004	1152		y	2212	3212	200			70	14000	2-5	4	56000	90	L	>100	natural	L	
9/1/2004	2047		y	3313	3212	130			80	10400	2-5	4	41600	90	L	>100	natural	L	
9/1/2004	1168		y	2211	2211	30			20	600	<2	1.5	900	100	M	50-100	natural	L	
9/1/2004	1446	1168B	y		1111	15			12	180	<2	1	180	100	L	1-10	natural	L	
9/1/2004	1167		y	1242	1111	10			40	400	<2	1	400	90	M	1-10	natural	L	
9/1/2004	67	1168C	y		1161	5			2	10	<2	1	10	100	H	1-20	natural	L	
9/1/2004	1445	1167B	y		1111	45			11	495	<2	2	990	70	H	10-20	natural	L	
9/1/2004	1167		y	1242	1112	60	50	10	13.5	810	2-5	3	2430	60	H	10-20	natural	L	
9/1/2004	1447	1167C	y		1111	40			12	480	<2	1.5	720	80	H	10-20	natural	L	
9/1/2004	1166		y	1242	1112	54	34	20	34	1836	2-5	3	5508	80	M	20-50	natural	L	
9/1/2004	2051		y	3312	2212	140	90	50	50	7000	2-5	3	21000	90	L	>100	natural	L	
9/1/2004	1163		y	1111	1111	52	32	20	16	832	<2	1.5	1248	90	M	10-20	natural	L	
9/1/2004	2166	2048B	y		1111	55	25	30	8	440	<2	1	440	100	L	1-10	natural	L	
9/1/2004	2048		y	2311	1112	120			55	6600	2-5	2.5	16500	100	L	20-50	natural	L	
9/1/2004	1164		y	2312	1111	120			37	4440	<2	1.5	6660	90	M	10-20	natural	L	
9/9/2004	1486	1403B	y		1121	24			65	1560	<2	0.5	780	80	M	1-10	road related	M	
9/9/2004	1403		y	1312	1142	79	47	32	56	4424	2-5	4	17696	95	M	10-20	natural	M	
9/9/2004	1400		y	2212	2112	30			34	1020	<2	2	2040	100	L	20-50	natural	L	Soil now scraped for pond dam,
9/9/2004	1485	1402B	y		1111	25			15	375	<2	1	375	100	L	10-20	natural	L	no future movement he
9/9/2004	1402		y	1212	2112	100			55	5500	2-5		0	60	H	20-50	natural	L	scraped for pond
9/9/2004	1488	1379B	y		1161	3			1.5	4.5	<2	0.5	2.25	100	L	1-10	road	M	
9/9/2004	1487	1379C	y		1111	45	30	15	7.5	337.5	<2	0.8	270	60	H	1-10	natural plus road	M	
9/9/2004	1379		y	1341	1111	65	25	40	40	2600	<2	1.5	3900	80	H	10-20	natural	L	
9/9/2004	1376		y	2212	2111	19.5	3.5	16	14.5	282.75	<2	1	282.75	90	M	50-100	natural	L	
9/9/2004	1377		y	1122	1113	130	60	70	45	5850	>5	7	40950	70	H	20-50	natural	M	
9/9/2004		1377L	y		1113	64	32	32	10	640	>5	4	2560	50	H	20-50	natural	M	
9/9/2004		1377M	y		1113	20			11	220			0						
9/9/2004		1377LM	y		1113	23.5			5	117.5			0						
9/9/2004	1378		y	1342	1113	200			100	20000	>5	6	120000	50	H	20-50	natural	M	
9/9/2004	1489	1378B	y		1162	24			8.5	204	2-5	3	612	90	M	1-10	natural	H	
9/9/2004	1374		y	1112	1112	45.5			44	2002	2-5	4	8008	80	M	10-20	natural	M	
9/9/2004	1375		y	1123	1113	200	120	80	118	23600	>5	6	141600	80	H	20	natural	M	
9/9/2004	2145		y	3311	1111	20.5	12.5	8	25	512.5	<2	1	512.5	90	M	10-20	natural	L	
9/9/2004	1370		y	1211	1111	60			25	1500	<2	1	1500	70	H	10-20	natural	L	
9/9/2004	2144		y	3311	1111	80	60	20	27	2160	<2	2	4320	50	H	10-20	natural	L	
9/9/2004	2143		y	3311	1162	32			10.5	336	2-5	3.5	1176	80	M	1-10	grazing and LS	M	
9/9/2004	1369		y	9999	1113	130			40	5200	>5	8	41600	70	H	10-20	natural	H	
9/9/2004	1368		y	1111	1112	20			14	280	2-5	3	840	90	L	10-20	natural	L	
9/9/2004	1494	1368B	y		1111	18			15	270	<2	1.5	405	90	L	1-10	natural	M	
9/9/2004	2142		y	3311	1111	25			9	225	<2	2	450	80	H	10-20	natural	L	
9/9/2004	2176	2145B	y		1111	30			20	600	<2	2	1200	60	H	1-10	natural	M	

Underlying geology

The underlying geologic rock units play an important role in the location and activity of landslides in the watershed. The following table illustrates the importance of specific rock units.

Table D-2. Rock unit control on landslide types. The percentage of total outcrop area that is mapped within each landslide type is shown.

Rock Type	Active gully	Active landslide	Dormant landslide	Holocene landslide	Full Rock Type Name and description
Qmz	0.00	0.21	0.00	0.00	Montezuma Fm. Sand, gravel, silt, clay
Qu	1.20	1.76	3.16	3.06	Surficial deposits
Tbh	2.27	8.24	6.13	1.37	Briones Hercules Shale
Tbl	2.19	8.89	0.97	3.70	Briones Lower sand and silt
Tbr	0.13	22.57	2.34	44.27	Briones sand, silt, cong
Tbu	1.47	7.82	2.39	3.77	Brione Upper sand and shale
Tcgl	0.00	3.83	0.00	0.00	Conglomerate, sand, silt
Tcglt	0.00	0.00	0.00	0.00	Conglomerate, sand, silt, tuff
Tcs	0.48	2.72	2.22	1.80	Claremond Shale
Tdi	0.00	1.17	3.04	1.70	Diatomite
Th	0.20	1.04	2.84	5.69	Hambre Sandstone
Tmu	0.00	0.00	0.39	0.00	Mudstone, silt, shale
Tn	0.33	2.47	2.85	2.85	Neroly sandstone
To	0.01	1.95	2.44	3.24	Oursan Sandstone
Tr	1.64	3.05	2.63	19.38	Rodeo Shale
Ts	0.87	2.82	2.80	3.00	Sobrante Sandstone
Ts?	0.00	0.00	19.24	23.71	Sobrante Sandstone
Tsa	0.00	0.81	3.17	1.34	Sandstone
Tshc	2.29	1.41	41.18	0.00	Shale and claystone
Tsr	0.00	0.00	0.00	0.00	San Ramon Sandstone
Tt	0.27	3.10	3.10	2.11	Tice Shale
Tts	0.00	0.00	0.00	0.00	Tuffaceous sandstone
Tut	0.00	0.00	0.00	0.00	Tuff

Soils

Besides geology, the soil units also play an important role in the location and activity of landslides in the watershed. The following table illustrates the importance of specific soil units.

Table D-3. Soil unit control on landslide types. The percentage of total outcrop area that is mapped within each landslide type is shown (Soil descriptions from Welch, 1977).

Soil Type	Active LS	Dormant LS	Holocene LS	Active Gully	Soil Name
AaF		0.43	1.59	0.26	Alo clay, 30 to 50 percent slopes
AbE	0.30	24.11	1.17	8.94	Altamont clay, 15 to 30 percent slopes
AcF	13.46	0.72	3.14		Altamont-Fontana complex, 30 to 50 percent slopes
BaC	2.88	0.64	1.73	0.07	Botella clay loam, 2 to 9 percent slopes
Cc		0.04	0.38	3.68	Clear Lake clay
CeA		0.41			Conejo clay loam, 0 to 2 percent slopes
CeB		0.14	0.07	0.08	Conejo clay loam, 2 to 5 percent slopes
ChA			0.00	5.44	Conejo clay loam, clay substratum, 0 to 2 percent slopes
CkB		2.71	0.28	22.77	Cropley clay, 2 to 5 percent slopes
CnE		0.07			Cut and fill land-Los Osos complex 9 to 30 percent slopes
CoF		0.17		1.28	Cut and fill land-Millsholm complex, 30 to 50 perecent slopes
DdE	44.47	0.17	3.92	0.80	Diablo clay, 15 to 30 percent slopes
DdF		0.30	0.06	0.37	Diablo clay, 30 to 50 percent slopes
DeE			0.24	4.60	Dibble silty clay, 15 to 30 percent slopes
DeF	27.35	4.42	2.89	1.10	Dibble silty clay loam, 30 to 50 percent slopes
GaB		0.21	0.28	1.09	Garretson loam, 2 to 5 percent slopes
GbE			0.15	2.21	Gaviota sandy loam, 15 to 30 percent slopes
GbF		4.60	3.12		Gaviota sandy loam, 30 to 50 percent slopes
LcE		1.15	0.48		Lodo clay loam, 9 to 30 percent slopes
LcF		2.90	1.78	0.53	Lodo clay loam, 30 to 50 percent slopes
LeF		1.61	0.52		Los Gatos loam, 30 to 50 percent slopes
LeG		2.01	1.32	0.07	Los Gatos loam, 50 to 75 percent slopes
LhE	0.54	2.68	6.48	4.70	Los Osos clay loam, 15 to 30 percent slopes
LhF	5.67	20.08	32.97	7.61	Los Osos clay loam, 30 to 50 percent slopes
Lk		4.20	1.29		Los Osos-Los Gatos complex
MeE	0.68	1.33	5.59		Millsholm loam, 15 to 30 percent slopes
MeF	4.22	16.88	14.34	7.26	Millsholm loam, 30 to 50 percent slopes
MeG		4.02	6.93		Millsholm loam, 50 to 75 percent slopes
RbC		0.10		4.90	Rincon clay loam, 2 to 9 percent slopes
Re		0.20		0.21	Rock outcrop-Xerorthents association
SdF	0.02	1.50	5.43		Sehorm clay, 30 to 50 percent slopes
SdG		1.41	0.36	5.03	Sehorm clay, 50 to 75 percent slopes
TaC		0.71	0.06	6.46	Tierra loam, 2 to 9 percent slopes
TaD	0.41		3.17	7.27	Tierra loam, 9 to 15 percent slopes
TaE		0.09	0.26	3.28	Tierra loam, 15 to 30 percent slopes

Landslide slope and aspect

As a part of the landslide mapping task, analysis of slide slope and aspect were completed using ArcView. A discussion of slope and aspect can be found in the main text. The following figures illustrate the data produced from the GIS analysis.

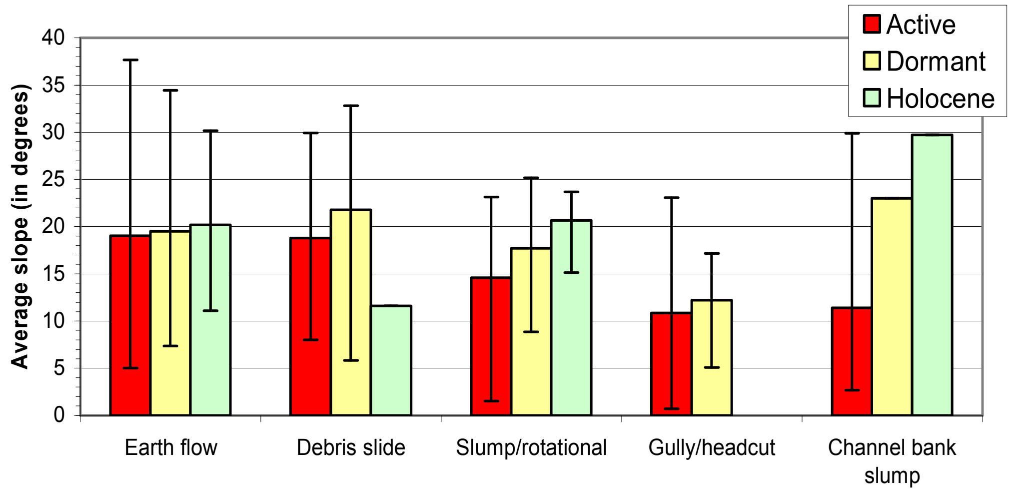

Figure D-1. Plot showing the average slope (in degrees) of each slide type. Error bars show the minimum and maximum measured.

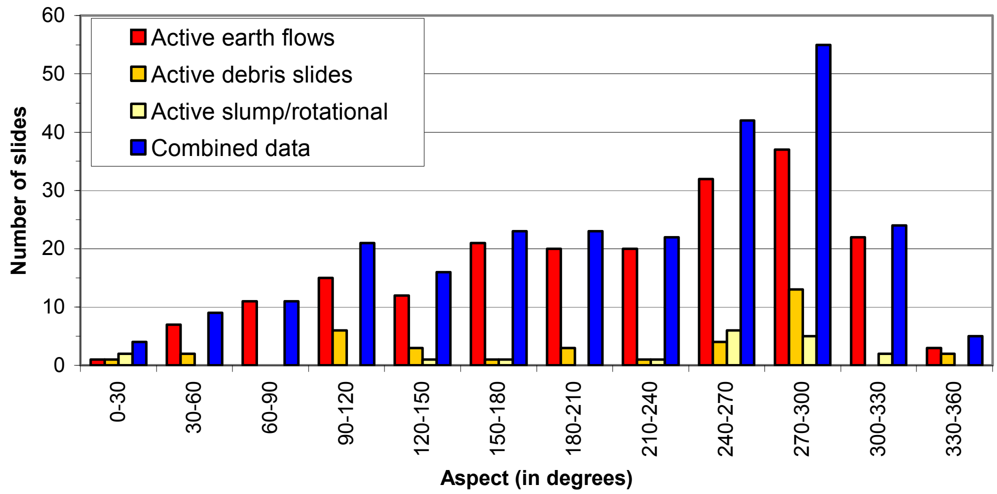

Figure D-2. Total number of slides in each slide class and their aspect (in degrees). 0 is north, 90 is east, 180 is south, and 270 is west.

Landslide photographs

All of the photographs taken during field-checking of the landslides are compiled on a CD available from SFEI. Contact Sarah Pearce at (510) 746-7354.

Roads

The roads analysis was based upon the following data collected from the aerial photographs, and from field observations and professional judgment.

Table D-4. Raw data for the road analysis.

Road Type	Length (km)	Length (mi)	Length (ft)	Ave Width (ft)	Area (ft2)	% slight	% moderate	% severe	% very severe
Paved	96.87	60.2	317856	25	7946400	70	20	7	3
Ranch	16.04	9.97	52641.6	14	736982.4	68	25	5	2
Fire trail	62.1	38.59	203755.2	15	3056328	85	10	4	1
Fire break	7.24	4.5	23760	16	380160	80	19	1	0

Slight erosion is described as: some bare roadbank, but active erosion not apparent. Some rills, but no vegetative overhang. Ditch bottom is grass or non-eroding. 0.01 to 0.05 ft/yr

Moderate erosion is described as: Roadbank is bare, with obvious rills and some vegetative overhang. Minor erosion or sediment in ditch bottoms. 0.06 to 0.15 ft/yr

Severe erosion is described as: Roadbank is bare with rills to one foot depth. Some gullies and overhanging vegetation. Active erosion or sedimentation in ditch bottom. Some fenceposts, powerlines, trees, and culverts eroding out. 0.16 to 0.30 ft/yr

Very severe is described as: Roadbank is bare, with gullies, washouts, and slips. Severe vegetative overhang. Fenceposts, powerlines, trees, and culverts eroded out. Active erosion or sedimentation in ditch bottom. 0.31+ ft/yr

From: Steffen, 1983.

Land use

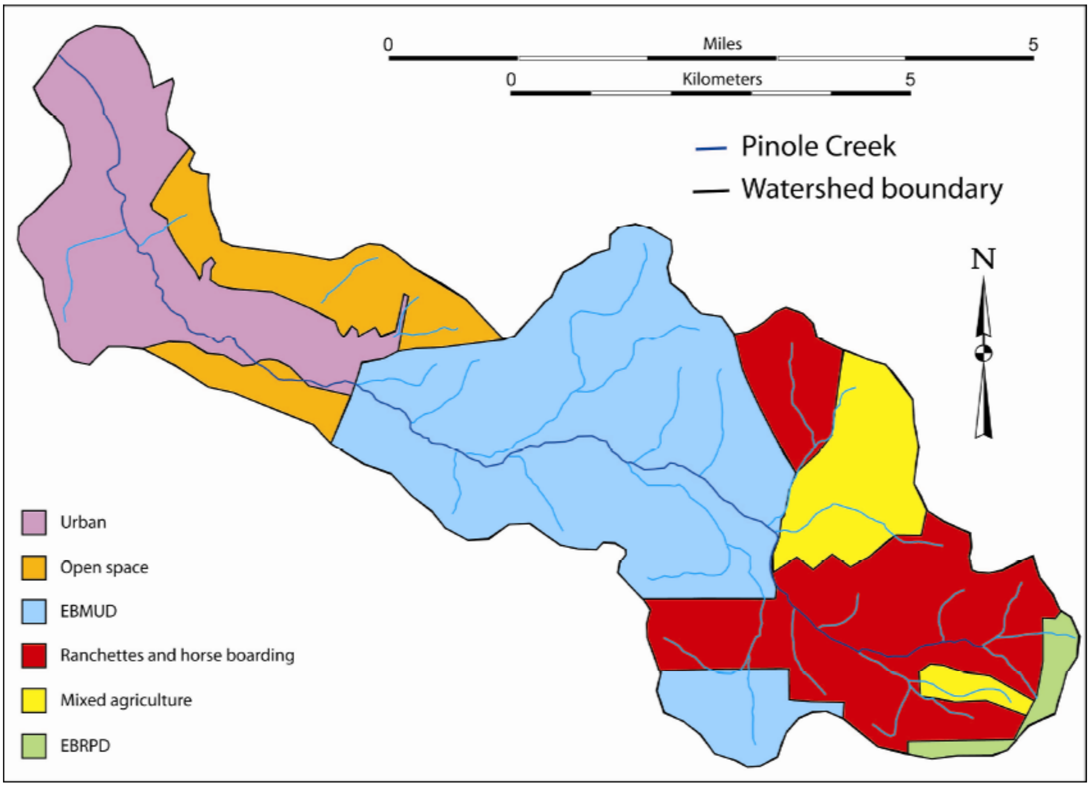

Figure D-3. Generalized land use patterns in the Pinole Creek Watershed. Data is based upon SFEI field observations, and is highly generalized. See text for description of units.

Appendix E- In-channel methods and data

This appendix gives a more detailed description of the methodology followed for collecting the in-channel data. See the Methods described in the Channel Processes section for a more basic description.

The field-based fluvial geomorphic survey of Pinole Creek was based upon previous work conducted by SFEI in other Bay Area creeks. As stated previously, the geomorphic survey uses a systematic random sampling approach to collect data within carefully chosen sample reaches. Because slope is known to be a good predictor of channel morphology, the longitudinal profile is utilized to determine larger channel segments of fairly constant slope. The channel longitudinal profile and five channel segments are shown in Figure E-1.

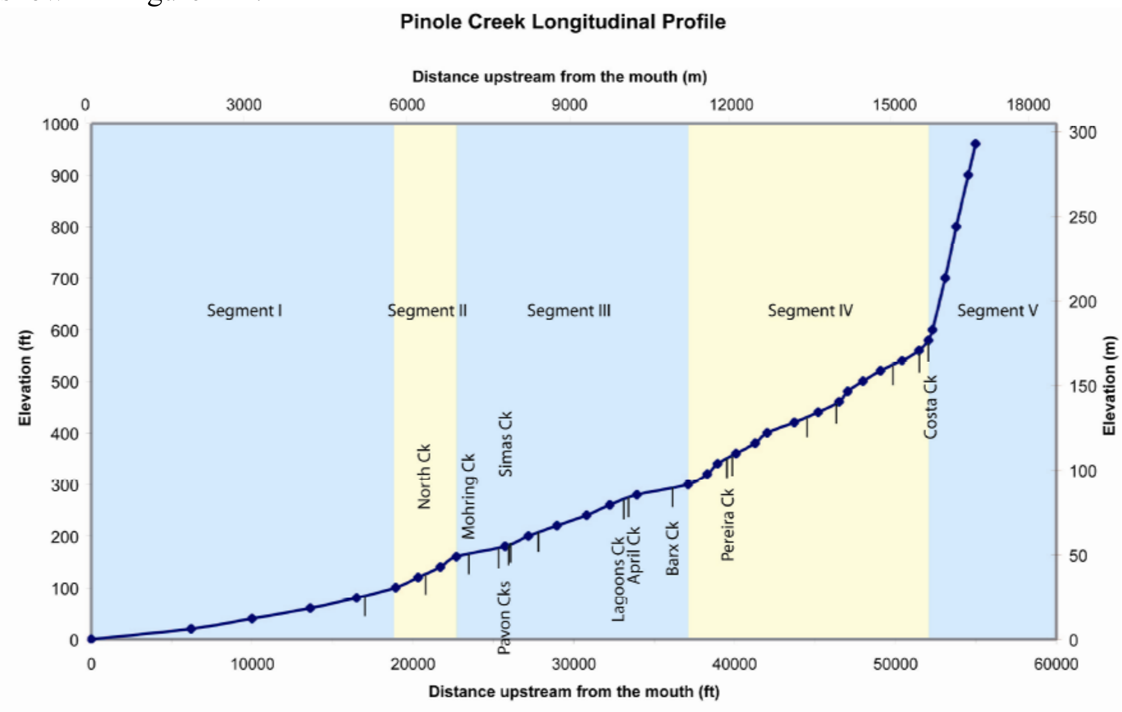

Figure E-1. Pinole Creek longitudinal profile and five segments highlighted, showing the major breaks in slope within the profile.

Within these channel segments, the actual locations of sample reach locations were selected by consideration of both the longitudinal profile and areas with access to private property. Because we were working with the County Public Works Department, and with EBMUD, we had been granted access to large lengths of the channel. Access to private property was generally not an issue in the lower or middle reaches, but was a limiting factor in the upper watershed. To better understand the current form and functioning of many of the tributaries, future studies should consider collecting additional data in reaches that this study was not able to access. Given this limitation, the field team attempted to evenly space the sample reaches across the entire profile while also capturing all major channel morphologies within the watershed. The locations of the 14 sample reaches are shown on the longitudinal profile in Figure E-2.

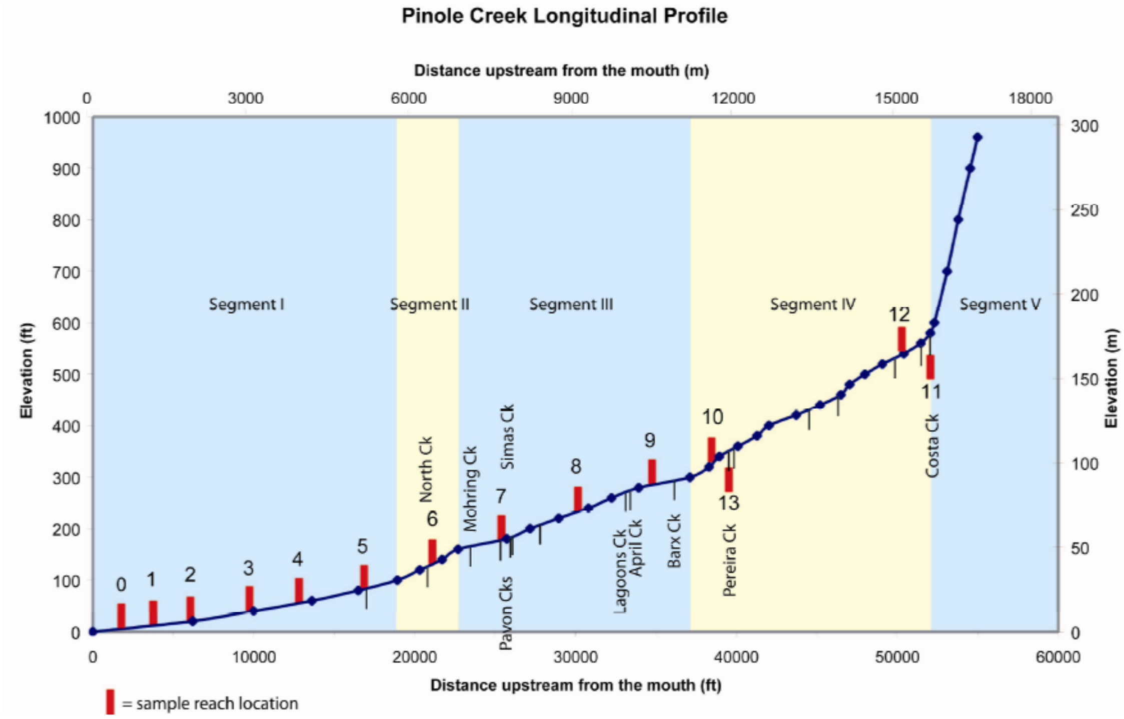

Figure E-2. Pinole Creek longitudinal profile and the 14 sample reach locations.

Table E-1. Raw data for the longitudinal profile.

Elevation (ft)	Cumulative distance (ft)	Trib mouth elevation (ft)	Trib mouth distance (ft)	Elevation (m)	Cumulative distance(m)
0	0	85	16889	0.0	0.0
20	6209	125	20663	6.1	1892.5
40	9985	165	23344	12.2	3043.4
60	13611	177	25481	18.3	4148.6
80	16492	182	25828	24.4	5026.8
100	18926	187	25927	30.5	5768.6
120	20316	208	27665	36.6	6192.3
140	21706	270	32980	42.7	6616.0
160	22699	275	33278	48.8	6918.7
180	25729	295	36010	54.9	7842.2
200	27169	350	39387	61.0	8281.1
220	28957	355	39734	67.1	8826.1
240	30795	430	44353	73.2	9386.3
260	32235	457	46191	79.2	9825.2
280	33924	530	49715	85.3	10340.0
300	37103	555	51354	91.4	11309.0
320	38295	575	51901	97.5	11672.3
340	38940			103.6	11868.9
360	40082			109.7	12217.0
380	41274			115.8	12580.3
400	42019			121.9	12807.4
420	43708			128.0	13322.2
440	45198			134.1	13776.4
460	46489			140.2	14169.8
480	47035			146.3	14336.3
500	47978			152.4	14623.7
520	49070			158.5	14956.5
540	50411			164.6	15365.3
560	51454			170.7	15683.2
580	52050			176.8	15864.8
600	52298			182.9	15940.4
700	53092			213.4	16182.4
800	53787			243.8	16394.3
900	54532			274.3	16621.4
960	54979			292.6	16757.6

In the field, the exact location of each sample reach is randomly chosen, but each is referenced to a fixed, known location. For each sample reach, the field team would arrive in the general location chosen from the longitudinal profile and access map. They would then choose a fixed, known location, such as a bridge, culvert, gated ranch road, or building to which the sample reach location would be tied. A random number was generated, representing a length (in meters), and the team would then proceed upstream the chosen distance. All distances were measured using a HipChain brand metric hipchain, which has an accuracy of ±2% based upon field tests and past experience. The random number methodology avoids biasing the data toward any feature, such as an outstanding pool, sediment deposit, or bank erosion. The field team determined that in some instances where the area of access was limited, the fixed location was arbitrary enough and did not bias towards particular features. In these cases, the sample reach began immediately at the fixed location. The fixed location, and description of each sample reach's location is described in Table E-2. The described location becomes the downstream limit of the sample reach, and was marked with field flagging. Here the field team would measure the channel's bankfull width (as evidenced by field indicators). The bankfull width measurement determined the reach length, as each sample reach is 25 times the measured bankfull width. This protocol was chosen because a channel length of at least 20 bankfull widths is necessary to fully capture the channel's pool-riffle sequence and accurately represent all of its features. Within each sample reach, field flagging was placed at intervals of five bankfull widths, to provide a sampling framework to collect in-channel data.

Table E-2. Description of exact location of each sample reach. Note: * denotes reaches where the fixed location describes the upstream limit of the sample reach. The field team worked downstream in these instances.

Sample reach	Fixed location	Distance from the fixed location (m)	Downstream bankfull width (m)	Total sample reach length (m)
0	Upstream edge of Railroad Ave bridge	0	7.5	187.5
1	Upstream edge of San Pablo Ave roadway in concrete culvert	0	6.5	162.5
2	Upstream edge of Tennent Ave culvert	134 upstream	6.6	165.0
3	Upstream edge of Pinole Valley Road bridge at the library	30 upstream	2.9	72.5
4	Downstream edge of Simas Ave bridge	38 downstream*	3.9	97.5
5	Upstream edge of Pinole Valley Road bridge number 5	25 upstream	6.4	160
6	Upstream edge of old bridge at historic USGS gauge location	41 upstream	3.3	82.5
7	Downstream edge of culvert under Pinole Valley Road at Castro Ranch Road	40 downstream*	2.8	70.0
8	EMBUD gated ranch road and cow crossing 0.8 mi upstream of the "Y"	0	3.9	97.5
9	EMBUD gated ranch road, upstream edge of culvert	101 upstream	2.6	65.0
10	Upstream edge of riprap where power lines cross Alhambra Valley Road	0	3.4	85.0
11	Costa Creek Tributary- second cow crossing upstream of corral	9 upstream	2.2	53.5
12	Downstream property line of a specific private property on Garcia Ranch road	0	3.1	77.5
13	Pereira Tributary-Upstream edge of culvert under Alhambra Valley Road	10 upstream	2.2	55.0

Table E-3. Measured bankfull widths, depths, width to depth ratio, and average slope.

Sample reach	Bankfull width (m)	Bankfull depth (m)	Width:Depth ratio	Average slope (%)
0	7.5	1.1	6.82	0.25
1	6.3	0.41	15.52	0.09
2	4.3	0.43	10.12	0.30
3	3.4	0.55	6.23	0.60
4	4.0	0.37	10.81	0.44
5	5.6	0.37	15.30	0.47
6	5.0	0.56	8.87	0.44
7	3.5	0.37	9.32	1.57
8	3.1	0.42	7.32	0.84
9	3.1	0.45	6.99	0.35
10	3.2	0.49	6.61	2.20
11	1.5	0.57	2.69	2.11
12	3.2	0.56	5.77	0.84
13	2.7	0.47	5.76	2.04

Table E-4. Watershed area for the entire watershed, and upstream of each of the sample reach locations.

Pinole Creek watershed areas	km^2	mi^2
Total watershed	39.60	15.29
Upper watershed	12.15	4.74
Middle watershed	15.66	6.08
Lower watershed	11.85	4.53
Area upstream of:		
Stream gauge location	31.60	12.20
Sample reach 13	3.35	1.29
Sample reach 12	1.86	0.72
Sample reach 11	0.25	0.10
Sample reach 10	12.31	4.75
Sample reach 9	13.60	5.25
Sample reach 8	19.83	7.66
Sample reach 7	26.00	10.04
Sample reach 6	27.77	10.72
Sample reach 5	31.60	12.20
Sample reach 4	33.64	12.99
Sample reach 3	34.54	13.34
Sample reach 2	37.41	14.45
Sample reach 1	38.00	14.67
Sample reach 0	39.50	15.25

Data collected in each sample reach falls into two categories: data collected continuously throughout the entire reach length, and data collected only at every fifth bankfull width. Continuously collected data includes channel bed and bank erosion and revetment data, sediment deposit data, and pool and large woody debris data. Data collected only at every fifth bankfull width includes sediment grain size distribution data, and surveyed channel cross-sections. The Channel Processes section adequately describes data collection methodologies for each of these channel components.

Additional information on channel bank erosion was collected besides that described in the text, including total amount of erosion, erosion per unit channel length, and age of erosion. The raw data is presented in the figures below.

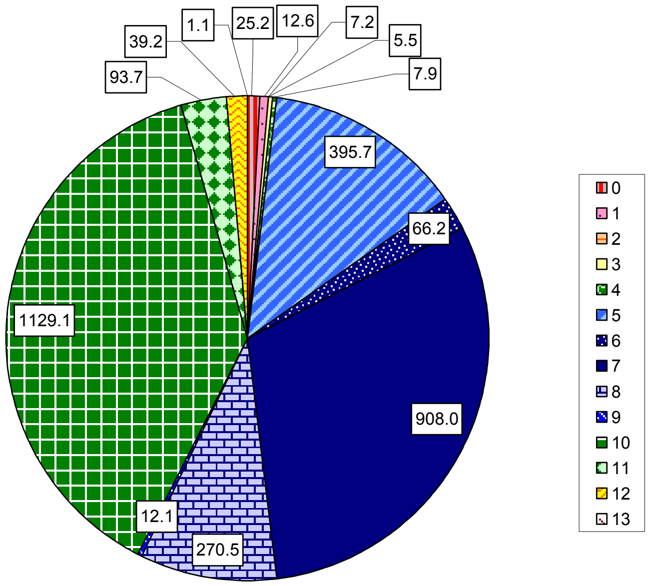

Figure E-3. Total volume (in m^3) and proportion of the total amount of bank erosion measured in each sample reach.

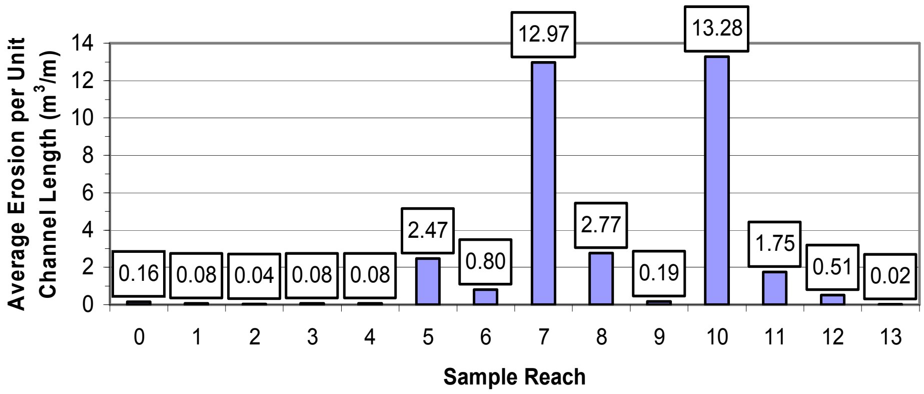

Figure E-4. Average volume of bank erosion normalized to sample reach length.

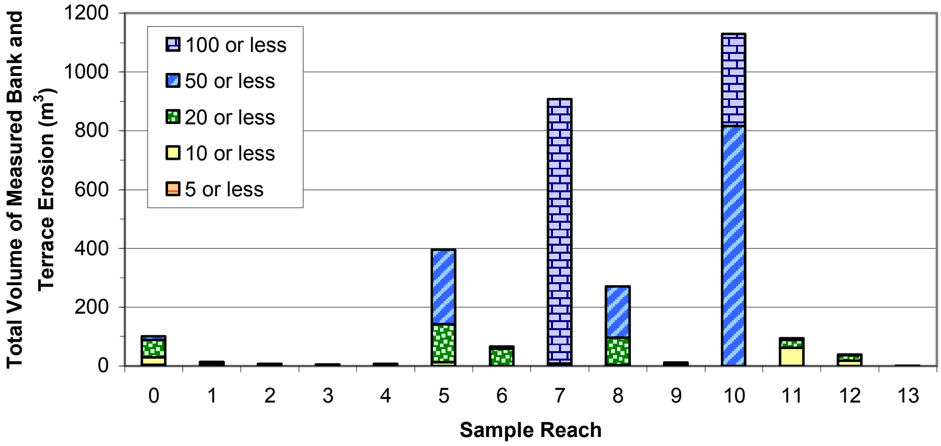

Figure E-5. Total volume (in m^3) and age class (in years) of measured bank erosion.

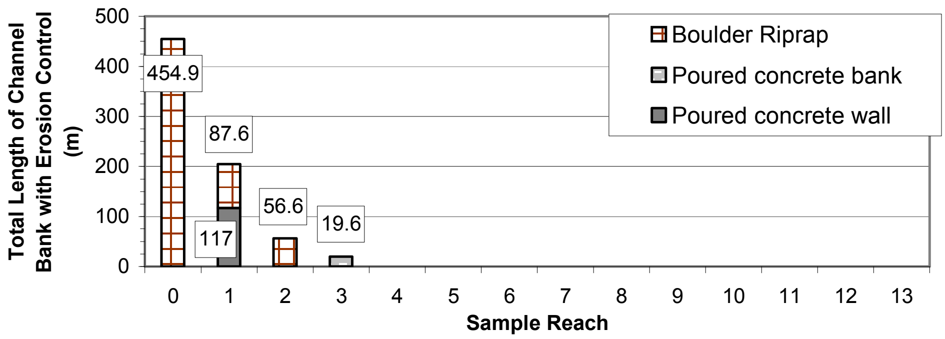

Figure E-6. Total length of each bank revetment type measured in each sample reach.

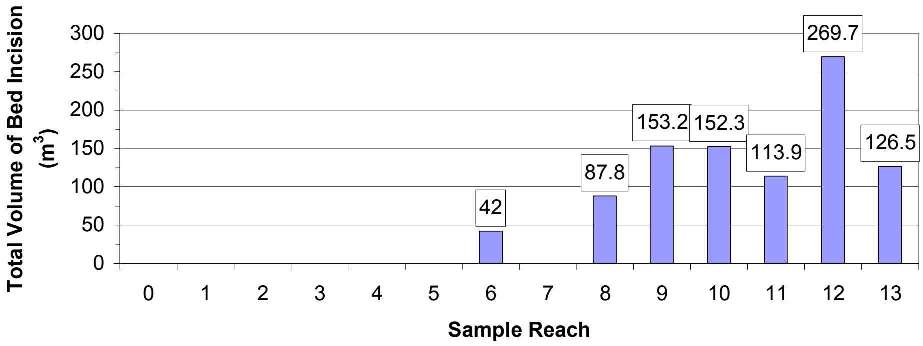

Figure E-7. Total volume (in m^3) of measured bed incision.

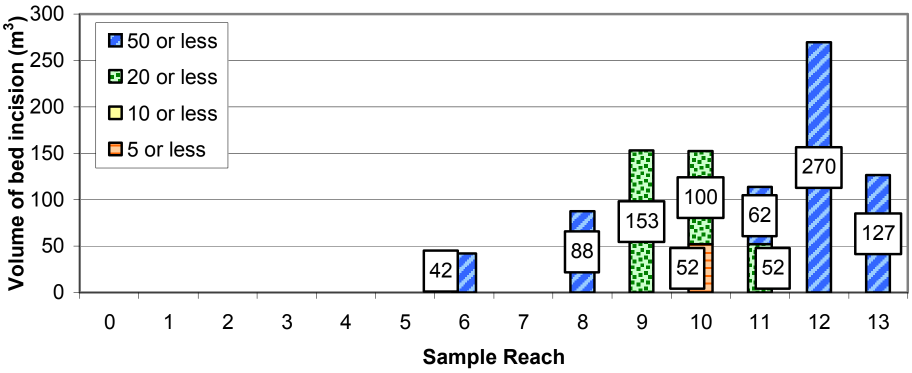

Figure E-8. Total volume (in m^3) and age class of measured bed incision.

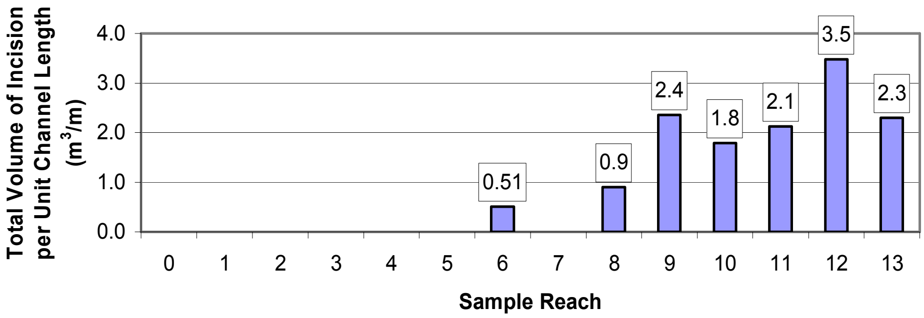

Figure E-9. Volume of bed incision normalized to sample reach length.

Additional data was also collected on sediment storage. This includes the total number and total volume of each type of sediment deposit, the total number and type of deposit in each sample reach, and the total volume of pool deposits in each reach. The focus of this data collection is on “active” sediment, rather than sediment that is not readily available for transport by the fluvial system. We define active as that sediment that is stored either in the channel bed, bars, or low terraces that has been deposited within the previous 50 to 100 years, or can be modified and reworked by approximately the 50 year return interval flood. In the field, the surface size distribution of individual bars and other deposits are compared against the size distribution of more stable, coarse-textured reaches to identify active sediment deposits and bars. In general, gravel and sands are regarded as mobile in ordinary peak stream flow events (i.e. extreme floods are not required), cobbles may be regarded as mobile depending on circumstances, and boulders are regarded as essentially immobile with respect to downstream sediment routing. Our measures of active sediment deposits do not include the terrace surface that currently has development (in the lower reach) or agricultural activities (in the middle and upper reaches) or equivalent deposits.

Although the width and length can be measured directly, the depth is estimated using field evidence of likely depth of scour. The depth of larger, rectangular bars is typically determined from measuring the difference between the maximum bar height and the thalweg elevation adjacent to the bar and/or in adjacent pools. However, a shape factor is used to adjust the deposit depth when the bar has a triangular cross-sectional geometry.

Deposit type is based upon types defined by the California Department of Fish and Game (Flosi, et al., 1998), previous work by SFEI, and definitions in the *Stream Channel Assessment of the Washington DNR Watershed Analysis Methodology* (Washington Forest Practices Board, 1997). The definitions for each bar type are listed below:

Alternate bar – found on channel margins in areas of local deposition. This bar pattern typically alternates between edges of the channel moving downstream, associated with the development of a meander pattern. This bar type lacks any discrete roughness element as for forced bars.

Active channel deposit – includes mobile bed material deposited on the channel bed, but not in the form of a bar. This category may include patches of sand and fine gravel dispersed in pockets of relatively immobile cobble clasts.

Pool deposit – Similar to active channel deposits, but is located in pool bottoms or pool tails. Often comprised of mud, silt and sand, and are typically mobile every year.

Forced bar – forms in the lee of flow obstruction such as woody debris or live vegetation, boulder clusters, bedrock outcrops, riprap or bridge pilings.

Point bar – forms opposite pools in meander bends. Deposition occurs due to helical flow in the pool.

Medial bar – occurs in the center of a channel where a channel diverges into multiple threads, and is typically associated with localized zones of accelerated bedload deposition.

Lateral bar – found on channel margins and is presumably formed in areas of local deposition associated with flow divergence or bank roughness, but lacks any discrete roughness element as for forced bars.

Bank slump – sediment deposited in-channel immediately below a bank failure. These failures are typically rotational style slumps, and deposit a relatively coherent block of bank material into the channel.

Terrace – a topographically flat deposit of sediment that is higher than the current channel elevation and is found on one or both channel edges. The terrace represents the current or historic channel floodplain, and typically receives only fine-grained sediment.

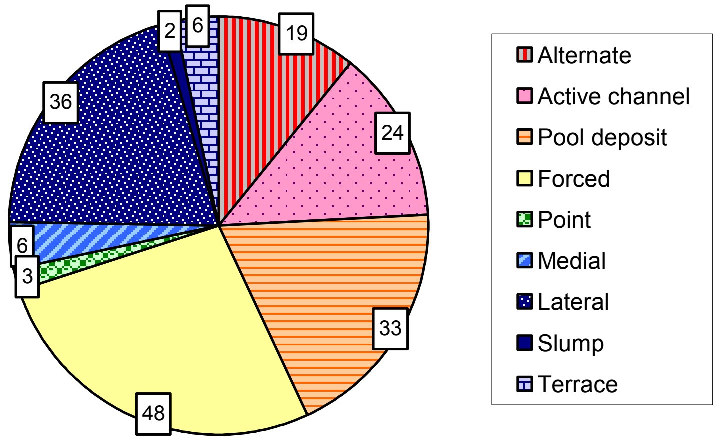

Figure E-10. Total number of each type of sediment deposits measured in all 14 sample reaches.

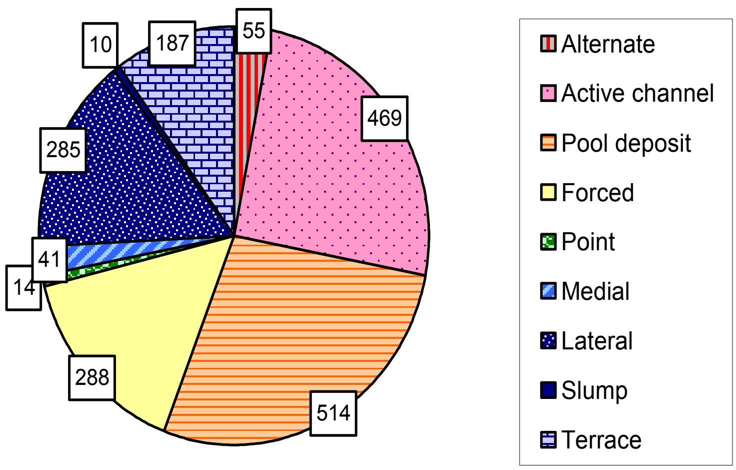

Figure E-11. Total volume (in m^3) of each type of sediment deposit measured in all 14 sample reaches.

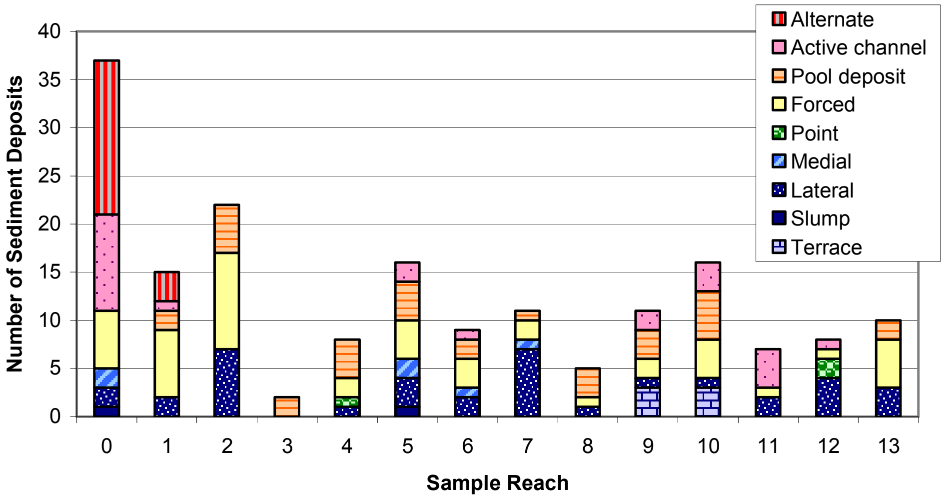

Figure E-12. Total number and type of sediment deposits in each sample reach.

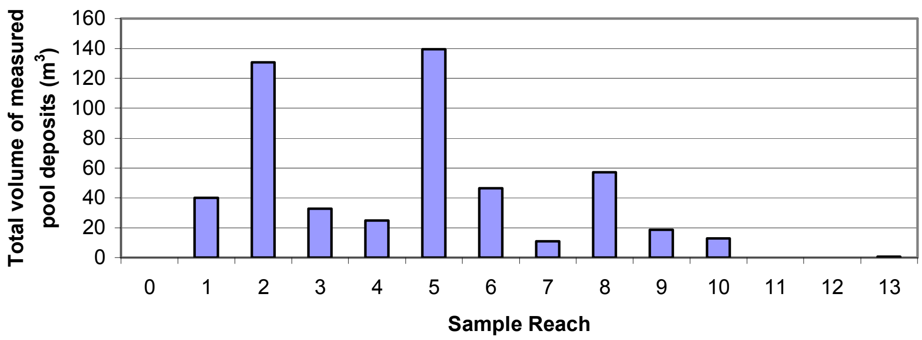

Figure E-13. Total volume (in m^3) of pool deposits in each sample reach.

Additional data on pools was also collected, and is presented in the figures below.

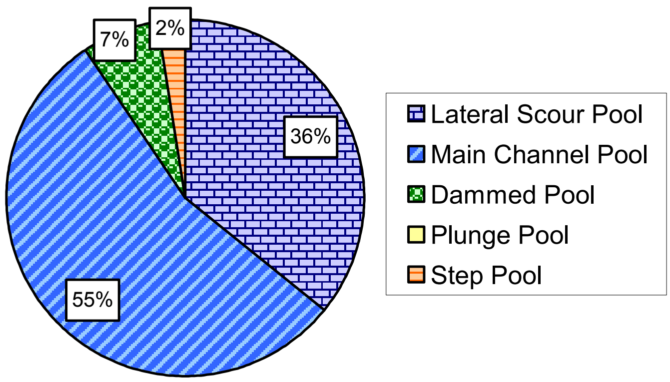

Figure E-14. Percentage of each pool type measured in all 14 sample reaches.

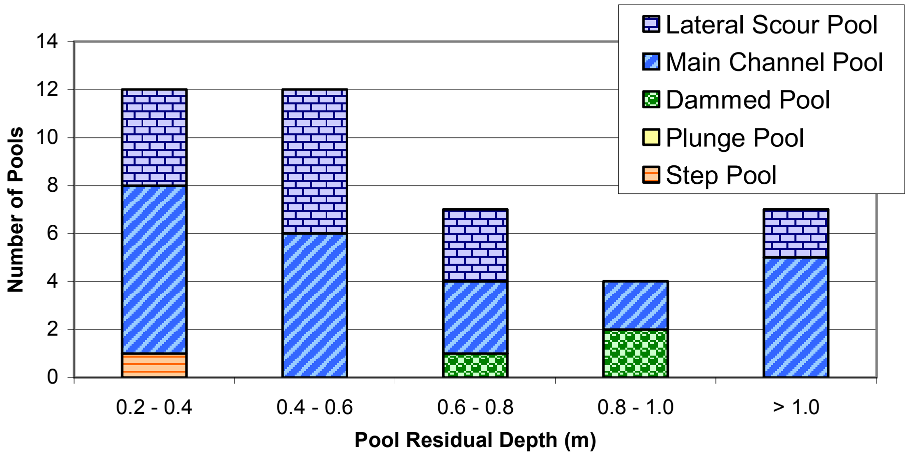

Figure E-15. Pool residual depth (in meters) for each pool type measured in all 14 sample reaches.

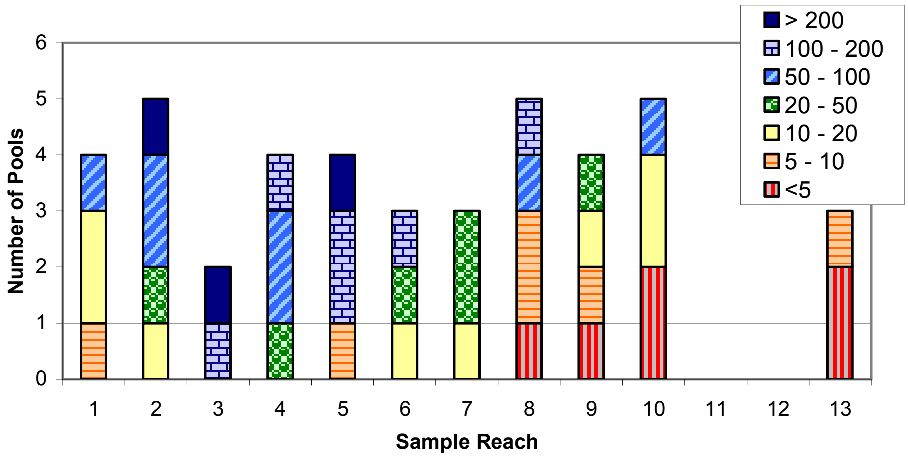

Figure E-16. Volume (in cubic meters) of each pool measured in each sample reach.

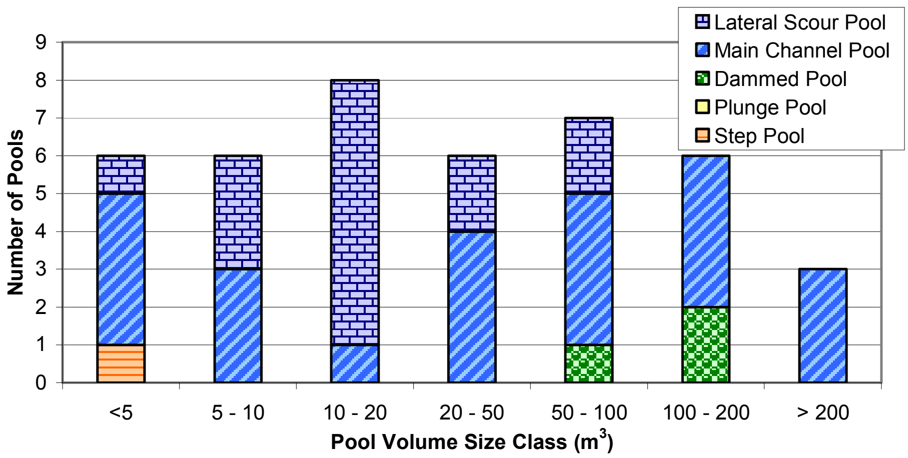

Figure E-17. Pool volume (in cubic meters) for each type of pool measured in all 14 sample reaches.

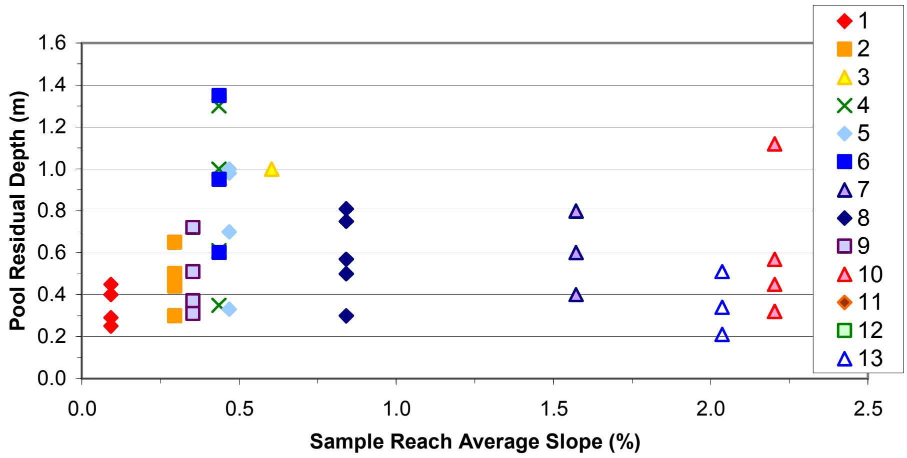

Figure E-18. Sample reach average slope (in percent) versus pool residual depth (in meters).

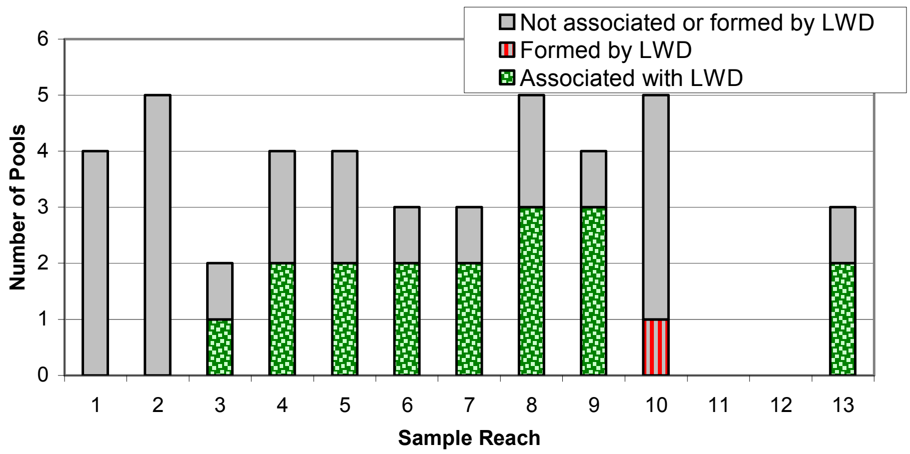

Figure E-19. Number of pools either directly formed by, or associated with large woody debris in each sample reach.

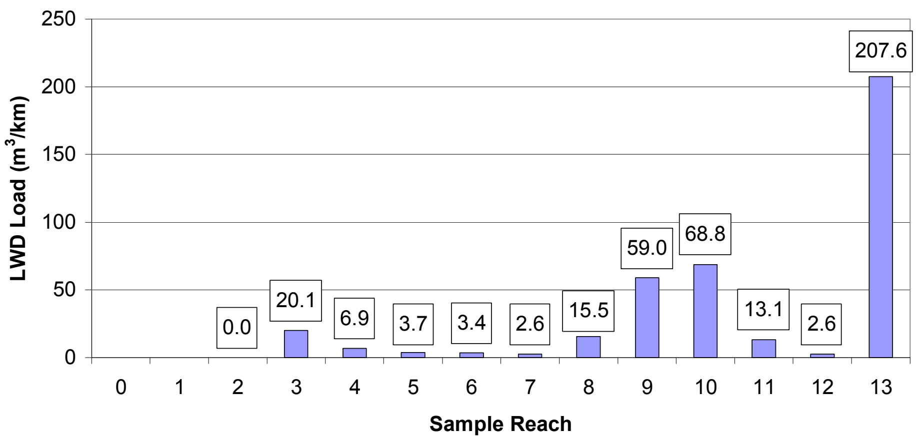

Figure E-20. Large woody debris load (in m^3/km) for each sample reach.

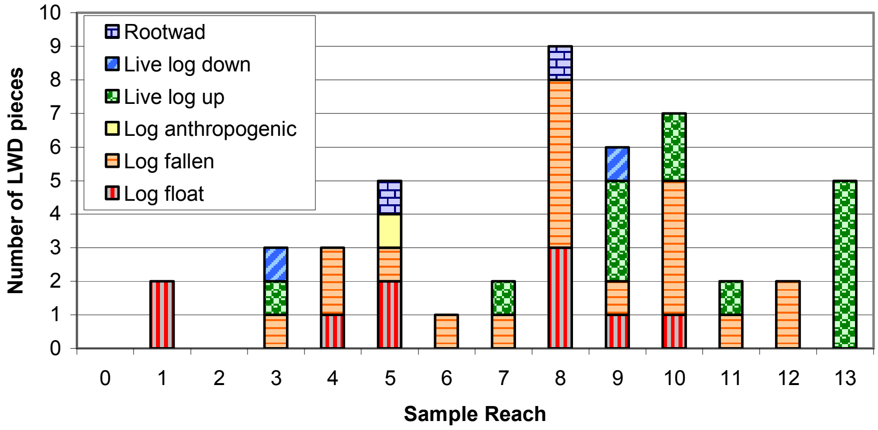

Figure E-21. Type of large wood debris measured in each sample reach. Live log down describes a tree that is no longer upright, but is still alive, and is affecting flow in the bankfull channel. Live log up describes a tree that is still upright and is affecting flow in the bankfull channel. Often this category describes roots or a rootball that is within the bankfull channel. Log anthropogenic describes a piece that clearly was added or modified by man; for example a log that has been sawed and thrown into the channel. Log fallen describes a piece that has fallen in from the bank or riparian zone and is affecting flow within the bankfull channel. Log float describes a piece that was recruited from elsewhere, and has since floated to its current position in the channel.

Channel cross sections

The following section contains all 41 cross sections measured by the field team. Cross sections are labeled by the sample reach, and the number of meters upstream of the bottom of the reach. For example, sample reach 2, location 33 meters upstream would be labeled “Reach 2, XS 33”. All cross sections are oriented perpendicular to the direction of flow, looking downstream, and are referenced to an arbitrary datum. Two times vertical exaggeration. Scale is in meters.

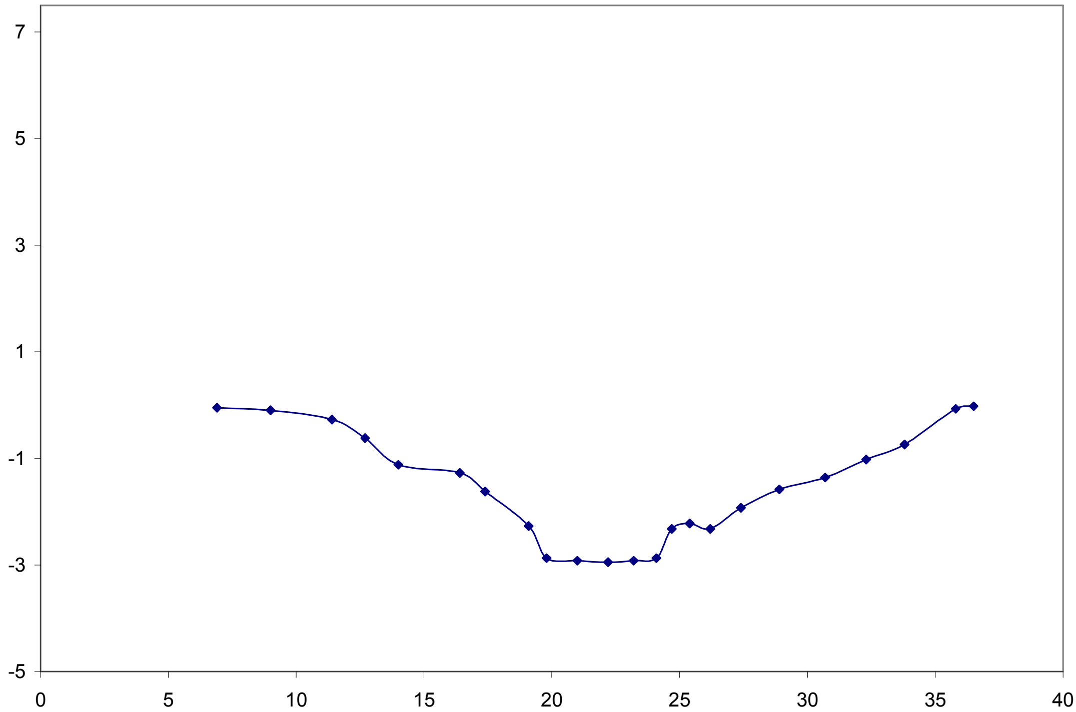

Figure E-22. Reach 0, XS 140. * this cross section is located 140 m downstream of the Santa Fe Railroad trestle.

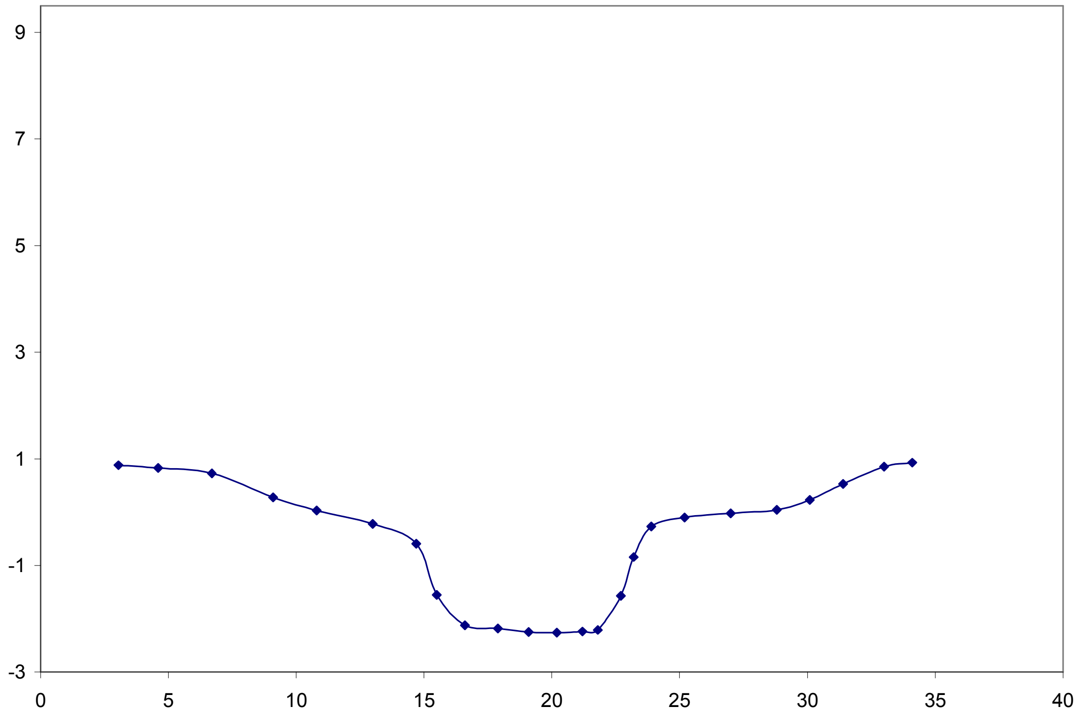

Figure E-23. Reach 0, XS 330. * this cross section is located 330 m downstream of the Santa Fe Railroad trestle.

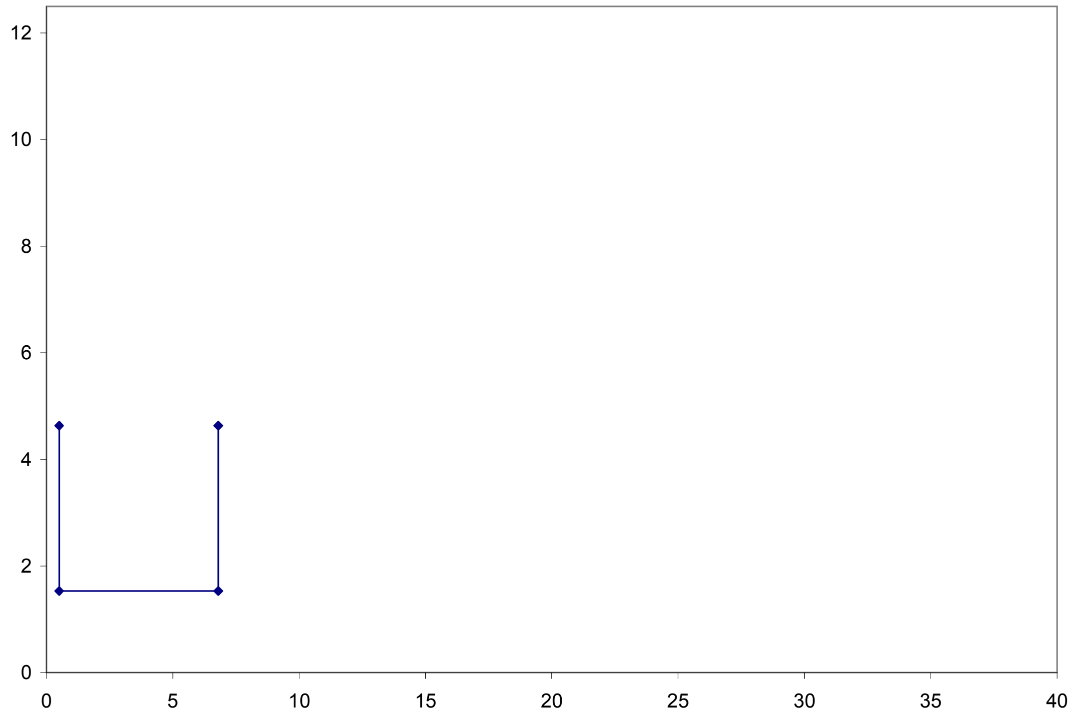

Figure E-24. Reach 1, XS 32.5.

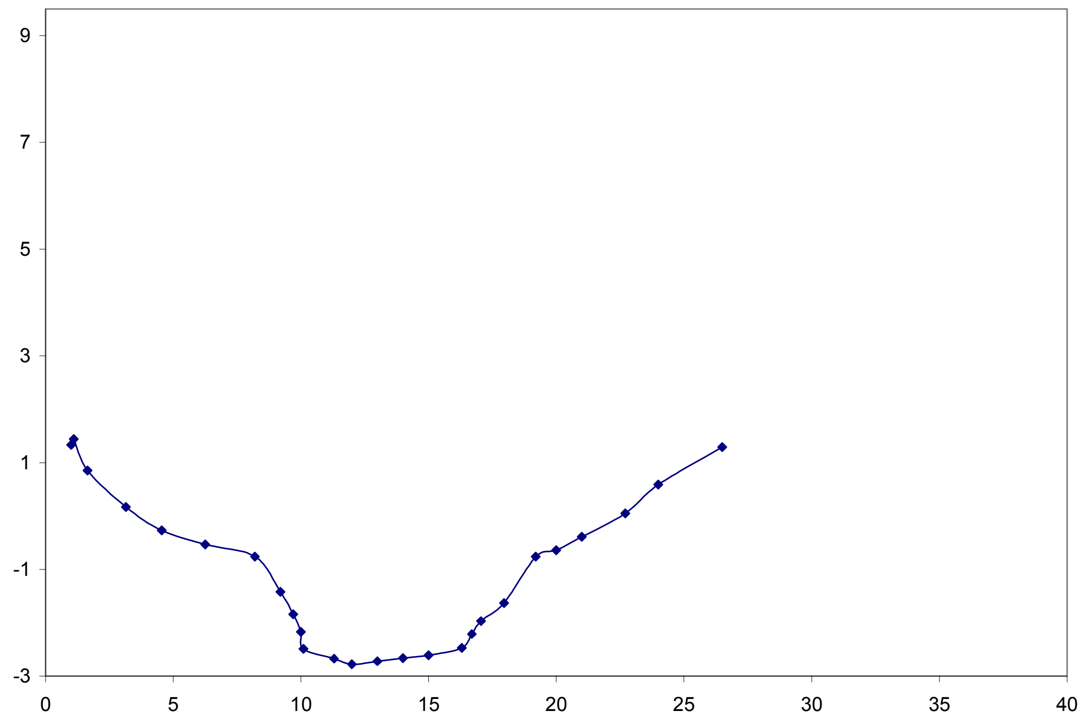

Figure E-25. Reach 1, XS 97.5.

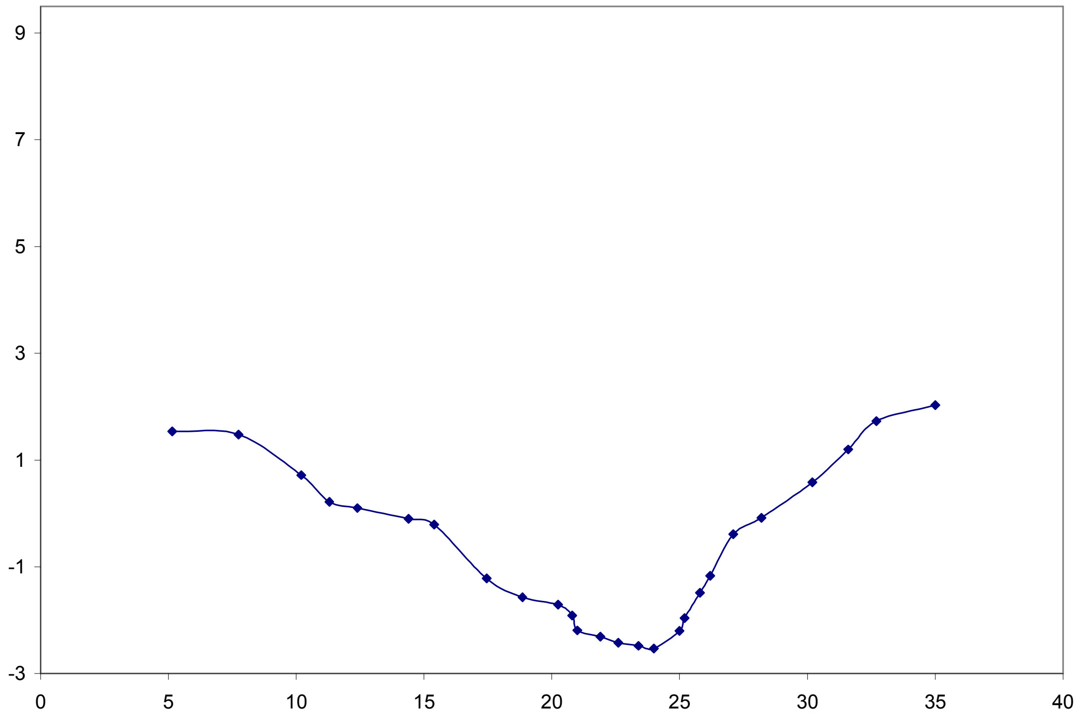

Figure E-26. Reach 1, XS 162.5.

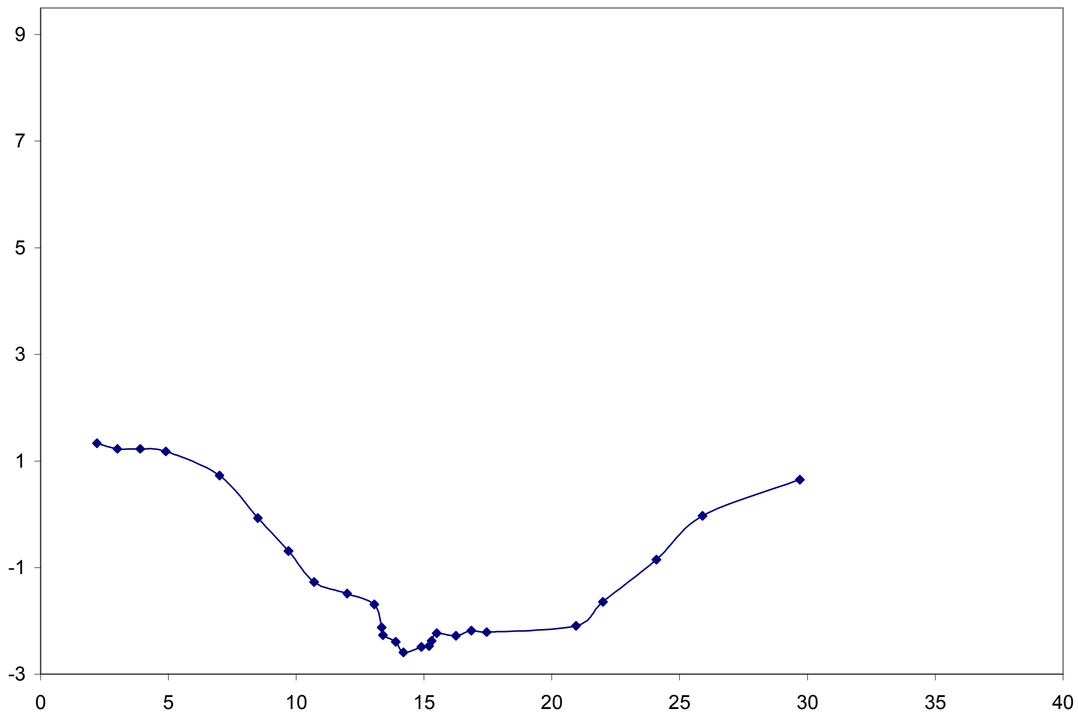

Figure E-27. Reach 2, XS 33.

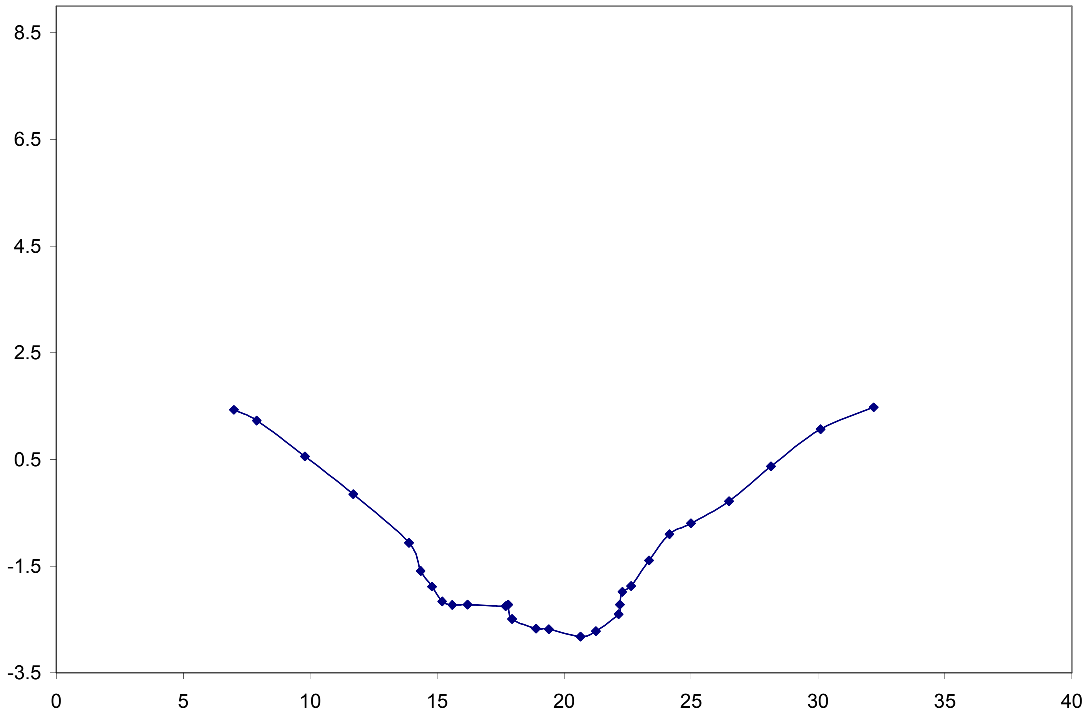

Figure E-28. Reach 2, XS 99.

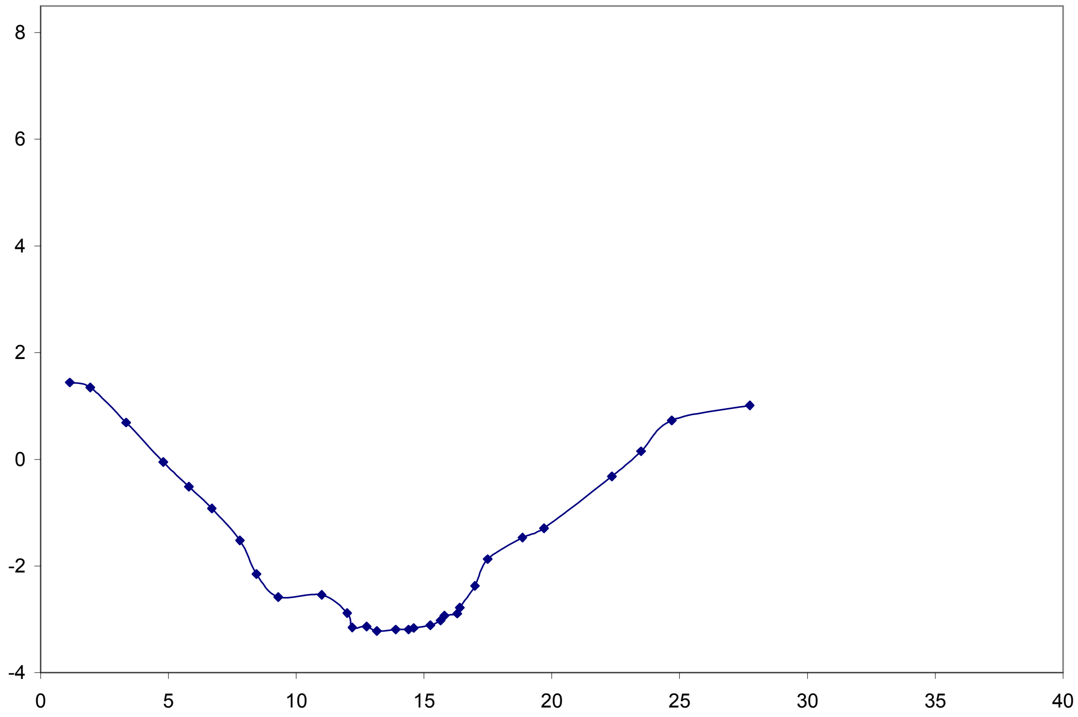

Figure E-29. Reach 2, XS 165.

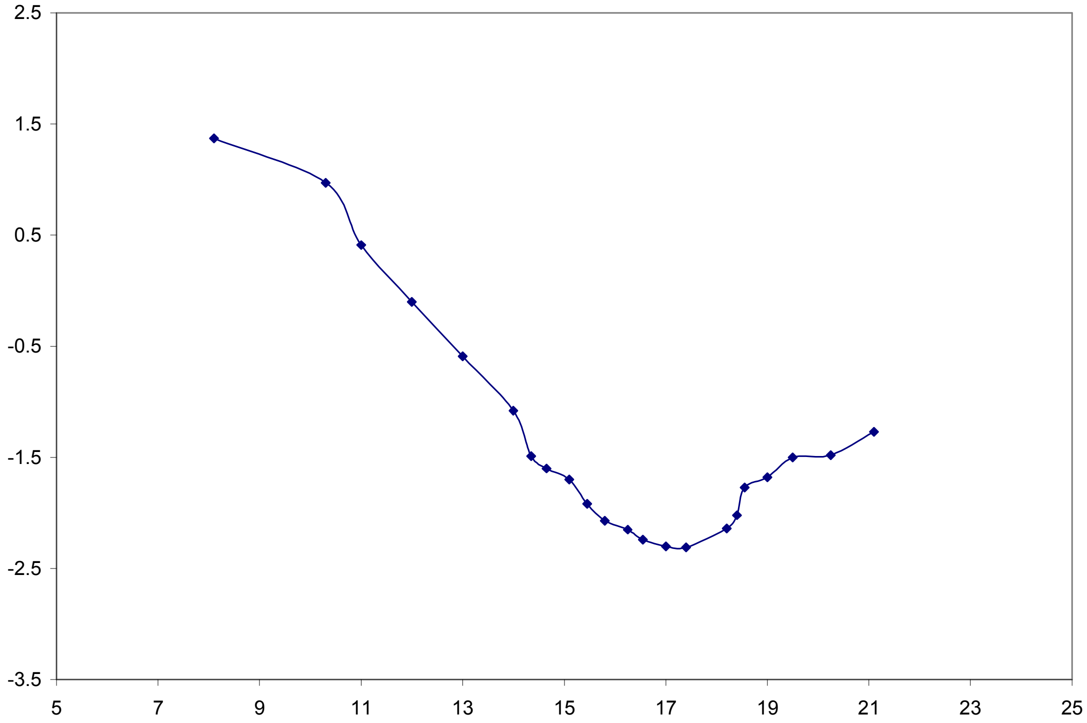

Figure E-30. Reach 3, XS 14.5.

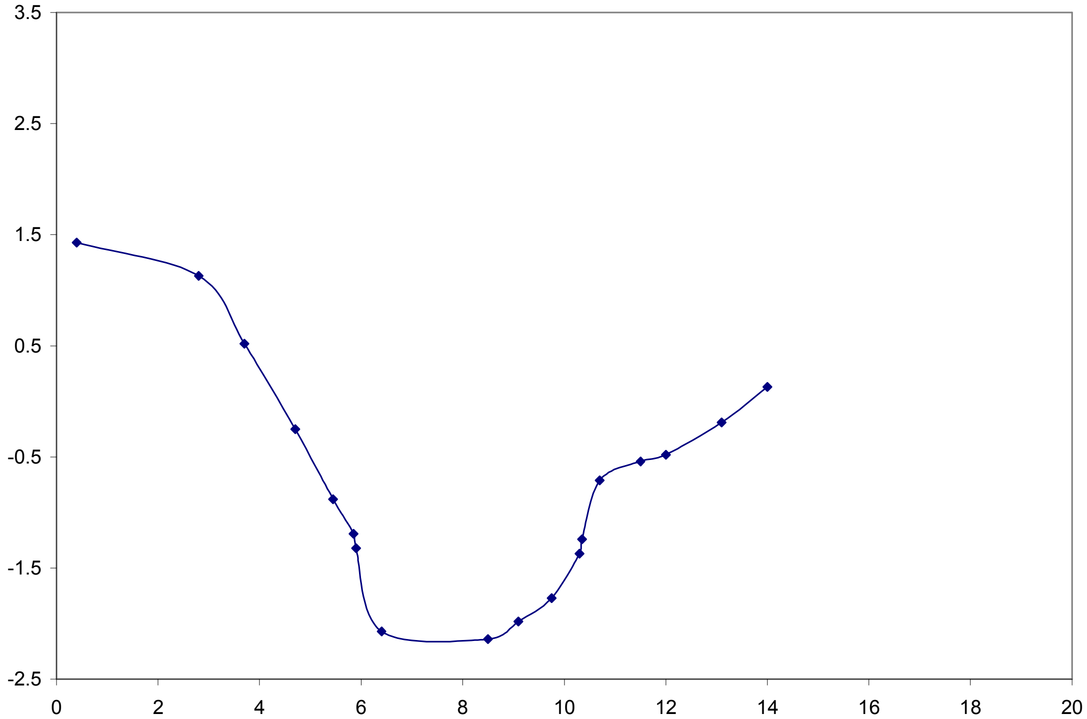

Figure E-31. Reach 3, XS 43.5.

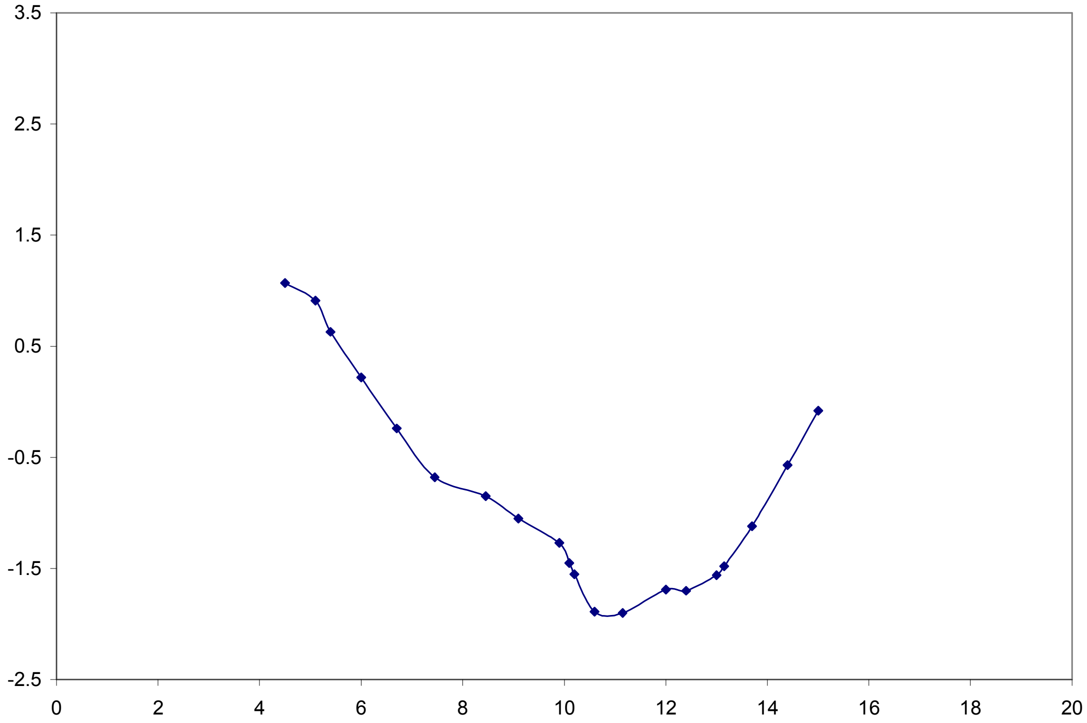

Figure E-32. Reach 3, XS 72.5.

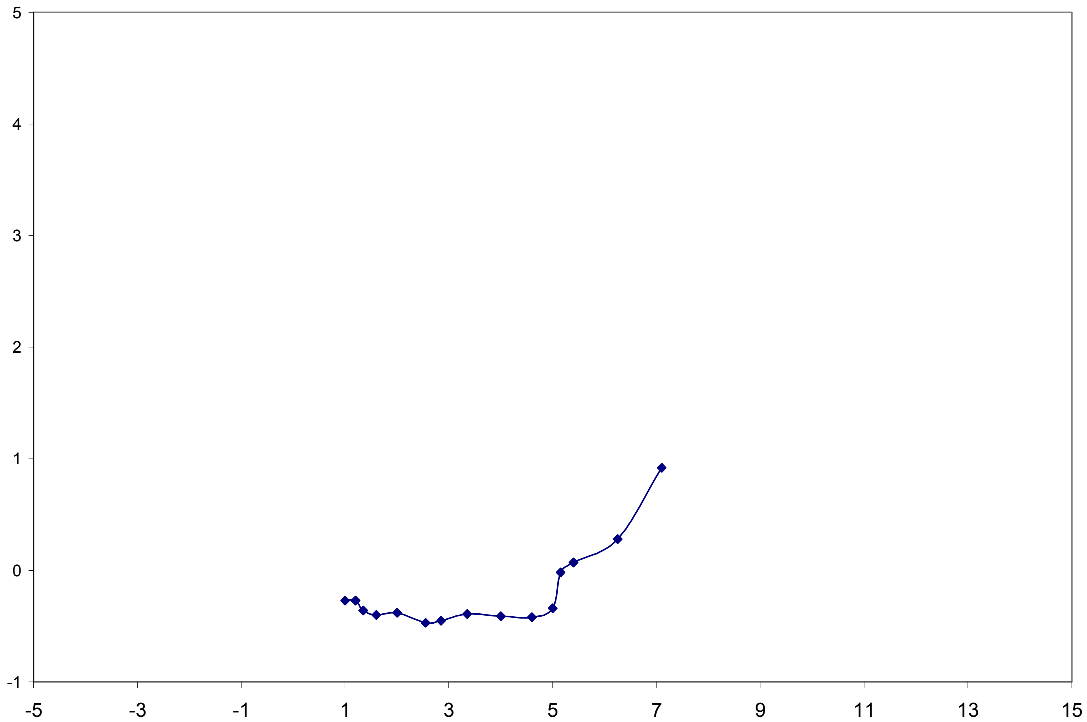

Figure E-33. Reach 4, XS 19.5. * this cross section is 19.5 m downstream of the Simas Avenue bridge.

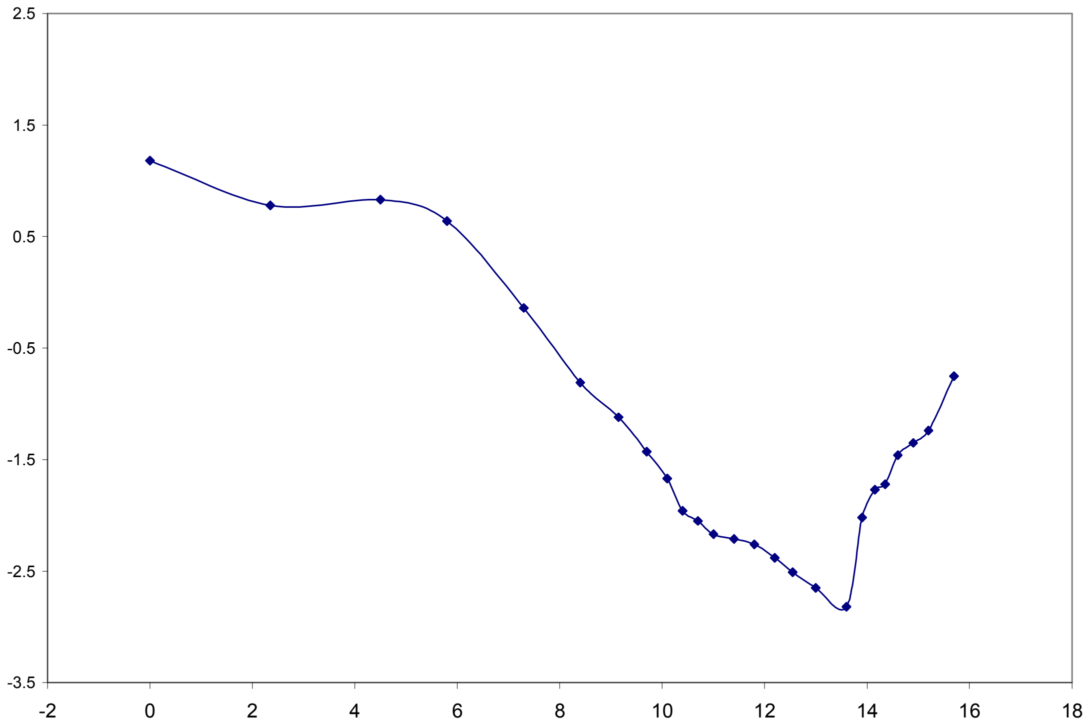

Figure E-34. Reach 4, XS 58.5. * this cross section is 58.5 m downstream of the Simas Avenue bridge.

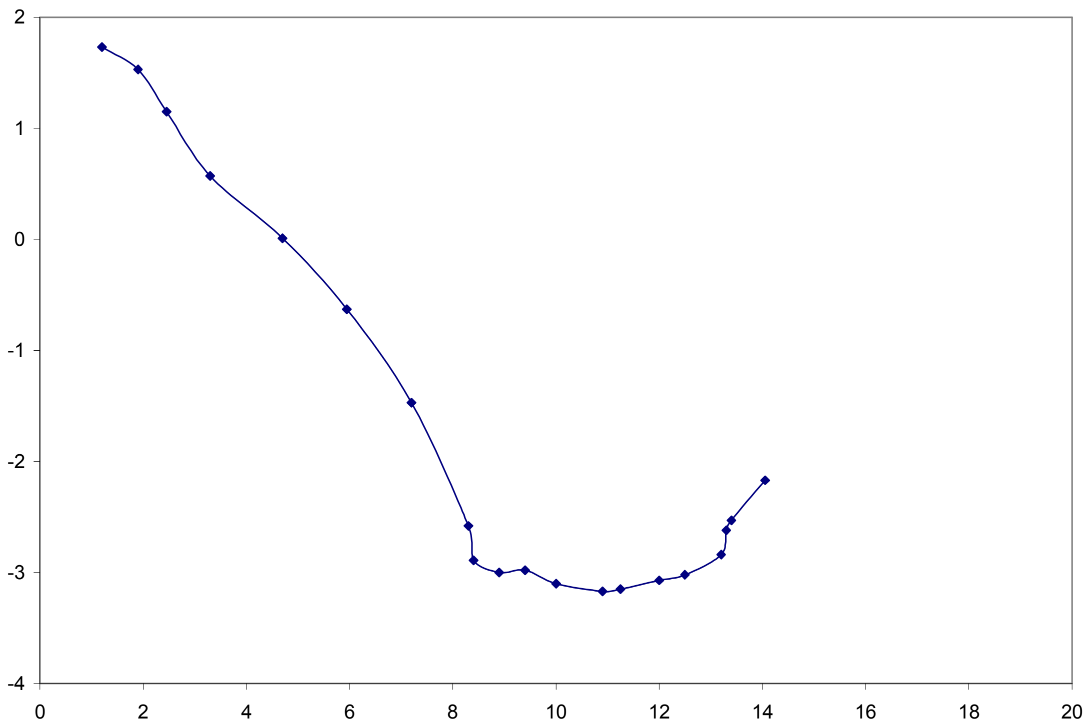

Figure E-35. Reach 4, XS 97.5. * this cross section is 97.5 m downstream of the Simas Avenue bridge.

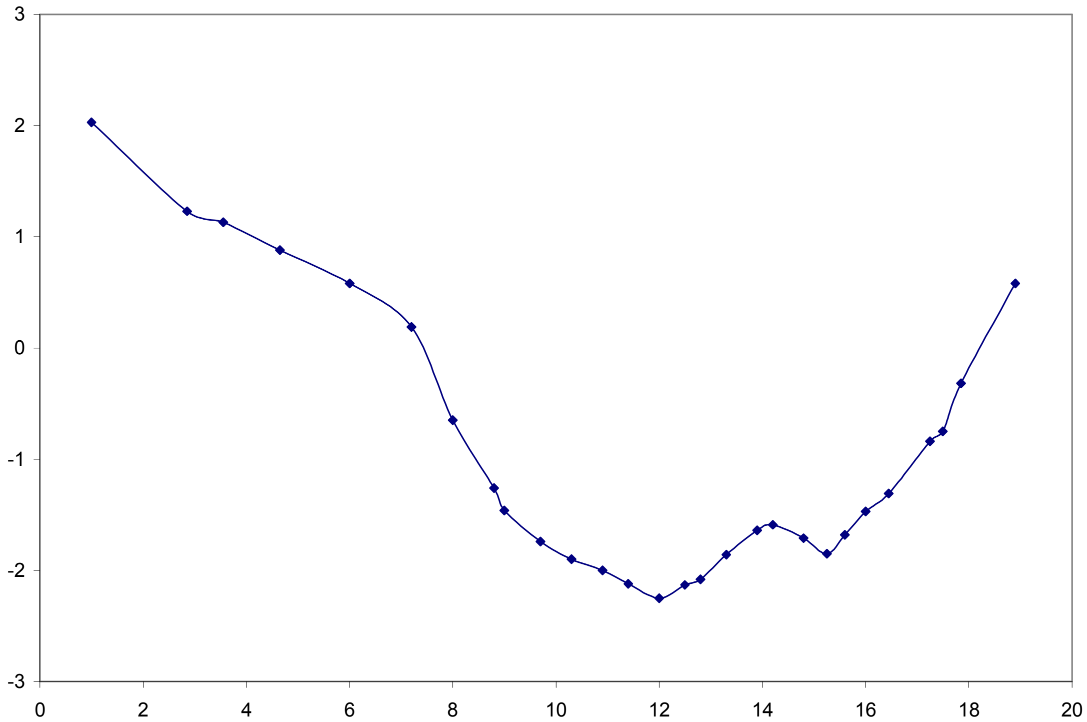

Figure E-36. Reach 5, XS 32.

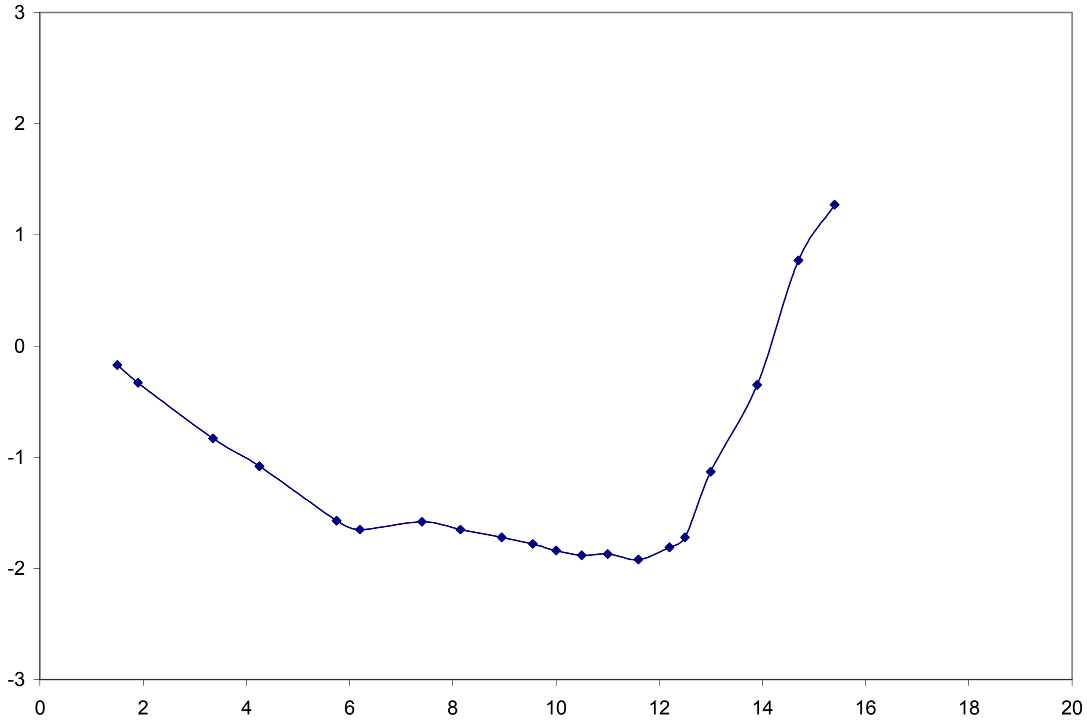

Figure E-37. Reach 5, XS 96.

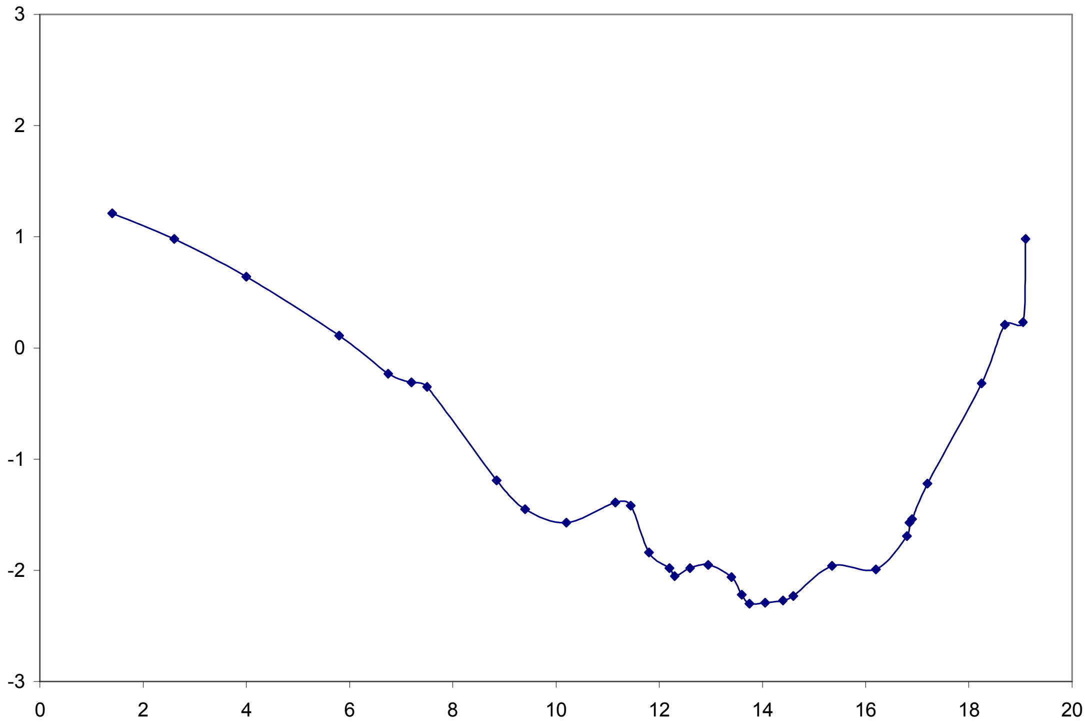

Figure E-38. Reach 5, XS 160.

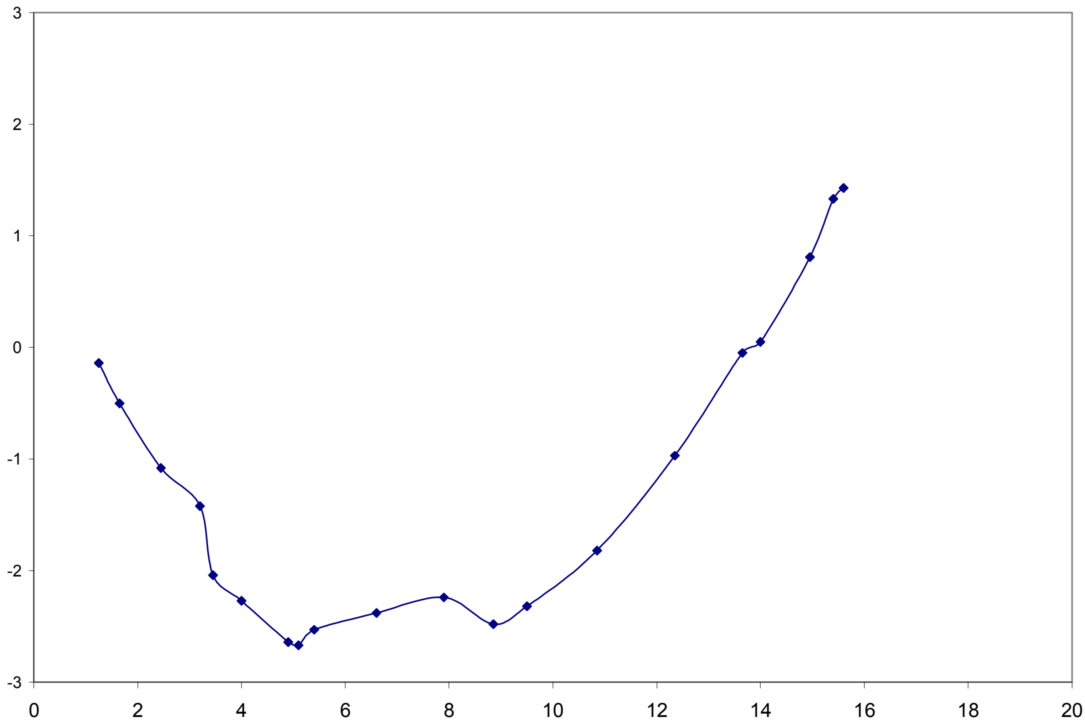

Figure E-39. Reach 6, XS 16.5.

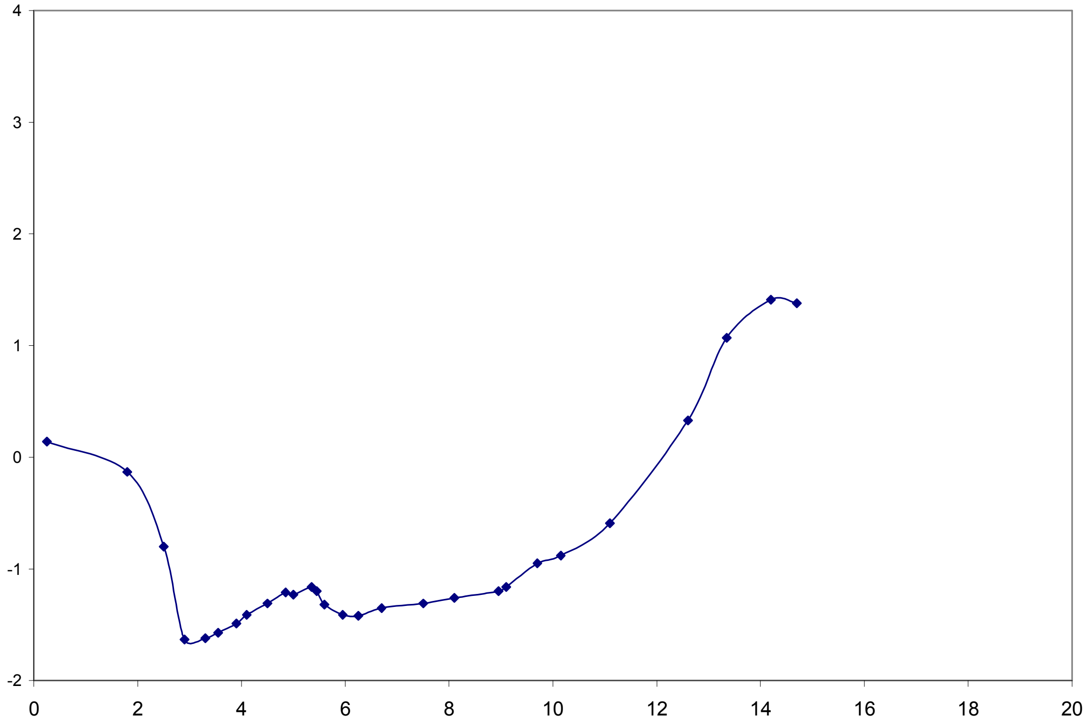

Figure E-40. Reach 6, XS 49.5.

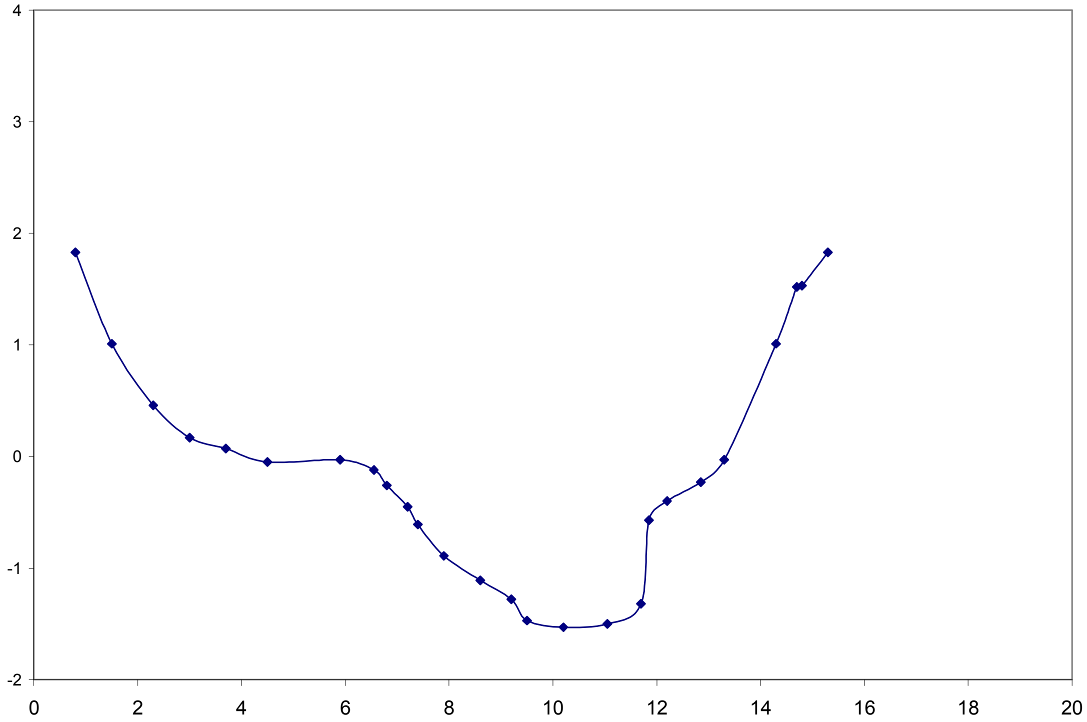

Figure E-41. Reach 6, XS 82.5.

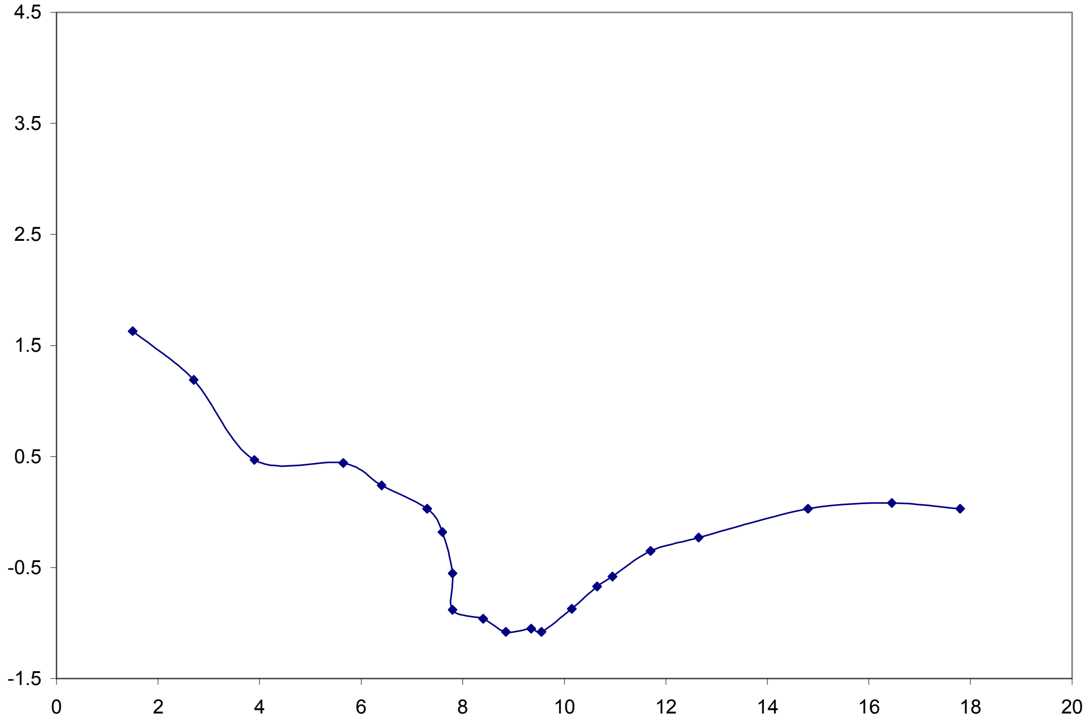

Figure E-42. Reach 7, XS 0. * this cross section is located 40 m downstream of the culvert under Pinole Valley Road and Castro Ranch Road.

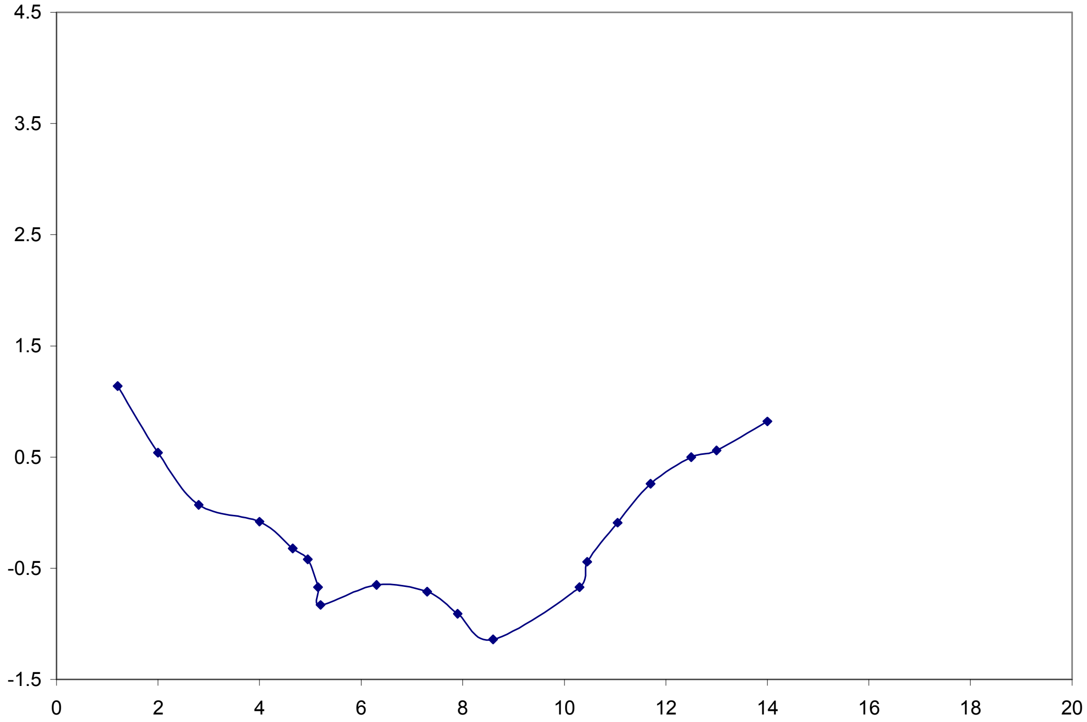

Figure E-43. Reach 7, XS 28. * this cross section is located 68 m downstream of the culvert under Pinole Valley Road and Castro Ranch Road.

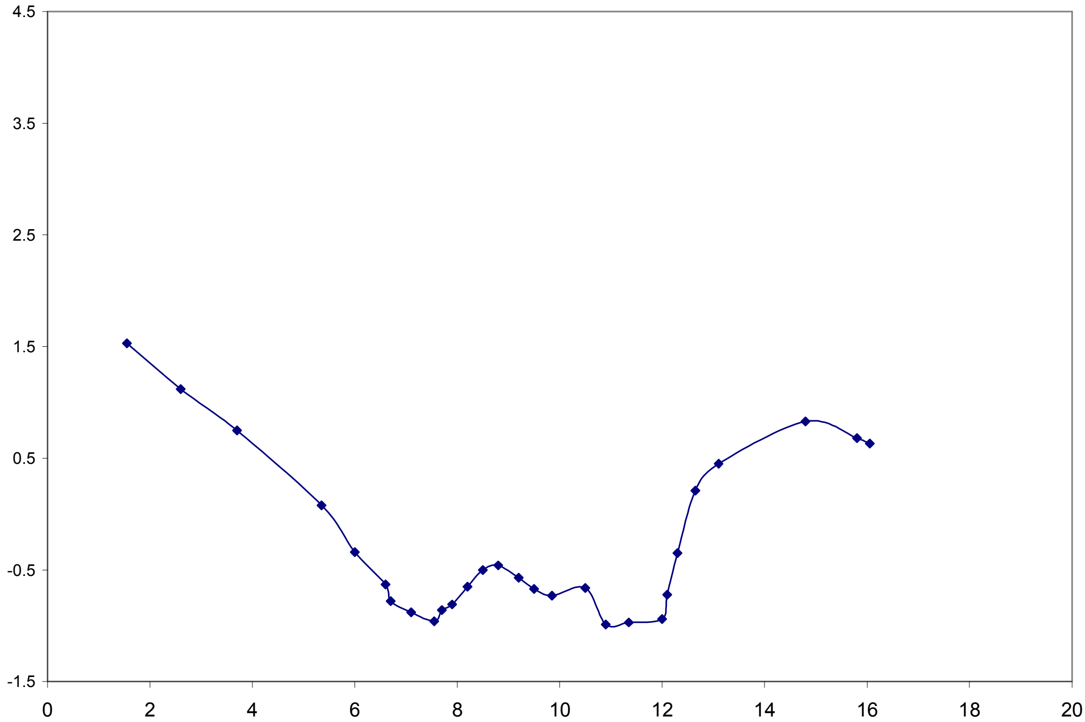

Figure E-44. Reach 7, XS 56. * this cross section is located 96 m downstream of the culvert under Pinole Valley Road and Castro Ranch Road.

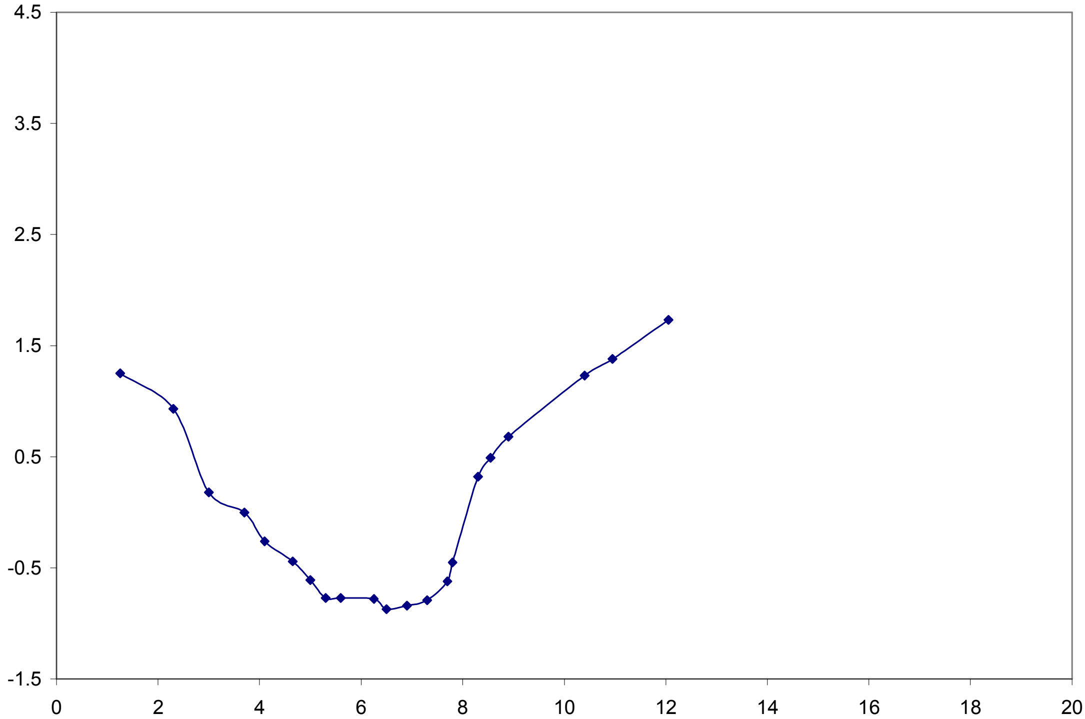

Figure E-45. Reach 8, XS 19.5

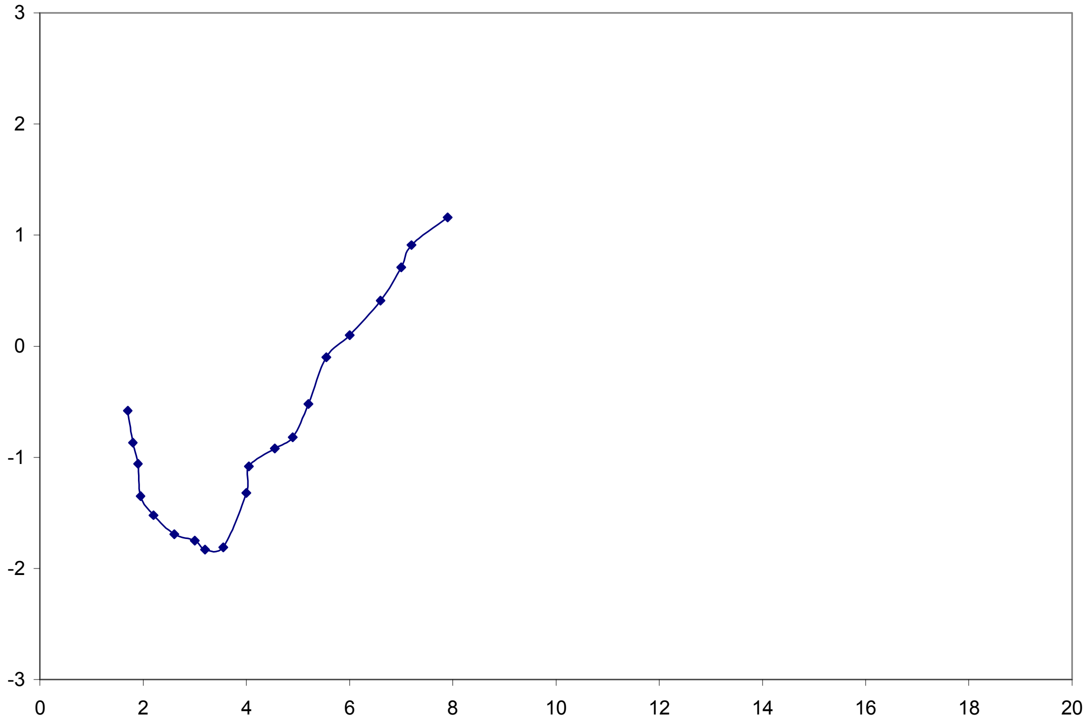

Figure E-46. Reach 8, XS 58.5

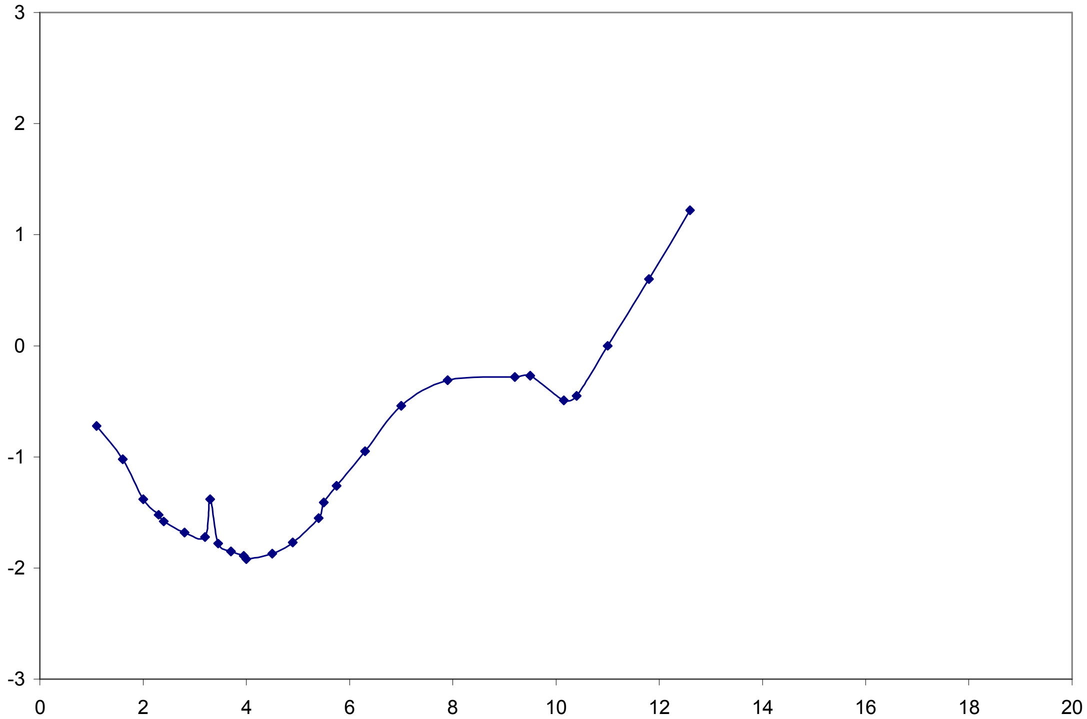

Figure E-47. Reach 8, XS 97.5

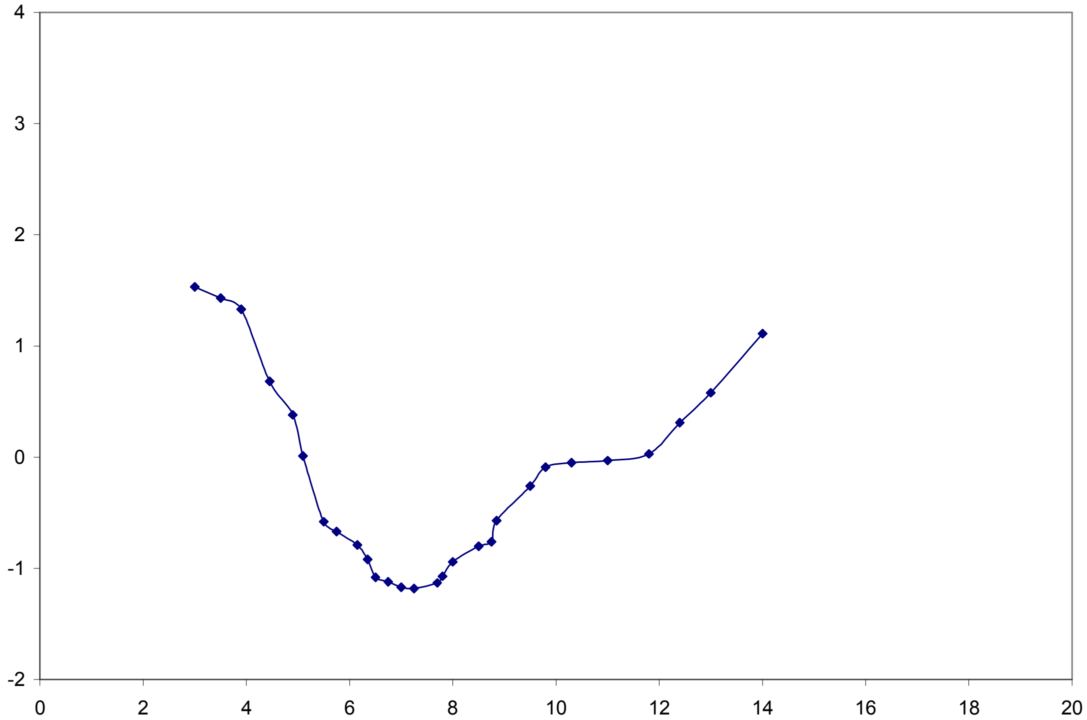

Figure E-48. Reach 9, XS 13.

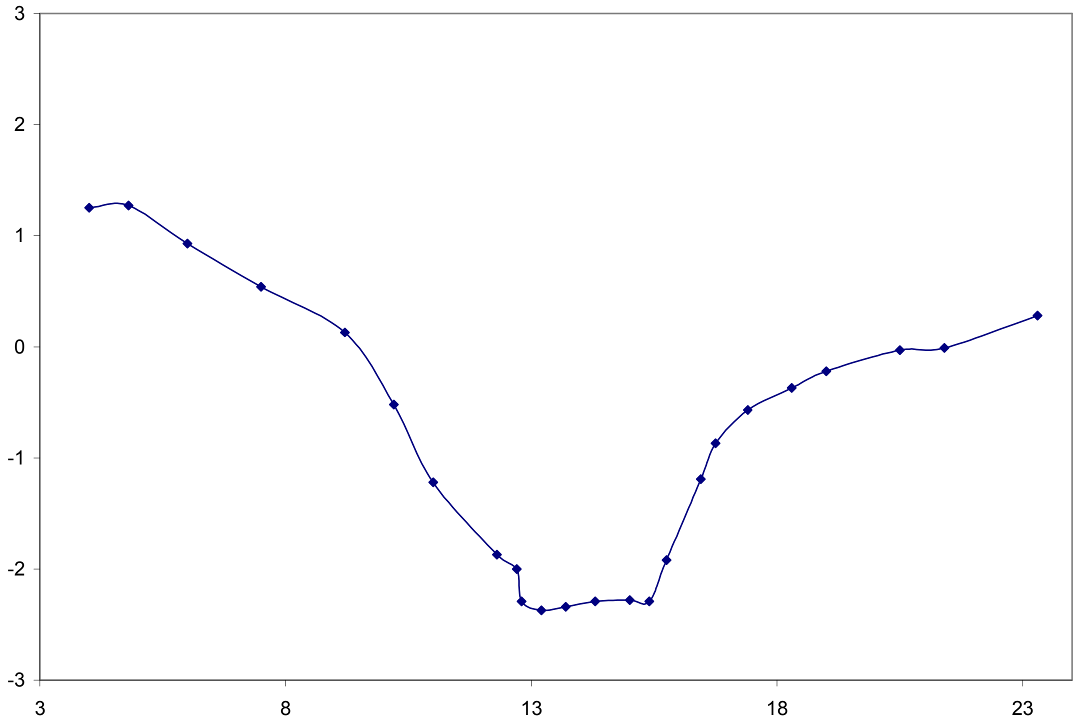

Figure E-49. Reach 9, XS 39.

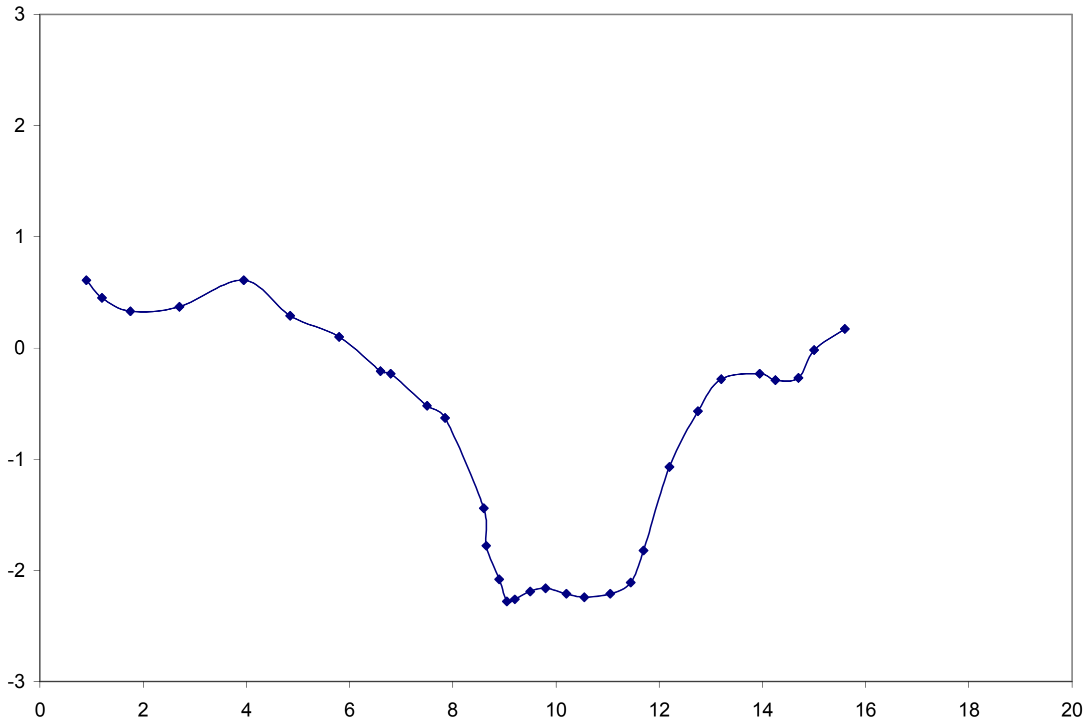

Figure E-50. Reach 9, XS 65.

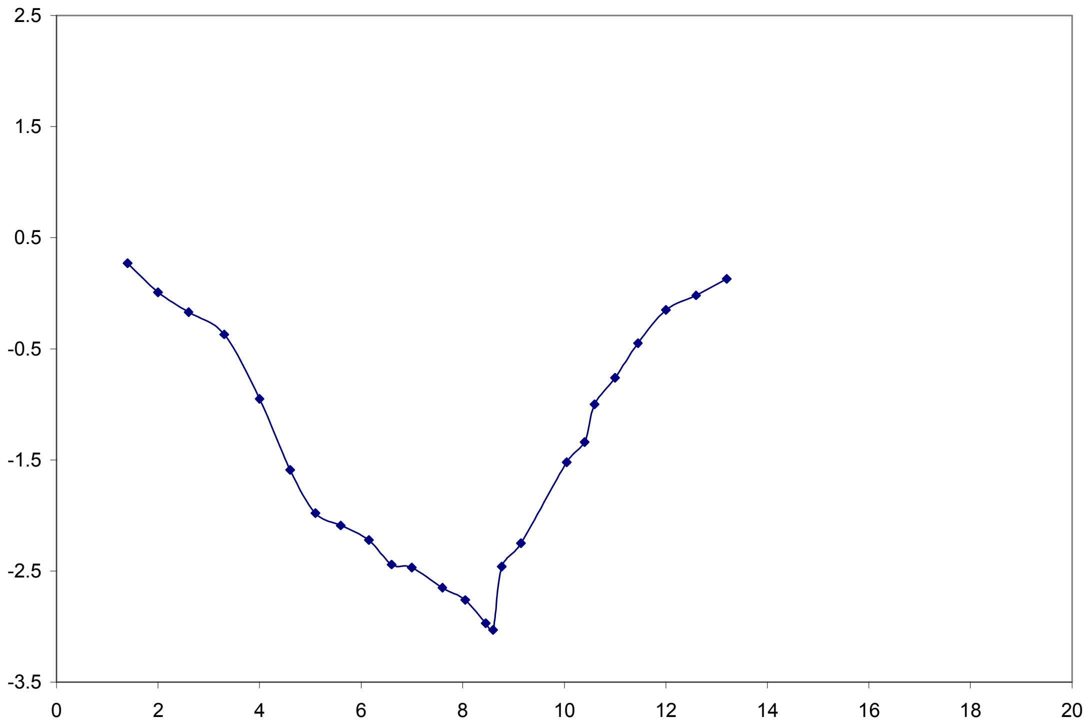

Figure E-51. Reach 10, XS 17.

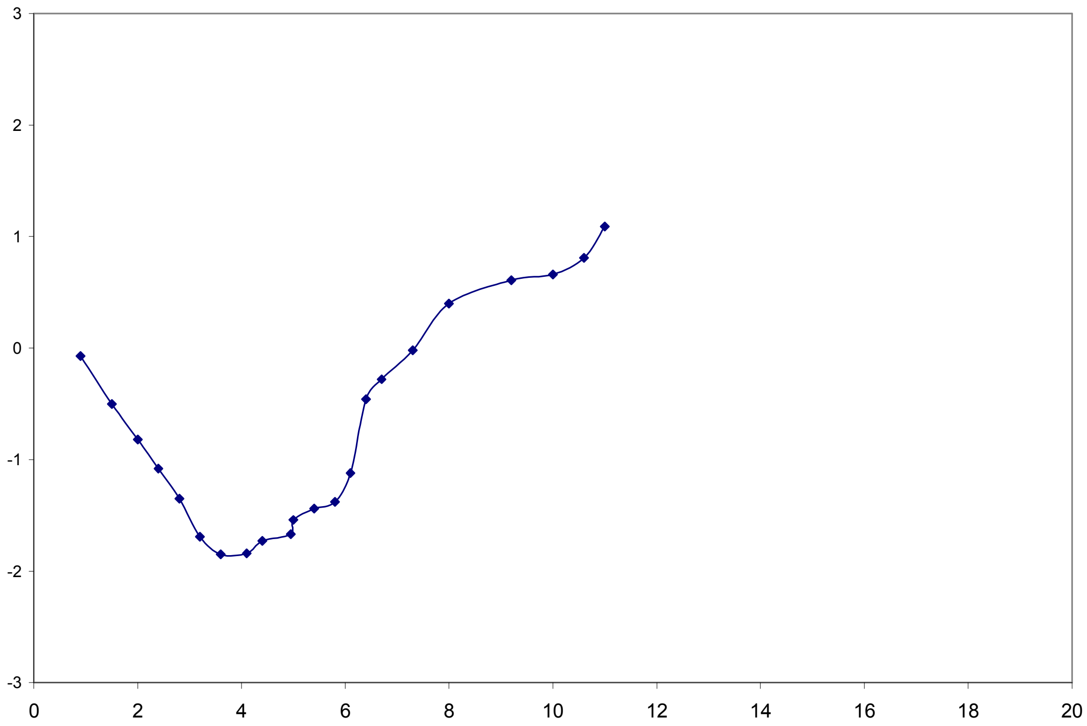

Figure E-52. Reach 10, XS 51.

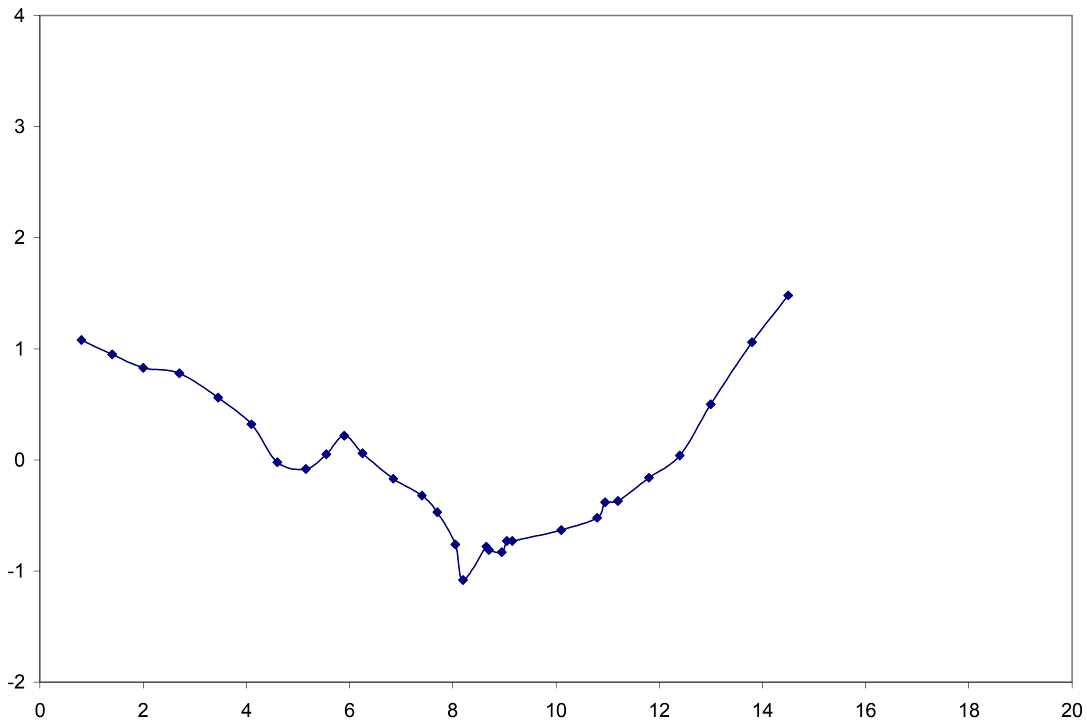

Figure E-53. Reach 10, XS 85.

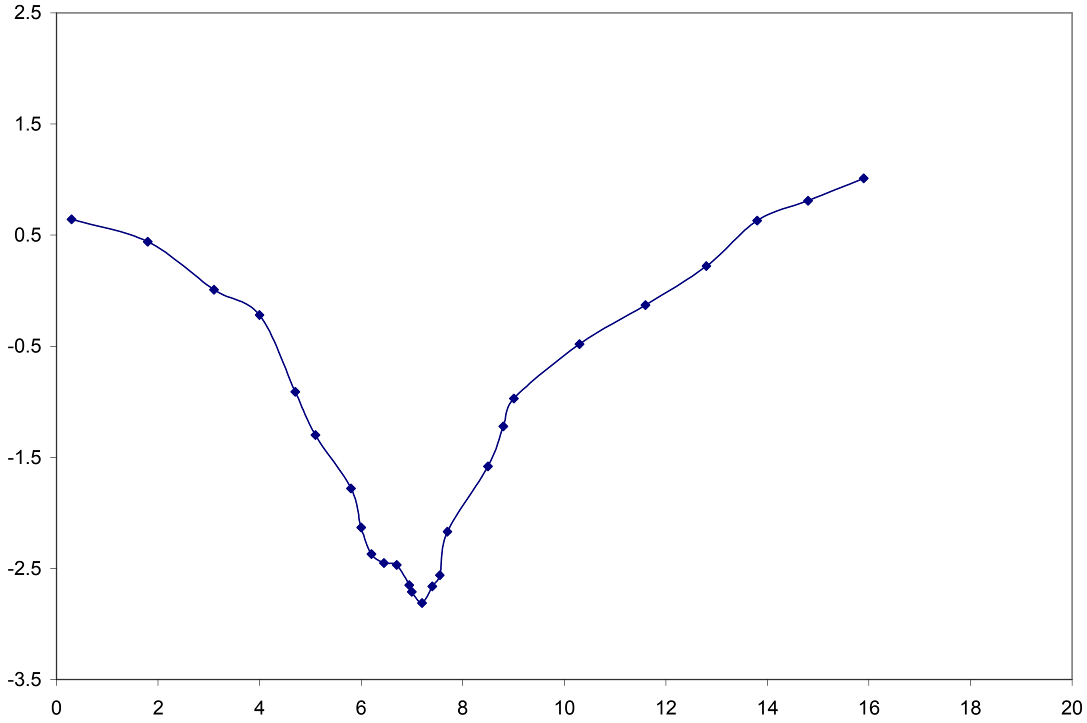

Figure E-54. Reach 11, XS 10.5.

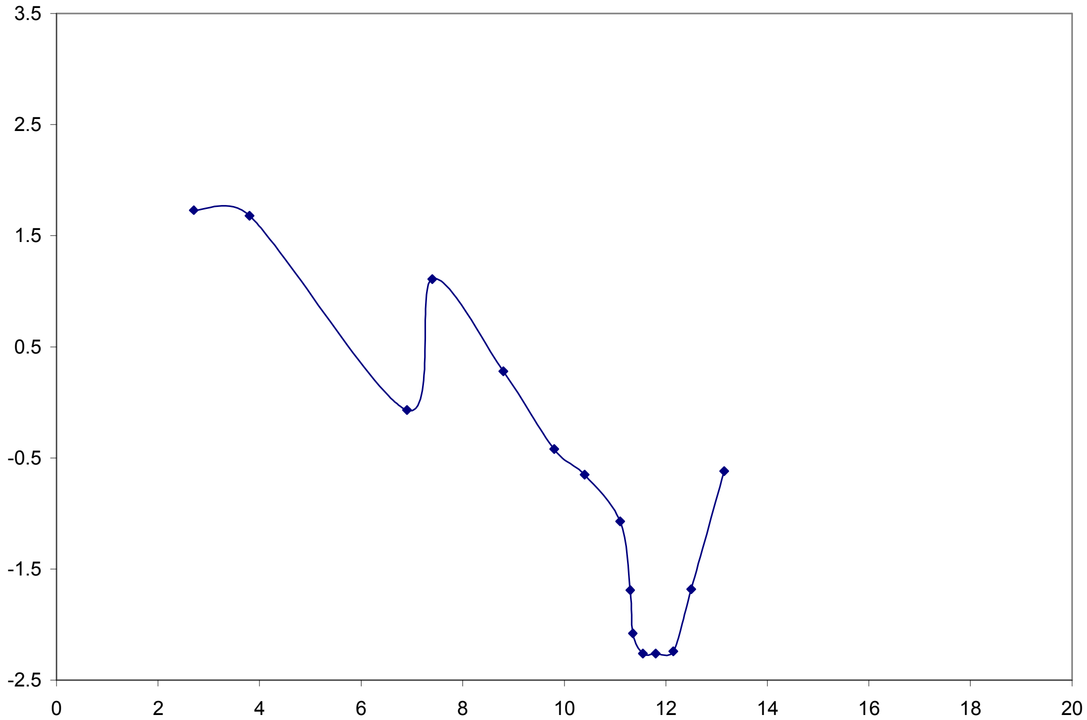

Figure E-55. Reach 11, XS 31.5.

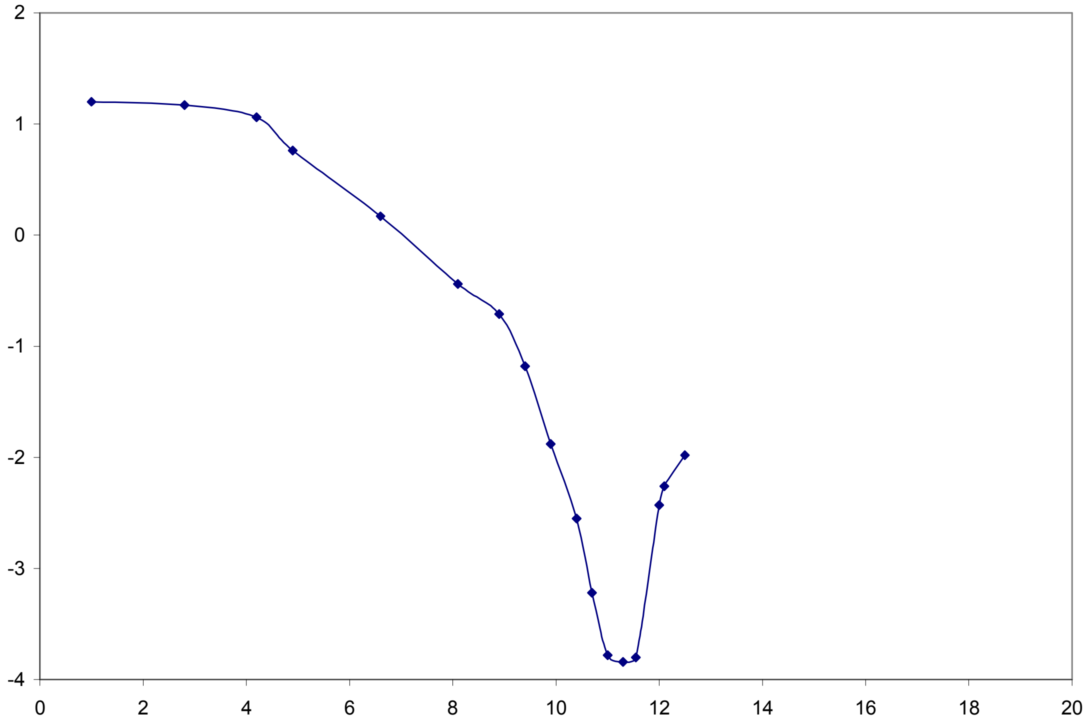

Figure E-56. Reach 11, XS 53.5.

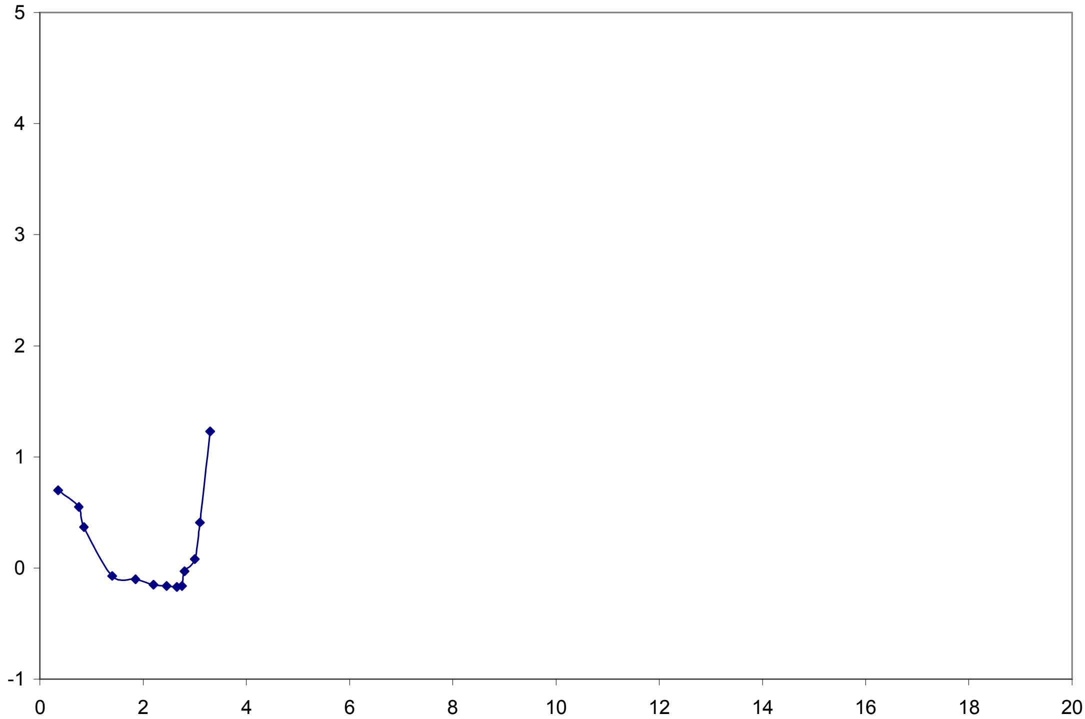

Figure E-57. Reach 12, XS 15.5.

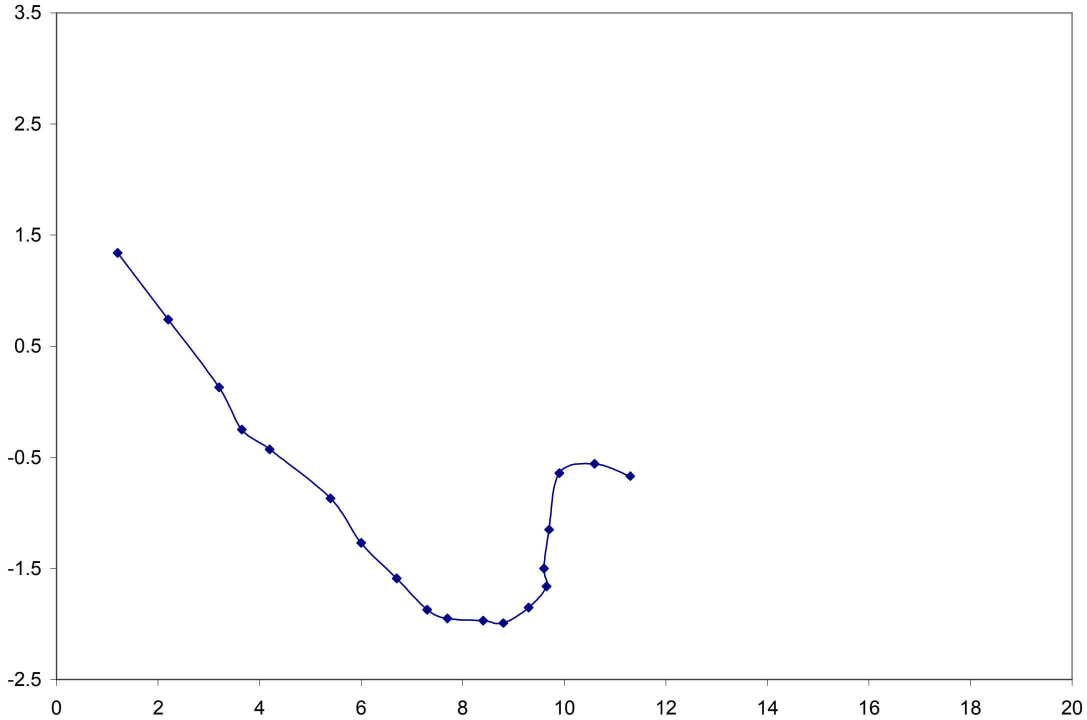

Figure E-58. Reach 12, XS 46.5.

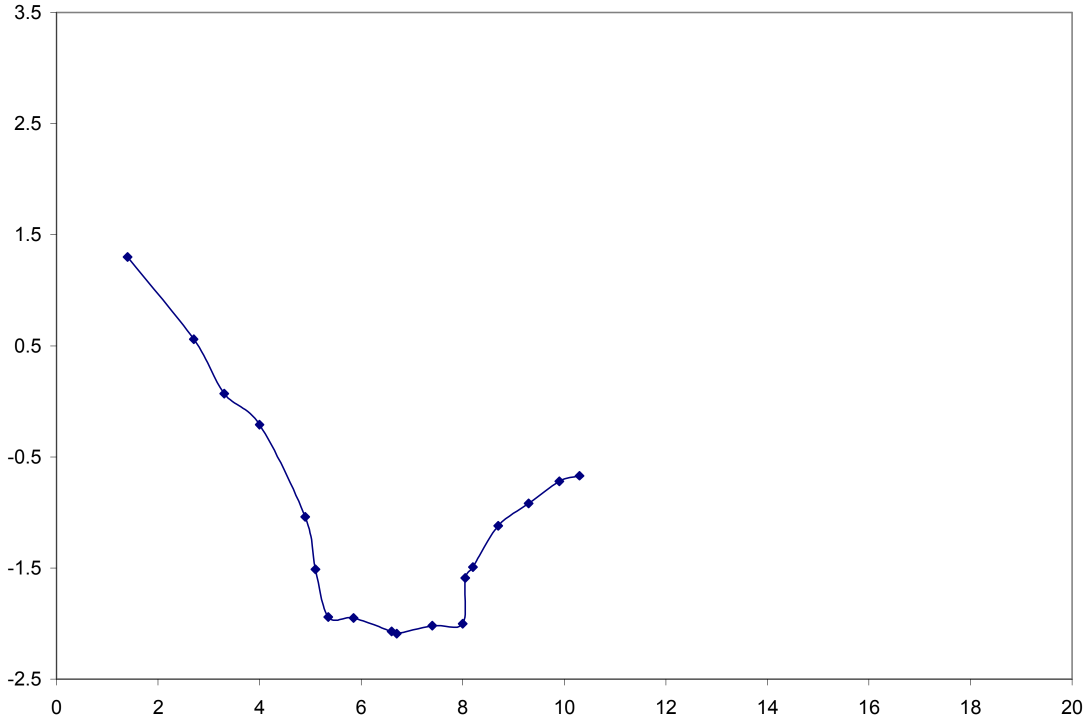

Figure E-59. Reach 12, XS 77.5.

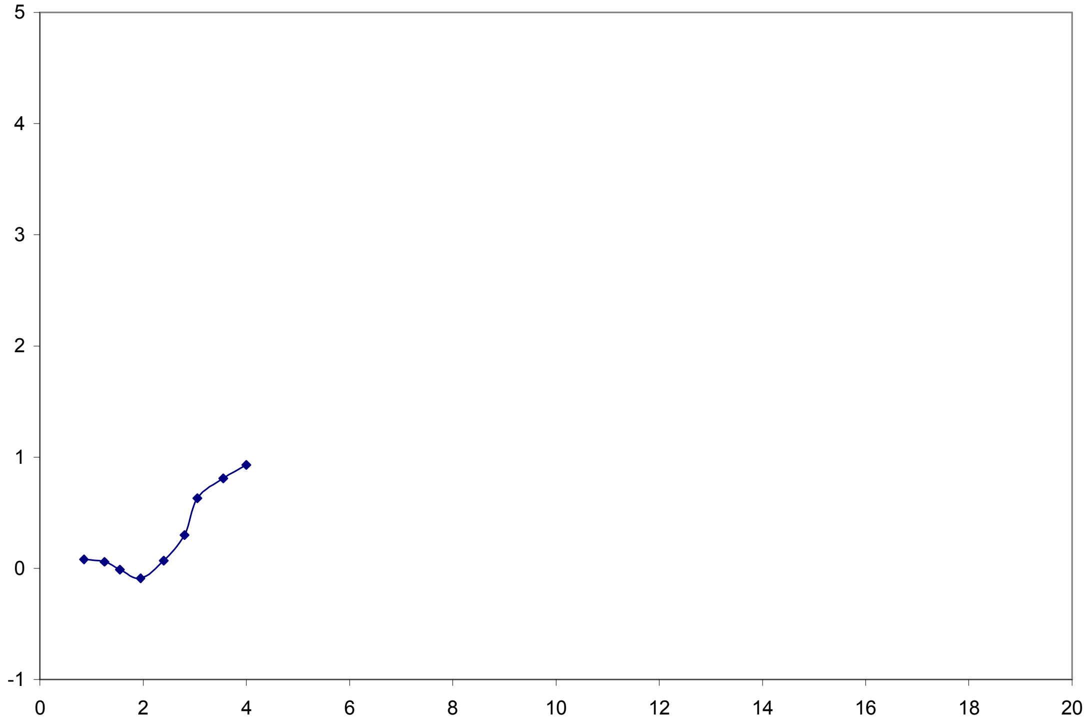

Figure E-60. Reach 13, XS 11.

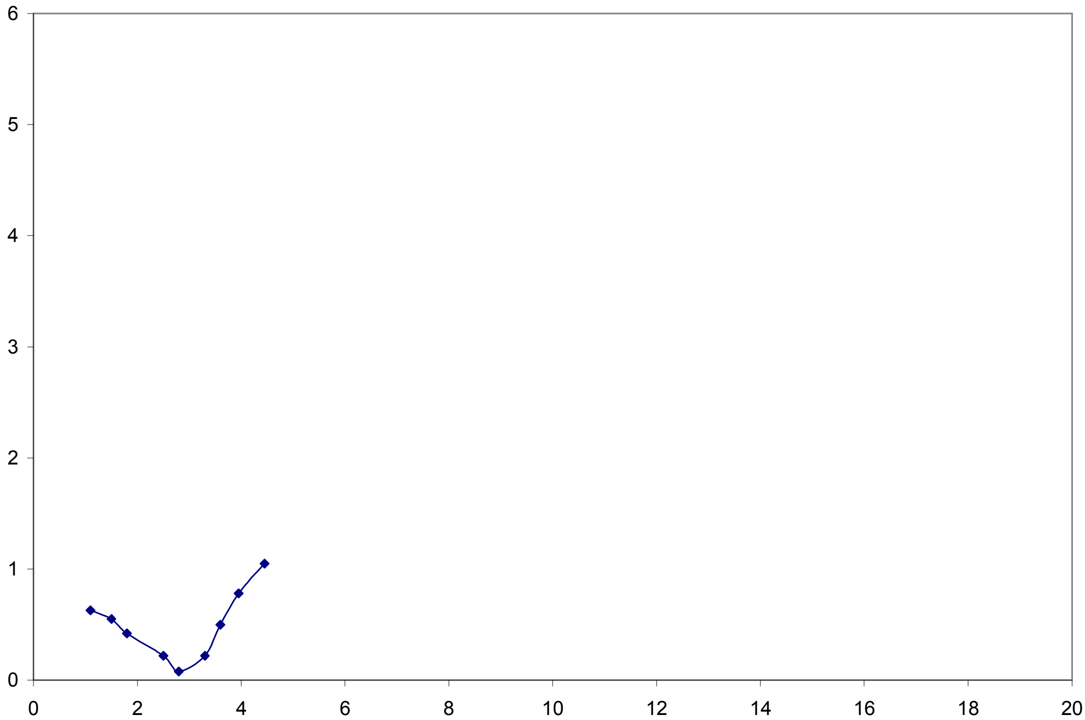

Figure E-61. Reach 13, XS 33.

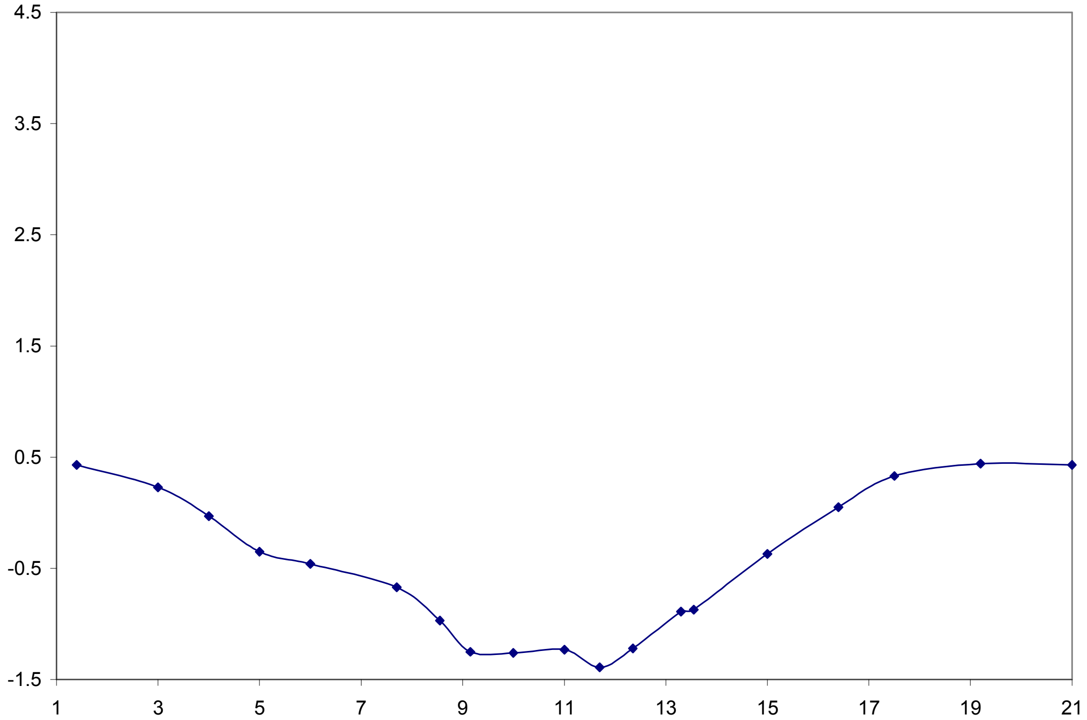

Figure E-62. Reach 13, XS 55.

Appendix F- Bed grain size distribution

The surface sediment grain size distribution was characterized in each sample reach by performing pebble counts at five locations, corresponding to every fifth bankfull width, following methods in Bunte and Abt (2001). At each location, 100 clasts were measured, giving a total of 500 clasts per sample reach, producing a statistically robust estimate of grain size distribution. A systematic random sampling approach was used wherein a grid pattern scaled to the local bankfull width and maximum particle size was used to measure the clasts. In most cases, a grid spacing of 0.2 m was adequate to avoid double counting a single clast. Clasts located at each grid node were measured by hand, and are reported as the phi sieve mesh on which the particle would be caught (2, 4, 5.6, 8, 11, 16, 22, 32, 45, 64, 90, 128, and 180 mm). Clasts finer than 2 mm were reported as <2 mm. This method provides high quality data for grain sizes larger than 8 mm, however, quality decreases at <8 mm because it is difficult to select a single grain from the bed by hand. Figures F-1 through F-3 illustrate the continuous grain size distribution for the lower, middle and upper watershed sample reaches. Figure F-4 shows the complete percentage of each size clast measured in each sample reach.

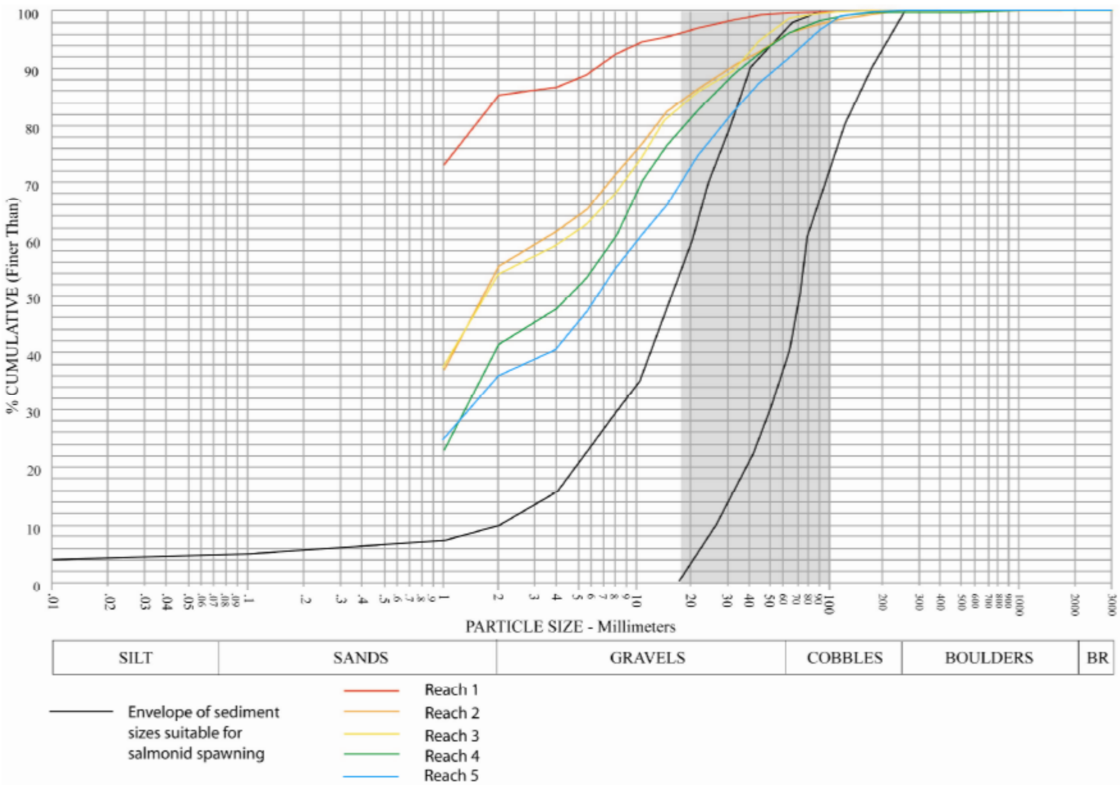

Figure F-1. Surface particle size distribution curves of samples in each sample reach in the lower watershed. Envelope and shaded area highlights framework grain sizes utilized by steelhead for spawning (Kondolf and Wolman, 1993).

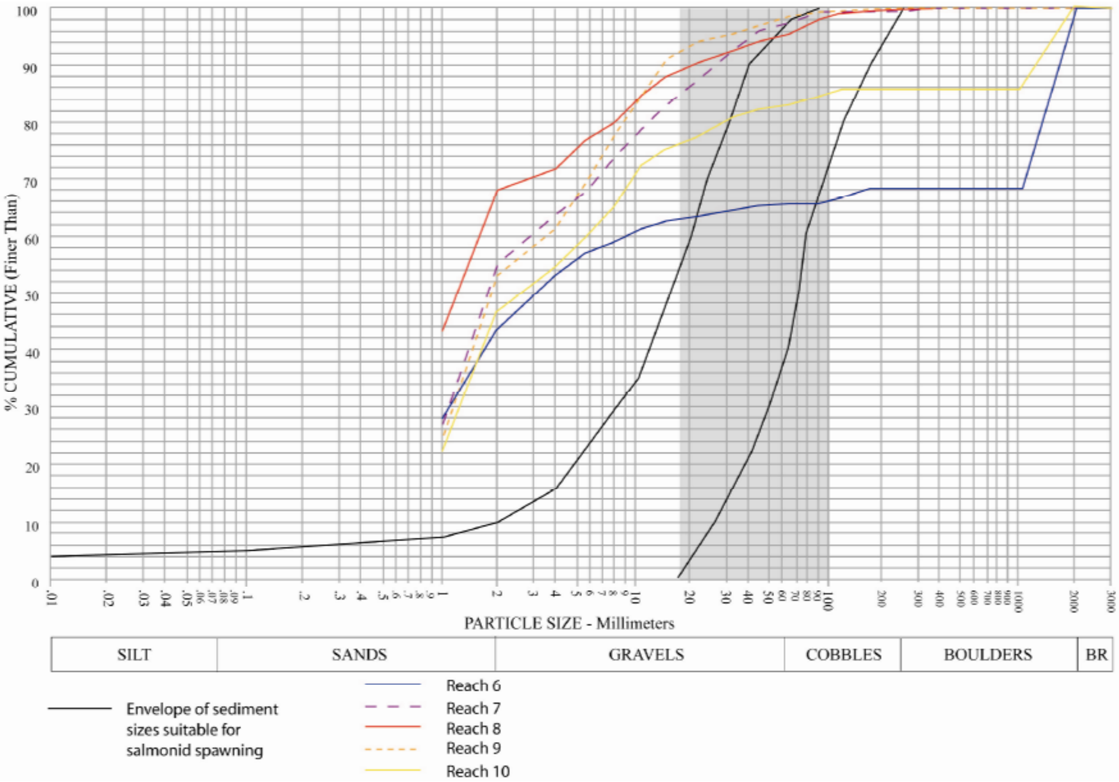

Figure F-2. Surface particle size distribution curves of samples in each sample reach in the middle watershed. Envelope and shaded area highlights framework grain sizes utilized by steelhead for spawning (Kondolf and Wolman, 1993).

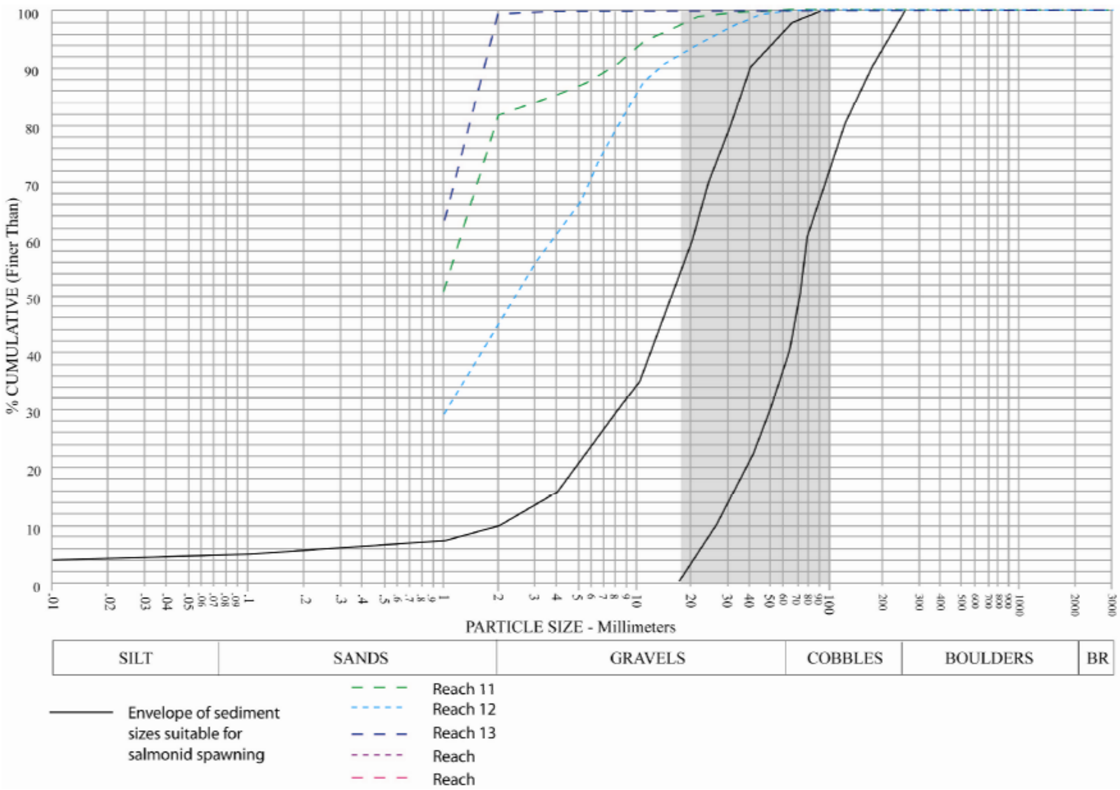

Figure F-3. Surface particle size distribution curves of samples in each sample reach in the upper watershed. Envelope and shaded area highlights framework grain sizes utilized by steelhead for spawning (Kondolf and Wolman, 1993).

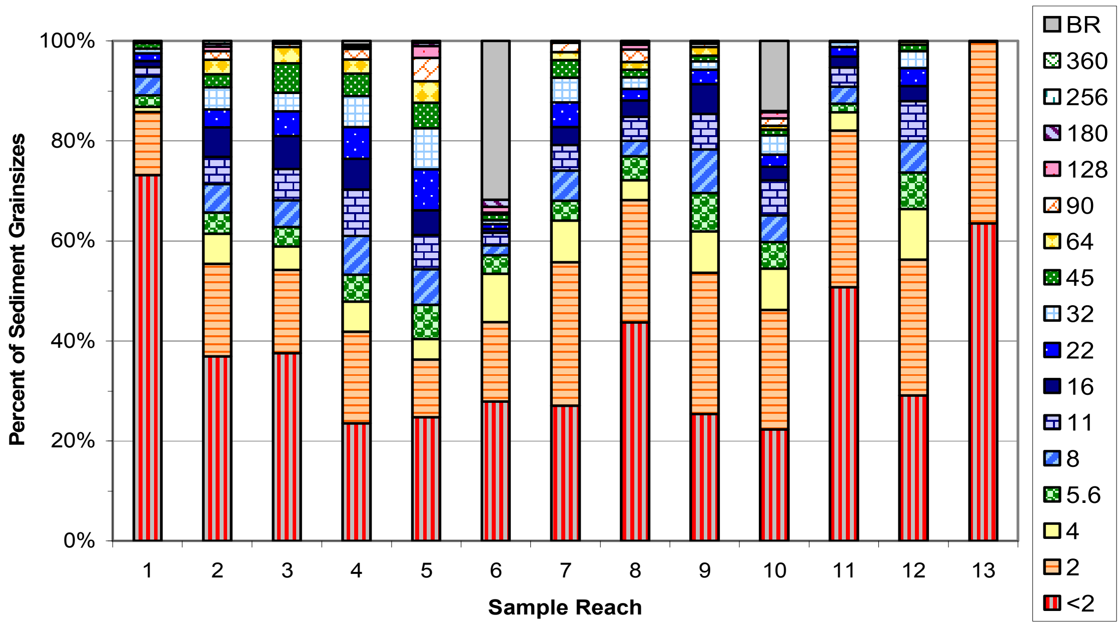

Figure F-4. Percentage of each grain size class (in mm) measured in the grain size distribution of each sample reach.

Table F-1. Average embeddedness of channel bed in each sample reach. A value of 1 = 0 to 25% embeddedness, a value of 2 = 25 to 50%, a value of 3 = 50 to 75%, and a value of 4 = 75 to 100% embedded.

Sample reach	Average embeddedness value
0	1.00
1	3.40
2	2.75
3	1.20
4	1.40
5	1.60
6	3.00
7	2.80
8	2.80
9	1.60
10	1.50
11	2.67
12	1.60
13	1.40

Appendix G- Water quality data

Laboratory Methods and Analysis

Analysis of water samples for nitrogen and phosphorus were carried out at the Romberg Tiburon Centers for Environmental Studies, San Francisco State University. This laboratory was chosen for it reputation of competence in the analysis of water samples with low magnitude nutrient concentrations.

Nitrate and Nitrite

Nitrogen is found in a number of oxidative states including (-3) NH_4^+, (0) N_2, (+2) N_2O, (+3) NO_2^-, and (+5) NO_3^- of which gaseous nitrogen (N_2) is the most abundant, yet the least bio-available to aquatic organisms. The most abundant bio-available species of inorganic nitrogen is nitrate-NO_3^-, which often is implicated a nutrient that can limit the growth of phytoplankton. Typically, nitrate is a new source of nitrogen for the ecosystem and its utilization (along with N_2) by primary producers has been termed "new production" and is an important concept in understanding the yield and possible export within an ecosystem. Consequently, nitrate levels are crucial to the understanding of linking phytoplankton dynamics to higher trophic levels (e.g. fish production). Nitrite (NO_2^-) is found in fresh waters at much lower concentrations than nitrate because it readily oxidizes to nitrate. However, in environments that are impacted by human or animal effluents, nitrite can become a good indicator of impairment.

Nitrate and nitrite analysis was performed using a Bran and Luebbe AutoAnalyzer II and field-filtered samples. The automated analysis for the determination of nitrate plus nitrite (NOx-N) is a colormetric assay that uses the procedure whereby nitrate is reduced to nitrite by a copper-cadmium reductor column. The nitrite ion then reacts with sulfanilamide under acidic conditions to form a diazo compound. This compound then couples with N-1-naphthylethyenediamine dihydrochloride to form a purple azo dye. Finally, the compound is passed through a 15-millimeter flowcell and the color intensity is measured by a colorimeter with 540 nanometer interference filters. By using a colorimeter at a specific wavelength, the amount of light that is absorbed depends directly on the concentration of the colored material following the Lambert-Beer law. These procedures are further outlined in Whitledge et al. (1981). NOx-N concentrations, expressed in μg/L-N, were calculated by regression analysis of known calibration standards ranging from 0-560 μg/L and unknown samples. Regression analysis for all NOx-N analyses resulted in very reliable correlation coefficients ($r^2 = 0.999$). When NOx-N concentrations exceeded the calibration range, the sample was diluted appropriately and reanalyzed. Nitrite was analyzed is the same manner, with the omission of the copper-cadmium redactor step. Nitrate (NO_3^-) can be determined by subtraction of nitrite (NO_2^-) concentrations from NOx-N concentrations in each sample.

Ammonia

Ammonia, present in aquatic systems mainly as the dissociated ion NH_4^+ (ammonium), is much more reactive than nitrate due to its higher chemical energy; and is usually rapidly assimilated by phytoplankton and other aquatic plants when available. However, despite rapid uptake by algae, ammonia will always persist in small quantities because it is also the major excretory product of aquatic animals. This “recycled” source of nitrogen is often distinguished from “new” sources of nitrogen, which can be present either seasonally, or derived from anthropogenic sources. The actual amount of ammonia present at any time depends on the balance between aquatic animal excretory rates, plant/algal uptake, and bacterial oxidation. Hence, the value of ammonium concentrations in any aquatic system is critical to the understanding of what nutrient sources (e.g. nitrogen) may be controlling algal growth.

Analysis for ammonia was carried out in the following manner (Solórzano, 1969; Strickland and Parsons, 1972). A field-filtered is treated in an alkaline citrate medium with sodium hypochlorite and phenol in the presence of sodium nitroprusside, which acts as a catalyzer. The sample is then allowed to sit in the dark for a minimum of 3 hours while a colormetric reaction takes place where a blue indophenol color is formed. Samples and standards (run in duplicate) are treated equally, and should yield standard curve linear regression *r*-values of >0.99. All samples are read on a single diode-array spectrophotometer at a wavelength of 640 nm using a 10-cm cell.

Phosphate

Phosphorous is essential for all living organisms; living matter contains about 0.3 percent dry weight phosphorous. Although phosphorous is not needed for growth in such large amounts as carbon, oxygen, hydrogen, or nitrogen, it is considered one of the major nutrients implicated in the limitation of phytoplankton growth in fresh and marine systems.

Phosphate (PO_4^{3-}) analysis was performed using a Bran and Luebbe AutoAnalyzer II and field-filtered samples. The automated analysis for the determination of orthophosphate is a colormetric assay in which a blue color is formed by the reaction of orthophosphate, molybdate ion and antimony ion followed by reduction with ascorbic acid under acidic conditions (pH<1). The reduced blue phospho-molybdenum complex is measured by a colorimeter with 880 nanometer interference filters. These procedures are further outlined in Bran and Luebbe Method G-175-96.

Phosphate concentrations, expressed in µg/L-P, were calculated by regression analysis of known calibration standards ranging from 0 – 155 µg/L and unknown samples. Regression analysis for all phosphate analyses resulted in very reliable correlation coefficients ($r^2 = 0.999$). When phosphate concentrations exceeded the calibration range, the sample was diluted appropriately and reanalyzed.

Total Dissolved Nitrogen

Most nitrogen found in natural waters is dissolved because nitrogen species do not strongly adsorb to sediment particles. Dissolved organic nitrogen can be determined by the subtraction of NOx-N and NH_3/NH_4^+-N from TDN. There can be a strong correlation between dissolved organic carbon (DOC) and DON and correlations between organic nitrogen and Chlorophyll-a are often found.

Total dissolved nitrogen (TDN) analyses were performed using a Bran and Luebbe AutoAnalyzer II. TDN was analyzed using a modification of the method described by Solórzano and Sharp (1980a). Filtered water samples were oxidized using a persulphate and sodium hydroxide solution and an autoclave. After oxidation, hydrochloric acid and an NH_4Cl/ NH_4OH buffer were used to prepare the samples for colormetric analysis following the method outlined above for NOx-N.

Total Dissolved Phosphorus

Unlike nitrogen, phosphorus readily adsorbs to inorganic particles. Organic phosphorus is normally a very small component of total phosphorus in natural waters; therefore, determination of total dissolved phosphorus (TDP) provides an understanding of the particulate fraction (likely to be mostly inorganic). In samples where there is very little particulate phosphorus, is can be assumed that TP and TDP are equivalent. The subtraction of phosphate from TDP provides a measure of dissolved organic phosphorus.

Total dissolved phosphorus (TDP) analyses were performed using a Bran and Luebbe AutoAnalyzer II. TDP was analyzed using a modification of the method described by Solórzano and Sharp (1980b). Filtered water samples were treated using magnesium sulphate and high temperature to decompose organic phosphorus compounds. After decomposition, the residue is then treated with HCL hydrolyze polyphosphates and prepare the samples for colormetric analysis following the method outlined above for phosphate.

Raw Data

Table G-1. Raw data for the 11 nutrient sample locations sampled in January, April, and July, 2004.

Sample #		Date	NOx (µg/L)	NO3 (µg/L)	NO2 (µg/l)	PO4 (µg/L)	NH3 (µg/L)	TN (µg/L)	TP (µg/L)
p1	Pinole Ck. @ Senior Center	1/8/2004	752	744	8	242	31	2446	399
p2	Pinole Ck. @ Collins School	1/8/2004	1023	1015	8	290	23	1180	263
p3	Pinole Ck. @ Library	1/8/2004	1018	1008	10	240	26	2497	300
p4	Pinole Ck. @ Amber Schwartz Park	1/8/2004	962	952	10	238	18	1404	275
p5	Pinole Ck. @ Riprap on EBMUD property	1/8/2004	677	670	7	270	18	2455	404
p6	Pinole Ck. @ upstream from Simas Ck	1/8/2004	796	786	10	287	20	2278	369
p7	Pinole Ck. @ Below Waterfall	1/8/2004	973	962	11	255	24	1539	253
p9	Pinole Ck. @ Bear Ck Road	1/8/2004	1368	1353	15	176	30	1734	178
p8	Periera Ck	1/8/2004	843	836	7	390	25	1865	410
p10	Tributary at Bear Ck Road	1/8/2004	602	596	5	278	22	1887	322
p11	Simas Ck	1/8/2004	1188	1182	6	336	8	1905	327
p21	Pinole Ck. @ Senior Center	4/28/2004	60	56	4	439	18	383	119
p22	Pinole Ck. @ Collins School	4/28/2004	37	33	4	420	11	372	743
p23	Pinole Ck. @ Library	4/28/2004	201	197	4	462	36	629	818
p24	Pinole Ck. @ Amber Schwartz Park	4/28/2004	192	189	2	468	20	538	496
p25	Pinole Ck. @ Riprap on EBMUD property	4/28/2004	11	9	2	465	20	377	481
p26	Pinole Ck. @ upstream from Simas Ck	4/28/2004	27	25	2	484	21	380	1061
p27	Pinole Ck. @ Below Waterfall	4/28/2004	51	49	2	493	15	365	1053
p29	Pinole Ck. @ Bear Ck Road	4/28/2004	64	62	3	253	13	429	535
p28	Periera Ck	4/28/2004	512	503	9	529	11	786	538
p30	Tributary at Bear Ck Road	4/28/2004	263	253	10	560	31	651	560
p31	Simas Ck	4/28/2004	0	0	1	762	13	371	838
p41	Pinole Ck. @ Senior Center	7/22/2004	50	47	4	458	29	472	894
p42	Pinole Ck. @ Collins School	7/22/2004	0	0	1	296	0	416	618
p43	Pinole Ck. @ Library	7/22/2004	215	210	6	384	25	587	610
p44	Pinole Ck. @ Amber Schwartz Park	7/22/2004	101	99	1	416	2	380	593
p45	Pinole Ck. @ Riprap on EBMUD property	7/22/2004	0	0	1	429	0	324	621
p46	Pinole Ck. @ upstream from Simas Ck	7/22/2004	8	7	1	639	0	337	751
p47	Pinole Ck. @ Below Waterfall	7/22/2004	1	0	1	602	0	253	686
p49	Pinole Ck. @ Bear Ck Road	7/22/2004	0	0	1	26	0	422	178
p48	Periera Ck	7/22/2004	1	0	1	673	1	309	760
p50	Tributary at Bear Ck Road	7/22/2004	61	60	2	571	9	387	714
p51	Simas Ck	7/23/2004	-	-	-	-	-	-	-

Sample locations

Table G-2. Description and coordinates for the 11 nutrient sampling locations. Note: these are the same locations used in previous macroinvertebrate sampling efforts by the Contra Costa Clean Water Program (2004).

Water Quality Sampling Locations (also Macroinvertebrate Sampling Station Coordinates) Pinole Creek Watershed			
STATION CODE	**STATION DESCRIPTION**	**ELEV. (ft)**	**LATITUDE & LONGITUDE**
PNL-1	Pinole Creek at Senior Center	16	38^0 00.435'
			122^0 17.422'
PNL-2	Pinole Creek behind Collins School	29	38^0 00.022'
			122^0 17.372'
PNL-3	Pinole Creek behind tennis courts and library	42	38^0 59.529'
			122^0 17.053'
PNL-4	Pinole Creek at Amber Schwartz Park	81	37^0 58.951'
			122^0 16.371'
PNL-5	Pinole Creek at riprap at EBMUD land	182	37^0 58.441'
			122^0 14.924'
PNL-6	Pinole Creek above Simas Creek	197	37^0 58.215'
			122^0 14.421'
PNL-7	Pinole Creek below waterfall	302	37^0 58.065'
			122^0 12.596'
PNL-8	Periera Creek 200 feet above Pinole Creek	361	38^0 57.839'
			122^0 12.087'
PNL-9	Pinole Creek along Bear Creek Road	357	37^0 57.760'
			122^0 12.070'
PNL-10	No Name Creek above Bear Creek Road	381	37^0 57.778'
			122^0 11.937'
SI-1	Simas Creek 400 feet above Pinole Creek	201	37^0 59.277'
			122^0 14.461'

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